OECD Development Policy Tools

Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT)

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Foreword

At its Fifth High-Level Meeting (HLM) held on 21 May 2019, the Members of the Governing Board invited the OECD Development Centre to "help design transformational development strategies aligned with the 2030 Agenda focusing on the sustainable transition of natural resource-rich developing countries towards a low-carbon economy and better integration into global value chains". The Development Centre responded to this request, by refocussing the activities of the Policy Dialogue on Natural Resource-based Development towards scaling up work to support the low-carbon transition in resource-rich countries. The objective is to identify economically shock-proof and socially viable policy options available to extractive-based economies.

Under the leadership of the European Commission and Nigeria, a multi-stakeholder Steering Committee, established in December 2020, provided guidance and supported the development of the *Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT*). The Steering Committee comprised experts and representatives from governments from the OECD, its Development Centre, and partner countries, international organisations, industry (including extractives), civil society, and development finance institutions.

EFFECT is the result of an open, intense, and enriching multi-stakeholder consultation process hosted by the Development Centre between January 2021 and September 2022. An initial draft, focusing primarily on *Pillar 1: Decarbonisation of extractives and managing uncertainties,* was presented for discussion at the Sixteenth Plenary Meeting of the Policy Dialogue on 29 and 30 June 2021. After this, *EFFECT* was continuously revised and improved, with changes discussed and agreed during monthly meetings of the Steering Committee. A revised version of *Pillar 1* and *Pillar 2: Sustainable fossil fuel exit strategies and just transition plans* was discussed at the Seventeenth Plenary Meeting of the Policy Dialogue on 14 and 15 December 2021. The full package of all three Pillars, with a particular focus on *Pillar 3: Systemic change and economy-wide decarbonisation* was presented at the Eighteenth Plenary Meeting of the Policy Dialogue on 27 and 28 June 2022. An advanced draft was submitted for on-line public consultation during the period 17 June to 7 July 2022, and comments received were reviewed by the Steering Committee.

After its high-level launch at COP27, hosted by the Canadian Pavilion in Sharm El-Sheikh, Egypt on 15 November 2022, *EFFECT* will support policy dialogues and peer learning on the cross-border and equity dimensions of the low-carbon transition, the development of tailored low-carbon transition roadmaps in developing and emerging producers as well as the shaping of transformative and just transition partnerships.

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The authors wish to express their deep gratitude to Brendan Devlin, Strategy and Foresight Counsellor, Directorate General for Energy, European Commission and Dr Kelechi O. Ofoegbu, Senior Technical Adviser to the Honourable Minister, Ministry of Petroleum Resources, Federal Republic of Nigeria, for their leadership and guidance as co-chairs of the EFFECT Steering Committee and for their continuous support throughout the multi-stakeholder consultations held as part of the Plenary Meetings of the Policy Dialogue over two years.

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Executive summary

Fossil fuel-producer developing economies have contributed least to cumulative greenhouse gas (GHG) emissions and yet are exposed to some of the worst impacts of climate change. They are also among the least equipped to navigate the risks and take advantage of the opportunities arising from the low-carbon transition. Many are in the midst of severe economic downturns caused by the enduring effects of the COVID-19 pandemic and Russia's invasion of Ukraine. These crises have created strong inflationary pressures, increased public debt to unsustainable levels and made it harder and more expensive to access international finance. Faced with rapid demographic growth, urbanisation and burgeoning demand for energy, they rely heavily on cheap access to fossil fuels for power generation and industry, with inadequate power networks, and significant gaps in technology, capacity and financing that could lock them into costly high-carbon development pathways.

Despite these challenges, and while there has been a strong push towards net-zero commitments at a global level, little attention has been paid to "how" fossil fuel-producer developing economies can manage to reduce their fossil fuel dependence in a way which safeguards the rights and interests of their citizens and supports the achievement of sustainable development objectives. The *Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT)* provides a toolbox for these countries to answer this question. Developed in close partnership with developing economies, *EFFECT* provides a menu of policy options and practical guidance for policy makers in extractive-based countries to chart just, realistic and sustainable pathways to a low-carbon future, accounting for the need to address short-term pressures, particularly energy access, affordability and security, without losing sight of long-term structural transformation and decarbonisation objectives.

EFFECT is structured around three interrelated Pillars.

Pillar 1: Decarbonising extractives and managing uncertainties is framed by the uncertain outlook for fossil fuels in a global decarbonised economy, renewed energy security concerns and the risks associated with continuous reliance on fossil fuels. The transformation of the global energy mix to renewable energy is necessary to meet the goals of the Paris Agreement and to prevent irreversible damage to the world's environment and ecosystems. However, fossil fuel use will continue in the short-medium term, and remain an important part of the energy mix even after the world has transitioned toward a low-carbon and green economy. For example, the International Energy Agency (IEA)'s Net Zero Roadmap finds that by 2050, fossil fuels would still represent a 20% share of the global energy supply. Consequently, as a transitional step, fossil fuel-producer developing countries, including national oil companies (NOCs), should ensure that fossil fuel production is as low-carbon as possible. This can be achieved through a mix of regulations, policy incentives and the deployment of best available technologies and practices to reduce flaring, venting, and methane emissions across the upstream oil and gas and mining sectors. To manage the transition, these countries need to ensure that measures to decarbonise the extractives sector are implemented at the same time as structural reforms to reduce fossil fuel dependence, and to accelerate systemic change and economy-wide decarbonisation.

Pillar 2: Sustainable fossil fuel exit strategies and just transition plans provides concrete recommendations for policy makers to navigate the implications of long-term trends in declining fossil fuel

demand. It addresses its impact on market access opportunities for emerging and developing producing countries – and therefore on their public budget, labour market, and overall economic, fiscal and political stability. Global climate commitments are changing the market outlook for high carbon commodities: the carbon footprint of fossil fuel extraction, processing, transportation and refining will de facto affect prospects for future market access, given the likelihood of expanding carbon constraints in importer countries. This has global equity implications, considering the difficulties that oil and gas export-dependent low-to-middle income economies face in securing capital, developing regulation, and building technical expertise to enable emissions reduction in the sector, compared with higher-income exporters.

A managed transition away from fossil fuels informed by inclusive, sustainable, and resilient low-carbon development strategies with international support will be essential. Ideally, supply-side and demand-side policies would go hand in hand, and efforts should be made to transparently co-ordinate these policies in line with the Paris Agreement. In the absence of such an approach, mismatches in fossil fuel supply and demand, exacerbated by geopolitical tensions, could create disruptions in both physical and financial markets across developed and developing countries during the transition: if production drops faster than demand, prices might go up, whereas if demand declines faster than production, revenue falls and stranded assets are likely, with increased exposure for asset owners. The prospect of this volatility requires economic policies and measures for robustness, to anticipate and cope with such turbulence. With likely increased energy market volatility, Pillar 2 considers the opportunities and challenges of managing revenues, reducing fossil fuel import or export dependence, creating new jobs, and increasing the share of cleaner, domestically sourced energy alternatives.

Pillar 2 considers how, through integrated policy making, governments can achieve ambitious action on climate change while maximising opportunities for quality jobs through skills transfer and reskilling policies, poverty reduction and minimising the risks of social disruption. This will require just transition plans and the mobilisation of new sources of finance, including crowding in private capital. It will also mean governments and industry working together to address the risks of stranded assets, both through legal contracts with a fair allocation of responsibility over time and through innovative approaches to re-using and re-purposing fossil fuel assets and infrastructure.

Pillar 3: Systemic change and economy-wide decarbonisation focuses on broader transition planning, including integration of nationally determined contributions (NDCs), decarbonisation and sustainable development planning. Pillar 3 provides guidance on “how” fossil fuel based developing economies can seize the transformational opportunities associated with economic diversification, the development of low-carbon value chains, green industrialisation and, where relevant, the responsible and sustainable supply of critical minerals for low-carbon technology manufacturing. It explores revenue substitution and recycling, as well as fiscal restructuring options, noting that the process of diversifying the economy will be a multi-decade endeavour for established producers, with no single industry or sector being capable of replacing revenue from fossil fuels.

Pillar 3 further seeks to chart the least-cost pathway to decarbonisation, by prioritising measures that yield the highest short-term benefits, lead to no regrets, and deliver net positive sustainable development outcomes. Recommendations aim to help governments address energy poverty, and improve energy security (in terms of reliability, affordability and sustainability). Pillar 3 further offers approaches to correct misaligned incentives and price negative externalities of carbon-intensive technologies and modes of production, to encourage industry and consumers to make low-carbon choices while preserving affordability and competitiveness.

Differentiation of recommendations

Recommendations fall into distinct categories: those that fossil fuel-producer developing countries should prioritise, and those that are more complex and challenging, where countries with lower institutional

capacity may require technical assistance. Recommendations directly targeting new and emerging producers have also been separated, given the specific trade-offs and choices facing this subset of countries. Lastly, though raising capacity across the board is a fundamental requirement of an equitable transition, *EFFECT* highlights capacity gaps common to many developing countries, and gaps that inhibit progress and the implementation of low-carbon strategies in particular policy areas.

Overview: Context, guiding principles and key policy recommendations

The *Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT)* provides action-oriented recommendations for fossil fuel-producer and mineral-rich developing economies, industry, and financial institutions to enable a just transition to a low-carbon future. While there has been a strong push towards achieving net-zero at a global level, little attention has been paid to "how" fossil fuel-producer developing countries can undertake a managed decline of production and use in a way which safeguards the rights and interests of their citizens.

In a context of increased uncertainty and volatility in global energy markets and geopolitical instability created by the Russian invasion of Ukraine, *EFFECT* accounts for the practical, political and financial constraints these countries are facing. It supports policy measures to deliver on the Sustainable Development Goals (SDGs) and climate objectives. The Framework aims to make fossil fuel-producer developing economies less vulnerable to the low-carbon transition by reducing their exposure to risk, increasing their resilience, and realising the benefits of a low-carbon economy.

The Framework addresses the short-term pressure to ensure energy security, without compromising on climate targets or losing sight of long-term structural transformation. Such a structural transformation is not just about replacing fossil fuel energy sources with cleaner alternatives: it is also about preparing for the manifold effects (positive and negative) on workers, communities, enterprises, and potential humanitarian consequences. *EFFECT* emphasises the need to manage the social, economic and environmental aspects of this structural transformation. In this regard, it supports a more equitable sharing of the benefits and costs of the transition across and within countries, wherever possible.

EFFECT recognises that delaying action implies sharper subsequent corrective measures with higher system costs and adverse distributional impacts, coupled with an increased risk of high-carbon lock-in and stranded assets.

Key findings

- Many **fossil fuel-producer developing countries are in the midst of severe economic downturns** caused by the enduring effects of the COVID-19 pandemic and Russia's invasion of Ukraine, exacerbated by high vulnerability to climate change and natural disasters.
- **Fossil fuel-producer developing countries are highly exposed to declining revenue from fossil fuels** as the global low-carbon transition reduces overall long-term demand, while continued

dependence on high-carbon commodities will affect competitiveness and prospects for future market access.

- Often characterised by **rapid demographic growth, urbanisation and burgeoning demand for energy,** these countries require a large amount of new sustainable infrastructure, yet they **face a significant capacity and technology gap, as well as substantial constraints in mobilising climate finance** and attracting private investment in low-carbon projects.
- Pervasive fossil fuel subsidies and the fact that negative externalities of carbon intensive technologies and products are not priced means that **investment incentives are distorted, most often at the expense of low-carbon alternatives**.
- At the same time, **growing global demand for critical minerals and low-carbon fuels presents a transformational opportunity** to create jobs, foster innovation, promote sustainable infrastructure and diversify the economy through the development of local value-added industries, as well as regional low-carbon value chains such as battery storage, electric vehicle manufacturing and hydrogen.
- **Net-zero plans in most advanced economies are largely unachievable without substantial hydrogen and renewable electricity imports from developing countries.** This presents an opportunity for fossil fuel-producer emerging and developing economies with abundant renewables potential, know-how and experience.
- The reorganisation of global energy trade relationships, prompted by Russia's invasion of Ukraine, offers an **opportunity for developing country producers to monetise their gas reserves in pursuit of national development objectives**, but it also raises risks of high-carbon lock-in and stranded assets, as well as competitiveness loss if countries are unable to adapt to more stringent emissions reduction requirements.

Guiding principles for a just, low-carbon transition

EFFECT emphasises the responsibility that producing and importing countries share in accelerating the low-carbon transition in fossil fuel producer developing countries. It calls for new forms of transformative partnerships – as set out across the three Pillars – supported by sustainable investments, technology transfer, capacity building and financing. In so doing, the Framework aims to support a more equitable sharing of the benefits and costs of the transition across and within countries, taking into consideration the increasing global demand for electricity due to growing electrification in the building, transport and industry sectors. An even distribution of the costs and benefits of the low-carbon transition within and across countries will be essential to generate public support for transition policies both at the local and global level.

EFFECT builds upon existing commitments contained in the 2030 Agenda for Sustainable Development, particularly SDG7 (Ensure access to affordable, reliable, sustainable, and modern energy for all), while outlining options for a sustainable low-carbon transition. *EFFECT* recognises that developing countries need to prioritise access to energy, industrialisation, clean cooking fuel, and broader sustainable development objectives, and that these investments should lead to improved health and environmental conditions and livelihoods.

EFFECT is based on the guiding principle of common but differentiated responsibilities, and respective capabilities in the light of different national circumstances, enshrined in the Paris Agreement. It emphasises the role of technology, finance and partnerships, and clarifies the type of support required for fossil fuel-producer emerging and developing economies to navigate through the transition. It builds on relevant existing international frameworks and guidance, such as the *ILO Guidelines for a just transition towards environmentally sustainable economies and societies for all*.

EFFECT recognises the heterogeneity of low-carbon development pathways across countries, the importance of flexibility and the need to consider a wide range of policies and technologies to develop tailored and context-specific low-carbon development roadmaps. These should reflect the differences between advanced and developing economies, as well as the fact that developing countries have contributed least to cumulative emissions yet suffer the worst physical impacts from climate change.

Key policy recommendations

Pillar 1: Decarbonising extractives and managing uncertainties

Pillar 1 provides guidance on how to manage the uncertain outlook for fossil fuels in a global decarbonised economy and how to ensure that fossil fuel extraction, processing, transportation and refining are as low-carbon as possible. Recommendations are primarily directed at ministries, departments and agencies of energy, petroleum, mining, finance, national oil companies, importing countries and the fossil fuel industry.

- **Carefully assess the risks of a continuous reliance on fossil fuels**, including exposure to high-carbon lock-in and path dependency, and the corresponding implications for fiscal stability and revenue spending as the speed of the global energy transition increases. In particular, national oil companies (NOCs)'s investment strategies need to align with national low-carbon transition strategies and objectives.
- As the outlook for high carbon commodities is changing, **reduce emissions from fuel extraction, processing, transportation and refining** to the fullest extent possible, by deploying the best available technologies and practices.
- Create an **enabling environment that discourages methane emissions and flaring, and encourages upstream electrification, and, where appropriate, carbon capture (utilisation) and storage (CC(U)S).**
- In particular, **consider integrating methane emissions reduction targets into National Determined Contributions**, and **establishing a measurement, disclosure and verification framework for methane emissions**. Governments may also consider **requiring the public disclosure of methane emissions data**. Governments and industry can work together to improve national methane emissions inventories, utilise existing reporting templates, and design leak detection and repair programmes (LDAR) across the oil and gas, LNG and coal mining value chains.
- **Provide incentives to put associated gas to productive use,** where economically feasible, by charging royalties on flared gas or by granting preferential access for associated gas to the national gas pipeline system and for electricity produced from associated gas to the wholesale market to create domestic demand.
- **Engage with importing countries to seek technical and financial support** for curbing flaring and venting in developing producing countries.
- **Explore the potential for scaling up the deployment of CC(U)S**, while assessing the risks of relying on assumptions about the timing and costs of global CC(U)S deployment as well as technological, economic, institutional, environmental and socio-cultural barriers to implementation. Bring together oil and gas operators and heavy industries to **identify CC(U)S hubs across energy-intensive industrial sectors to achieve scale and create demand for CO_2 storage**. **Decouple repurposing and decommissioning regulations** and address legal liability for decommissioning.
- **Create an enabling environment to facilitate low-carbon technology transfer**, including by reducing trade tariffs and leveraging partnerships between national and international oil and gas companies to foster sustainable technology transfer.

Pillar 2: Sustainable fossil fuel exit strategies and just transition plans

Pillar 2 provides guidance on how to manage progressive fossil fuel phase down/out and related transition risks, while safeguarding the livelihoods of people who will be negatively affected, future proofing new fossil fuel infrastructure to minimise risk of stranded assets, and enhancing affordability and access to climate finance. Recommendations are primarily addressed to finance, planning, economy and labour ministries, departments and agencies.

- **Centralise and consolidate identification, assessment and management of transition risks, raising cross-government capacity** to adopt innovative techniques, including stress-testing and scenario modelling.
- **Structure inclusive and effective just transition management processes.** These include leveraging tripartite social dialogue mechanisms between government, employers and workers, as well as inclusive consultations to build a shared understanding of the costs and opportunities of the low-carbon transition and ways to realise benefits for local people.
- **Assess who will be affected by fossil fuel phase-down/out,** accounting for labour market informality. Blend quantitative and qualitative approaches to data collection, including interviews and household surveys, to assess impacts on jobs and households and how these will vary by region, to provide a nuanced picture of the distributional impacts of the low-carbon transition.
- **Put in place measures, such as targeted cash transfers, fuel vouchers and other targeted support, to mitigate impacts on those who will be adversely affected,** particularly fossil fuel workers and poorer households. Given the skills overlap, active labour market measures can support the transfer of workers from fossil fuel industries to low-carbon jobs. Such measures must be complemented **by robust social protection coverage and effective public services** to support workers through retraining and reskilling.
- Where feasible, **transition-proof new fossil fuel infrastructure,** enabling future repurposing for low-carbon re-use to mitigate risks of stranded assets and high-carbon lock in, and to accelerate the pace and reduce the overall CAPEX requirements of the transition. Repurposing existing fossil fuel infrastructure can avoid enormous decommissioning costs, extend the life of infrastructure for low-carbon re-use, help to decarbonise industrial production, create jobs, and accelerate the pace of the low-carbon transition in fossil fuel-producer developing countries.
- **Pursue cluster-based industrial decarbonisation**, where feasible, connecting depleted oil and gas reservoirs with heavy emitting industries via repurposed pipelines that sequester CO_2 using CC(U)S, while renewables installations and green hydrogen facilities can provide low-carbon feedstock to industry. This requires policy frameworks that guide partnerships between upstream operators, gas and electricity infrastructure operators, onshore and offshore regulators and industry; fiscal terms which incentivise investment; fair distribution of risks and costs between government and industry; and decoupling repurposing from decommissioning regulations, clarifying legal liabilities for decommissioning.
- **Clearly define decarbonisation, diversification and emissions reduction objectives,** and establish credible verification and reporting mechanisms to build investor confidence.
- To attract private capital, **enhance project planning and preparation capacity to develop robust pipelines of investible low-carbon projects** to which investors can readily commit their time, efforts and resources.
- **Deploy blended finance strategically**, maximising impact on low-carbon projects where limited public support can have the greatest impact in encouraging the private sector to invest, before moving to more frontier technologies which require greater levels of de-risking.

Pillar 3: Systemic change and economy-wide decarbonisation

Pillar 3 outlines strategies to achieve the long-term transition to a sustainable, low-carbon economy, while realising economic development priorities and improving citizens' well-being. Governments should capitalise on emerging low-carbon opportunities to diversify their economies and create jobs, while at the same time reforming fiscal systems to correct misaligned incentives, and greening electricity networks to decarbonise industry and expand energy access. Recommendations are primarily addressed to advanced economy governments, industry and international organisations, and energy, finance, trade, foreign affairs, economy and planning ministries, departments and agencies in developing economies.

- **Pursue long-term integrated development planning**, incorporating interconnected energy, climate, environmental, macro-economic, fiscal, labour, skills, industrial, infrastructure and transport policies. To do so, strengthen fossil fuel producers' capacities to mainstream low-carbon development strategies into national development planning. Mainstreaming and alignment will entail co-ordinated and harmonised actions being taken horizontally within government and vertically across levels of governance (national, regional, local, with meaningful stakeholder engagement), all pulling in the same direction, as opposed to an array of isolated policy measures, often implemented in an inconsistent manner, and leading to suboptimal or even contradictory outcomes.
- **Undertake a fundamental reshaping of the social contract**, emphasising equitable income distribution, promotion of human capital, poverty alleviation and responsible social and environmental practices through inclusive decision making as a necessary condition to building public support for decarbonisation policies.
- **Define credible transition plans, including milestones and targets and reporting mechanisms to mobilise transition finance.** This can enable financing of activities which are carbon intensive or in hard-to-abate sectors which are necessary for socio-economic development, but where there are few viable alternatives, if credible interim decarbonisation targets can be identified and fulfilled.
- **Forge new win-win partnerships between producer and importer economies**, accounting for a fair share of resources to address energy poverty and support local and regional development**.** These partnerships can be leveraged **to deliver the sustainable investments, technology transfer, capacity building and financing** necessary to achieve industrialisation, energy access, economic development and decarbonisation in developing countries. In the short to medium term, this can involve meeting energy demand in return for investments in abatement technology transfer, resource-efficient infrastructure, scaling up renewables' generation, expanding access to energy services, while increasing the revenue predictability for producer economies. At the same time, it requires a clear commitment from advanced economies to invest in long-term transition pathways that enable developing countries to manage the phase down/out of fossil fuel dependence to support economic diversification and broad systemic change.
- **Capitalise on the increasing global demand for the resources of the future**, including critical minerals through sustainable mining development, underpinned by circular economy principles, and alternative low-carbon fuels, to diversify revenue away from oil, gas and coal. Enhance regional collaboration to create new demand for green products and technologies, such as green hydrogen, battery storage and electric vehicles, building the know-how and business case for investment in local value-added activities.
- **Place greater emphasis on valuing natural assets and biodiversity**, introducing natural capital into national accounting systems, creating incentives to preserve existing ecosystems and establishing mechanisms which enable developing economies to get paid for the provision of global ecosystem services, such as forests storing carbon.

- **Reform fiscal systems to broaden the tax base, develop more redistributive tax and spending frameworks, and correct misaligned incentives.** This will level the playing field between carbon intensive products and technologies and greener alternatives through gradual reform of fossil fuel subsidies and carbon pricing. Assess and mitigate negative distributional impacts of price increases on poorer households through targeted support measures, such as cash handouts, in parallel to scaling up social protection coverage and investing in more effective public services.
- **Optimise the blend of power generation technologies, storage, demand-side measures and investments in transmission and distribution infrastructure, through co-ordinated power sector planning**. These plans should be delivered through **well-structured public procurement programmes and enabled by investment-ready regulatory frameworks** to decarbonise power systems and scale up renewables. This will support industrial decarbonisation through reducing the carbon content of electricity sourced from the grid, as well as the development of affordable and green decentralised solutions to rural electrification given declining costs of solar PV and battery storage.
- Given the scale of buildings and urban infrastructure yet to be built in developing economies, **progressively improve buildings' efficiency standards and incentivise on-site renewables solutions. Encourage systems planning which takes a holistic approach to mobility**. This should reduce overall demand for vehicles, bringing services closer to demand and prioritising effective and accessible public transport.

Pillar 1 Decarbonisation of extractives and managing uncertainties

This Pillar provides guidance on how fossil fuel developing economies can manage the risks associated with the continuous reliance on fossil fuels in a global decarbonised economy, while at the same time balancing renewed energy security concerns. It provides guidance on how to reduce emissions from production, processing, transportation and refining through an enabling environment that incentivises the deployment of best available technologies and practices. In that regard, Pillar 1 sets out detailed recommendations for developing producer governments, fossil fuel companies, and importer countries to reduce methane emissions and routine flaring across the fossil fuel value chain, to integrate renewable energy into upstream extractive projects, and to explore the potential for the deployment of Carbon Capture (Utilisation) and Storage to reduce emissions from energy intensive and hard-to-abate industrial sectors over the long term.

1.1. Understanding and managing the uncertainties and risks of continuous reliance on fossil fuels

Policy makers face the challenge of managing uncertainties associated with low-carbon pathways. Uncertainty exists with respect to the characteristics of the future energy mix over time and the speed of the transition. Developments in geopolitics, energy security, international climate policy and global energy markets that are beyond national governments' control, including the revival of interest in carbon border taxation or in the carbon content of energy sources, can accelerate the need for fossil fuel producing developing countries to transition to a low-carbon development pathway.

Russia's invasion of Ukraine has caused significant volatility in global commodity markets, causing prices for energy to rise. This ongoing instability in the global energy landscape can cause uncertainty around the reliability of future export revenues as importer economies diversify their sources of supply, while also pursuing strategies to expand carbon constraints and foster their energy independence.

Uncertainty about technology development, including the availability and affordability of substitute technologies, means that governments have to anticipate a variety of outcomes under different scenarios, including those that could prove most disruptive to their economies (Bradley, Lahn and Pye, 2018[1]). The transition risks related to the oil and gas sector may affect the fiscal stability of fossil fuel producer countries, as well as their ability to spend revenues, invest in infrastructure for future generations, and increase their macroeconomic exposure to carbon lock-in and value destruction (Laan and Giulio Maino, 2022[2]).

In order to improve understanding about the uncertainties and risks of continuous reliance on fossil fuels, governments should carry out an economy-wide analysis of their exposure to risks, including the linkages between fossil fuel production, revenues and investment in infrastructure, and fully appreciate the implications for fiscal stability and revenue spending.

Governments should also consider the value stranding and high-carbon infrastructure lock-in created by conventional technologies, which leads to path dependence, constraining or making more challenging the pursuit of alternative low-carbon pathways. The risk for producer countries of being locked into carbon intensive development trajectories has increased with Russia's invasion of Ukraine as crude oil and natural gas prices have risen significantly, leaving little incentives for producer countries to reduce fossil production and exports.

Governments should consider prioritising the following actions:

- Assess their exposure to continuous reliance on fossil fuels by determining the total sum of public finance invested in the fossil fuel sector, including the assets and liabilities of national oil companies (NOCs) and public finance reinvested in the fossil fuel sector.
- Consider the implications of lower fossil fuel revenues for foreign exchange reserves that are crucial for a country's ability to make international payments, including for imports of fossil fuel products, food and medicines.
- Consider the potential delays impacting the flow of fossil fuel revenues and the distribution of risks between governments and investors; and structure fiscal terms in order to ensure the payment of early revenue as soon as production starts, in accordance with Guiding Principle VIII of the OECD Development Centre's Guiding Principles for Durable Extractive Contracts (OECD, 2020[3]).
- Consider that the revenue-generation potential of fossil fuel projects depends on how production is allocated to domestic and export markets, as prioritisation of supply to the domestic market may result in lower revenues (where prices are subsidised or kept under the market value of the resources).
- Assess the implications of continuous reliance on fossil fuels on domestic fiscal stability, including budgetary dependence on fossil fuel revenues, growing local fossil fuel consumption (including rising import dependence), and higher debt exposure.

- Consider the risk of sovereign credit rating downgrades due to carbon risk exposure, with increased cost of borrowing, and the resulting difficulties in accessing climate finance and green finance mechanisms.
- Review the applicable legal and fiscal regimes for extractive industries, as well as existing contractual terms to identify provisions that increase exposure to risks, such as "take or pay" clauses where the host country must take supply or pay a penalty.
- Understand the impact of continuous reliance on fossil fuels on direct and indirect employment along the oil and gas value chain, including in industries that supply the fossil fuel sector.
- Consider the economy-wide impacts of upstream fossil fuel developments, beyond the sector itself.
- Develop a long-term strategy towards net-zero and set short-term targets for the implementation of carbon-abatement measures in the fossil fuel sector, as detailed under Pillar 1, Section 1.2.
- Consider that in the longer-term, re-investment in the sector and replacement of reserves will become increasingly challenging in a declining market, particularly where higher-cost, high-carbon marginal production is concerned.
- Reduce reliance on external debt, by broadening financing capacity and the domestic tax base, find alternative foreign exchange flows and redress the balance of trade (see Pillar 3, Section 3.3).
- Manage rent-seeking and incumbent interests, knowing that gaining broad societal support will be crucial to overcoming resistance to the transition. This calls for building a shared understanding within society of the goals to be achieved, articulating the steps to be undertaken and the resources to be deployed to realise such a large-scale and profound transformation.

Box 1.1. Impact of the low-carbon transition on government revenues

Several studies have found that fossil fuel producer countries could see major losses in revenues by 2030 and 2050, in particular under high price scenarios and if failing to restructure their fiscal regimes in line with the low-carbon transition (see Pillar 3). In an analysis of the impact of the low-carbon transition on government revenues from oil and gas, Carbon Tracker use the Sustainable Development Scenario of the International Energy Agency (IEA) as a low-carbon demand scenario. The analysis assumes a flat real long-term oil price of USD 40 per barrel of oil (bbl), and compares it with industry expectations of mid USD 60s/bbl derived from Rystad Energy's base case price outlook, and demand volumes under the IEA's Stated Policies Scenario. In this analysis, total government revenues would be USD 18 trillion lower over the next two decades under the low-carbon scenario, compared with industry expectations –corresponding to a 58% drop. Such a drop, if it happens, would take place in a context where the average debt level of fossil fuel-dependent countries increased from 24% of GDP in 2010 to 46% in 2018 and even further after the COVID-19 pandemic. In countries that lack sovereign wealth funds, or access to credit markets, this will contribute to fiscal strains.

According to IISD projections, a global phase-out of fossil fuels consistent with the 2°C pathway would reduce direct public fossil fuel revenues for Brazil, the People's Republic of China (hereafter "China"), Indonesia and the Russian Federation to around 35% of 2019 levels by 2050, and for India and South Africa to around 65% of 2019 levels. Under a 1.5°C pathway, the IISD estimated that fossil fuel revenues in BRIICS countries would fall to around 10% of 2019 levels by 2050 consistent with the IEA's Net Zero Emissions by 2050 Scenario (Laan and Giulio Maino, 2022[2]).

In its analysis of NOCs investments, the Natural Resource Governance Institute finds that NOCs could invest more than USD 400 billion (in 2021 prices), or 22% of total capital expenditures through 2030, in oil and gas projects that will break even only if the world exceeds the global carbon budget. Most of this capital expenditure – more than USD 365 billion – corresponds to developing and emerging economies. The analysis emphasises that NOCs can profit from these investments only if the world fails to limit

climate change, and also raises the possibility of government bailouts of NOCs that overinvest in future production capacity.

Source: (Coffin, Dalman and Grant, 2021[4]; Manley and Heller, 2021[5]).

Actions requiring international support in contexts where government capacity is low:

- Consider the likely significant decline in fossil fuel revenues linked to the anticipated reduction of global demand for fossil fuels and tightening emission reduction requirements and environmental standards on imports.
- Use prudent price scenarios for fossil fuel prices to limit potentially significant revenue losses, given the anticipated speed of decline in oil and gas demand and prices under a 1.5°C pathway.
- Consider the declining economic value of carbon-intensive investment projects and the risk of stranded assets, as fossil fuel resources and associated infrastructure, may be prematurely written down and/or stranded due to climate commitments, energy and investment trends.
- Consider that the long-term and capital-intensive nature of fossil fuel-based infrastructure investments that require fossil fuels as either energy for domestic power production, process heat generation, feedstock (affecting national energy demand and emissions trajectories) or that are necessary to bring the fuels to export may create or exacerbate path dependence (unless high costs for replacement or retrofitting are incurred). This can lock-out new technologies as they become more competitive, by hindering or considerably slowing down alternative pathways to support growing access to energy and green industrial development.
- Assess the sustainability of debt linked to fossil fuels and the specific vulnerability associated with borrowing against future fossil fuel production (resource-backed loans), taking into consideration the full potential range of fossil fuel revenue outcomes (and therefore foreign exchange earnings or needs) and time frames for production (and thus diversification) under different climate scenarios, including the 'lowest-case' scenario for fossil fuel demand. Developing countries should take particular care when deciding to enter into resource-backed loans. In this respect, analysis and recommendations from the OECD-DAC's Programme of Work on Illicit Financial Flows in Oil Commodity Trading provides useful guidance (Porter and Anderson, 2021[6]).
- Increase resilience and reduce dependence on fossil fuel exports, by prioritising the use of fossil fuel revenues to support the implementation of a wider green growth and sustainable diversification strategy, beyond fossil fuel-based value chains (see Pillar 3, Section 3.2).

Central banks, ministries of finance and revenue management institutions should consider prioritising the following actions:

- Review revenue management frameworks in light of the risks of continuous reliance on fossil fuels and low-carbon opportunities, including the regulations and mechanisms that allocate fossil fuel revenues to spending through the national budget, investment (e.g. through a national development bank) and savings through Sovereign Wealth Funds (SWFs), where in place (including stabilisation and "future generations" funds).
- Consider the implications for the profitability and fiscal stability of government (where significant sums of public and private finance are invested in the sector), the companies (including NOCs), as well as the sectors and economies that are most exposed to market risks (e.g. devalued or stranded assets).
- When allocating fossil fuel revenues through the national budget, consider how best to distribute revenues between short-term needs, including delivering core physical and social infrastructure and long-term wealth creation, and how revenues might be used to drive clean energy and green growth and finance the implementation of Nationally Determined Contributions (NDC) (where they are likely to arrive in time).

- Consider that established fossil fuel revenues could in principle be used to support the implementation of a green transformation strategy at home while production is exported – instead of following the traditional "fossil fuel-led" development pathway that emphasises the development of linkages between the fossil fuel sector and fossil fuel-based value chains, which serve to increase risks. This option is unlikely to be available to new producers, given the timeframe to market and anticipated speed of decline in oil and gas demand and prices under a 1.5°C pathway.
- Develop robust investment strategies, including through increased collaboration between SWFs (where in place) and strategic investment funds, in order to hedge the national budget from shocks, and develop alternative industries that are likely to replace fossil fuel as an energy source or invest in sustainable infrastructure, sustainable agriculture and other green growth opportunities.

Actions requiring international support in contexts where government capacity is low:

- Develop carbon-pricing capacities to support broader fiscal reforms, including the gradual introduction of carbon tax regimes, and where appropriate, the incorporation of shadow carbon pricing in investment decisions and market access, and the removal of inefficient fossil fuel subsidies (see Pillar 3, Section 3.3).
- Develop robust climate-related disclosure and reporting mechanisms for the financial sector, based on the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD).

Energy and industry ministries should consider prioritising the following actions:

- Assess demand for energy services by households, industry and transport, and systematically review the stages (and delivery modalities) of energy systems needed to deliver them (e.g. decisions on extraction, generation, transmission, and distribution).
- Prioritise the end goal of improving reliable and affordable access to clean and sustainable energy services and associated needs (e.g. operational flexibility and resilience, greenhouse gas abatement) and enable competition between different solutions, rather than the means (fossil fuel supply), choosing fossil fuel supply only when truly needed. This will help: 1) draw upon the broad range of available resources that can cost-effectively and reliably meet those needs; 2) more accurately project domestic energy demand; 3) identify the "lowest-cost" means of delivering reliable and affordable access to achieve energy and industrialisation goals, including the right balance between on- and off-grid power supplies; and 4) counterbalance the political economy, rent-seeking, and path dependence that tend to emerge around the development of the fossil fuel sector.
- Consider the impact on land, air and water use that the development of the fossil fuel sector would entail, compared to potential alternative uses of the same scarce resources. Assessing the "trade-offs" and costs of the externalities of energy choices also requires consideration of the current and future value of livelihoods, land and economic potential that may be affected by large-scale infrastructure decisions.
- Identify forms of state support to the production and consumption of fossil fuels and determine how they affect the economic viability of fossil fuel projects. For further guidance on fossil fuel subsidies reform, refer to Pillar 3, Section 3.3.1.
- Identify industries and sectors that are most affected and/or less prepared for the low-carbon transition, with due consideration given to local small producers and businesses.

Actions requiring international support in contexts where government capacity is low:

- Monitor the value of fossil fuel investments over time. Assess the vulnerability of any project to being stranded (or of resources being left undeveloped) by determining its position on the cost curve of production. Compare a project's break-even price (or shut-in price) to those of other projects along the cost curve, and best available data on commercially viable cost of production

under different transition scenarios. Projects that are high-carbon and with a higher cost of production will be more vulnerable to stranding.

- Consider the costs of expensive retrofitting or retirement of high-carbon infrastructure in initial decision-making regarding the role of fossil fuels in the domestic economy, and risks of associated infrastructure investments.
- Consider that, with an anticipated physical life span of at least 30 years, any new large-scale power and industrial infrastructure should be or have the capacity to become carbon neutral. This means that infrastructure should either be designed to have zero emissions in use, or that emissions should be offset in some other way (e.g. through some combination of CC(U)S, afforestation and other negative emissions technologies) or built to be as energy efficient as possible with the capacity to integrate an increased share of on-grid or off-grid renewables or hydrogen (see Pillar 2, Section 2.3).

1.1.1. Understanding the transition risks facing new and emerging producers

New and emerging fossil fuel producer developing countries planning to monetise their resources face additional transition risks compared with mature producers. Long-term declining market dynamics mean more projects will be competing for a smaller pool of capital, and projects with a shorter investment cycle, that are less risky, low-carbon and where production costs are lower will be more likely to attract financing. For new and emerging producers that have yet to build oil and gas infrastructure and have high production costs, leapfrogging to renewables may be a better option than investing in oil and gas.

New and emerging producers with low production costs can reasonably expect to be able to exploit their reserves, but will need to reduce emissions as far as possible to remain competitive and find an export market, unless they supply the domestic market or markets where carbon is not priced.

At the same time, new and emerging producers investing in low-cost oil and gas projects and associated infrastructure should carefully assess the risk of stranded assets and being locked into carbon intensive development pathways. Governments and their NOCs need to assess whether investments in oil and gas will generate sufficient returns to justify risks, and should adjust the risk-reward equation in light of these considerations. Understanding whether oil and gas investments, including in downstream industries, will be capable of generating the same returns in the future as they do today, and balancing these considerations against the benefits of investing in renewable energy instead will be key to managing downside risks and capturing remaining value from resources for citizens.

Abatement is becoming a metric factored into sourcing and financing decisions for oil and gas projects. Importing countries and investors will assess project emission profiles in the light of environmental, social and governance (ESG) requirements and only those at the bottom of the emissions curve are likely to be exported or succeed in attracting finance. In some respects, new and emerging producers have an advantage because they are starting from scratch in terms of their infrastructure and systems which they can design and construct to: 1) minimise emissions from the outset (rather than undertaking a potentially expensive exercise of retrofitting existing infrastructure); and 2) be transition ready, enabling a gradual switch to renewable and/or low-carbon fuels use (see also Pillar 2, Section 2.3).

Building a “first class” modern oil and gas industry means minimising fugitive emissions, and deploying the best available technologies, such as upstream electrification through renewables, flaring and methane emissions reduction mechanisms, and CO_2 abatement through carbon capture, utilisation and storage (CC(U)S), in order to develop systems that are as low-carbon as possible.

Governments of new and emerging producers should consider prioritising the following actions:

- Leapfrog to renewables if oil and gas production costs are high and there is no infrastructure in place. Projects which get stranded in the low-carbon transition are likely to be the most expensive ones, and a realistic assessment of whether an asset will still be considered as such and

economically viable in the medium and long term is key to managing downside risks and avoiding wasteful expenditure. The opportunity cost of investing in oil and gas should be assessed against the benefits of investing in alternative low-carbon technologies and renewables.

- Differentiate between investment and value to a country and its citizens. Governments need to carefully consider the balance of risk and reward for oil and gas projects and the development of downstream industries (e.g. petrochemical manufacturing), understanding that a project which is capable of generating returns now may not be capable of doing so in the relatively near future, given the rapidly changing market dynamics for oil and gas.
- If pursuing plans to develop their oil and gas resources, governments should develop a modern and efficient oil and gas industry that leverages the best available technologies for emissions abatement and minimises fugitive emissions.
- Adopt responsive fiscal terms for oil and gas investment, whereby the government share of financial benefits automatically increases when profitability is high, and conversely decreases when profitability is low, consistent with Guiding Principle VIII of the OECD Development Centre's *Guiding Principles for Durable Extractive Contracts.* This can contribute to the long-term sustainability of extractive contracts and reduce the incentives for either party to seek renegotiation (OECD, 2020[3]).
- Develop a long-term green strategy from the outset and avoid high-carbon dependence (including upon oil and gas revenues, fuel inputs to energy and industry, and employment).
- Foster greater accountability for how fossil fuel revenues are spent and assess whether these contribute effectively to economic diversification, including through consultative processes.

Actions requiring international support in contexts where government capacity is low:

- Align the fossil fuel sector with NDCs and long-term low greenhouse gas (GHG) emission development strategies to 2050 under the United Nations Framework Convention on Climate Change (UNFCCC) process, by considering the full costs of a fossil fuel-led development pathway, and the co-benefits of a low-carbon pathway, including reduced air pollution and water stress, sustainable land use and investment in sustainable infrastructure and green sectors of the economy.
- Consider how the country might leapfrog traditional fossil fuel led high-emissions industrial development, with associated adverse public health and environmental impacts and avoid rent dependence that can "crowd out" agriculture, light manufacturing, services and other industries that can support sustainable economic diversification (see Pillar 3, Section 3.2).
- Review production or expansion plans in the light of the likely lower value proposition of fossil fuels and declining export market.

1.1.2. Aligning the investment strategies of national oil companies with low-carbon transition pathways

National oil companies (NOCs) are important players in developing countries. The revenue collected is equivalent to 20% of government revenue in 25 countries. However, on average only USD 1 in every USD 4 earned by the NOC is transferred back to government. In many cases, the expansionist mandate of NOCs, designed when it was created to maximise state capture of value in the oil and gas sector, means that NOCs prioritise spending on oil and gas projects at the expense of other areas of the economy (Manley and Heller, 2021[7]). The NRGI estimates that on current investment trajectories, NOCs will invest USD 400 billion over the next decade in high-cost projects which will break even only if global warming exceeds a 2-degree increase. Some USD 365 billion of investment is in fossil fuel producer emerging and developing economies. The dominant role of an NOC in the economy can in some contexts mean it is considered too big to fail, and in consequence, the NOC is permitted to take on more and more debt to avoid collapse. If the NOC continues to pursue high-cost investments which do not pay off, it may request

a bailout, at substantial cost to the taxpayer, and with implications for a country's credit rating (Manley and Heller, 2021[7]).

Moreover, investing in projects which may not break even could also entail significant opportunity costs, given that public money would be better spent on furthering socio-economic objectives, investing in the low-carbon transition, paying off national debt, or invested elsewhere for higher returns (Manley and Heller, 2021[7]).

Governments and NOCs should also be cognisant of existing long-term oil and gas agreements as these may contain terms that limit the ability of governments to transition toward a low-carbon economy. Stabilisation, force majeure and arbitration clauses may constrain governments that seek to apply new regulations to existing petroleum projects and may not adequately allocate risk or the costs of climate impacts between the government or NOCs and the investor (Woodroffe, 2021[8]). New or re-negotiated oil and gas agreements should specifically consider the imposition of new requirements related to climate change that may be introduced by governments consistent with the OECD Development Centre's *Guiding Principles for Durable Extractive Contracts*. Guiding Principle VII can be used for dealing with new requirements related to climate change adaptation issues. In addition, the provisions of Guiding Principle VII and VIII can also be used to share the costs of the deployment of new clean technology to reduce emissions (OECD, 2020[3]) (see Pillar 1, Section 1.2).

Governments should consider prioritising the following actions:

- Assess planned NOC investments against national low-carbon development strategies, including how planned projects perform against multiple demand scenarios. This assessment should consider which scenarios are likely to generate returns. A similar exercise needs to take place for existing projects. Through this exercise, the government can understand the exposure of national finances and the economy if planned investments fail to break even (Manley and Heller, 2021[5]).
- Consider shortening investment cycles with shorter payback periods to avoid risks of stranded assets and technological lock-in.
- For countries with high production costs, and particularly where NOC debt is high and government is highly dependent on NOC revenue to maintain public spending, consider strategies to gradually reduce exposure to NOC' financial difficulties, including by enhancing efficiency of operations, lowering their Unit Operating Costs., and eventually putting a limit on NOC spending or limit state participation in projects. (Manley and Heller, 2021[7]).
- Address expansionist mandates (where applicable) which incentivise an NOC to spend much of what it earns to grow the national oil industry. Whilst an expansionist approach made sense when most NOCs were created, it is no longer appropriate given market changes. Adapting NOCs' mandates to pursue less risky projects which can in turn fund low-carbon investments in other areas of the economy will help to manage risks and gradually reduce fossil fuel dependence. This is particularly the case where a country has high production costs, given that projects are less likely to break even, and stranded assets are likely.
- Assess the terms of existing long-term oil and gas agreements to determine if there are any limitations on the government's ability to enforce new regulatory requirements to respond to climate change and advance the low-carbon transition.
- When negotiating or re-negotiating oil and gas agreements, introduce terms consistent with Guiding Principle VII of the OECD Development Centre's Guiding Principles for Durable Extractive Contracts to avoid liability for regulatory changes necessary to meet the objectives of the Paris Agreement and advance the low-carbon transition (OECD, 2020[3]).
- Where possible, resist NOC' requests for tax breaks to maintain production levels for projects where production costs are high. Tax breaks only serve to shift the cost burden from the NOC to the taxpayer and make it more challenging for governments to take capital out of the NOC.

Ultimately, governments should avoid a race to the bottom where production is maintained but tax exemptions result in limited or no benefit to citizens (Manley and Heller, 2021[5]).

- Consider establishing NOC borrowing ceilings and require government approval to exceed limits. Taking on more debt to maintain production increases the risk of an expensive government bailout, particularly if production costs are high, as the NOC will have limited recourse to more profitable projects to keep pace with debt repayments if prices are low. Governments can also limit borrowing from domestic lenders, such as commercial banks, given that the economic implications could be more profound if the NOC gets into financial difficulty (Manley and Heller, 2021[7]).
- Limit state participation in projects as a means to reduce exposure to risk. Carried interests can also limit up front costs for governments and NOCs and reduce risks, as NOCs will have spent less money up front if projects fail (NRGI, 2021).

1.2. Decarbonising extractives

Future trajectories regarding the role of fossil fuels in the global energy system depend on assumptions made regarding transition pathways and the availability and affordability of clean technologies. Meeting the growing demand for energy, while achieving sustainable development (including economic, environmental and social objectives) requires transforming the way energy is produced and consumed by relying on negative emission or carbon neutral technologies. The discovery of new information regarding non-CO_2 emissions may also have implications for the choice of fossil fuels and their sustainable use unless abatement technologies are deployed.

A transitional step towards a net-zero economy, where fossil fuels are part of the energy mix, is to reduce emissions from production, processing, transportation and refining through the deployment of the best available technologies and practices. Although it is important that emissions from oil and gas production are reduced as much as possible, EFFECT recognises that the implementation of some of the technological options set out in this section will depend on the specific circumstances of the operations, country or region and may not be feasible for all countries (e.g. CC(U)S). However, all countries should endeavour to take steps to implement regulations and measures to reduce flaring, venting and fugitive methane emissions across the value chain of oil and gas projects.

The adoption of new technologies and best practices will come with costs that will need to be borne by the parties involved in oil and gas production (governments, NOCs, IOCs etc.). To allocate these costs on an equitable basis, EFFECT recommends an alternative approach for existing and new oil and gas projects and depending on the deployment of different low carbon technologies.

For existing oil and gas projects:

- The costs of the adoption of best available technologies and best practices are shared between the government and the investor and treated as any other project costs for the purposes of tax deductibility, and cost recovery in production sharing contracts, in line with the OECD Development Centre's *Guiding Principles for Durable Extractive Contracts* (OECD, 2020[3]). In oil and gas production sharing agreements, these additional costs would be recoverable from the allocation of "cost oil" or "cost gas". In mining contracts, these additional costs would be treated as deductible expenses in both income taxes and rent taxes.

For new oil and gas projects:

- The costs for the deployment of methane emissions reduction technologies should be borne by the investor.
- The costs for the deployment of technologies to capture associated gas should be borne by the investor. When associated gas is captured and put to productive use, with the creation of additional

value for the host country, the parties might consider whether the costs associated with stopping flaring and gathering gas are chargeable against oil and gas project development expenses.

- The costs for the deployment of upstream renewable energy electrification for new projects should be borne by the investor. When upstream renewable energy electrification generates excess power with co-benefits for the host country, the parties might consider whether the costs associated with stopping flaring and gathering gas are chargeable against oil and gas project development expenses.
- The costs for the deployment of CC(U)S should be borne by industry, but government support is still required (see Pillar 1, Section 1.2.7).

Table 1.1. Sources of emissions in the oil and gas value chain and technological options for their reduction

Upstream			Midstream	Downstream		
Extraction and drilling (10%)	Flaring (CO_2) (5%)	Fugitive emissions/venting (47%)	Crude transport (5%)	Gas processing, refinery heat and power systems (20%)	Hydrogen production (3%)	Fugitive emissions (10%)
Energy efficiency Electrification CC(U)S with the use of low-carbon or CO_2 cured concrete Trapping any gases produced during well drilling and production to reduce fugitive emissions and venting. (Trapped gases can be reinjected or used on site depending on the type of gas) Ensuring proper management and sealing of wells to make sure they are not leaking (gas, methane, oil, water) between exploration and production phases can reduce emissions.	Improving energy efficiency by ensuring the correct gas-mix for optimal combustion Using high/low pressure separators at well sites to reduce production of waste gas or co-production of natural gas Recovering co-produced gases for use on site or offsite including processing and selling (see modular small-scale or mini natural gas processing plants) Recovering co-produced gases and reinjecting them either for reservoir flooding (secondary production) or for EOR (tertiary production) No flaring (e.g. replace equipment, improve maintenance, capture methane)	Vapour recovery units Leak detection and repair systems at compression stations (e.g. preventative maintenance, replace leaking equipment and pipelines)	Crude transport via ships (e.g. change GHG-intensive fuel to low-carbon biofuel) Crude transport via pipelines (e.g. low-carbon electrification) Fugitive emissions from transport	Energy efficiency Change fuel to biofuel, biogas or hydrogen Electrification Carbon capture, use and storage Change refinery feedstock from petroleum-based to biofuel or vegetable oil	Renewable hydrogen Hydrogen steam methane reforming and carbon capture, use and storage Bio-based hydrogen made on site Change refinery feedstock from petroleum-based to biofuel or vegetable oil	Vapour-recovery units on large tanks Leak detection and repair, mainly for compressors Replacing leaking equipment and pipelines Improvements in orphan/abandoned well management and fugitive emissions from a lack of proper well closure due to well orphaning or abandonment

Note: Chart is without prejudice to any technologies that might arise in the future.
Source: Adapted by authors from (Beck et al., 2020[9]) and based on input from the IEA.

To do so, governments should:

- Determine the carbon footprint of current and planned fossil fuel production, transport and use, by understanding the sources of emissions in the oil and gas value chain, noting that CO_2 emissions are concentrated in the upstream oil production phase, whereas methane emissions occur more broadly across the value chain (Lorenzato et al., 2022[10]).
- Enhance the efficiency of oil and gas operations by reducing methane leakages, electrifying upstream operations and deploying carbon capture and storage (where feasible).
- Ensure that any new investments in oil and gas production are really necessary for energy security needs, have multi-purpose use (i.e. the ability to transport low-carbon fuels such as hydrogen and ammonia), and are designed to have the smallest carbon footprint possible (Bordoff and O'Sullivan, 2022[11]).
- Grant preference to new oil and gas infrastructure investments with shorter payback periods. These investments may include conditions where the government has the right to wind down the asset against compensation after a specified time, or where the investment has yielded a certain return (Bordoff and O'Sullivan, 2022[11]).

1.2.1. Methane emissions reduction

Reducing methane emissions is the single most important and cost-effective way to bring down emissions and improve efficiency in the oil and gas industry.

Methane emissions can be released at different stages of the oil and gas value chain, from the production and processing of gas, and the transmission and distribution to end-users, to the decommissioning of well sites, including orphaned wells. While some emissions are fugitive (i.e. accidental, through faulty seals or leaking valves), others are vented (i.e. intentionally) and often carried out for safety reasons or due to the design of the facility or equipment. Fugitive emissions (leakages) from "super emitter" sources can occur across the different segments of the gas value chain: at well sites, gas-processing plants, liquids storage tanks, transmission compressor stations, and distribution systems.

In contrast to coal, natural gas use can contribute to the reduction of CO_2 emissions due to its lower carbon intensity. However, the benefits associated with the reduction of CO_2 emissions may be partially, or completely, offset by methane emissions from gas production, transport and use. This may also undermine the benefits of the use of gas over other fossil fuels in terms of their carbon footprint, due to the high global warming effect of methane emissions.

A wide variety of technologies and measures are available to reduce methane emissions from the oil and gas value chain. If all available technologies and measures were to be deployed across the oil and gas value chain, the IEA estimates that this would reduce methane emissions by 75%. Furthermore, the IEA estimates that around 45% of the 79 Mt total emissions could be avoided with measures that would have no net cost (IEA, 2021[12]). Methane is also a valuable product and in many cases can be sold if it is captured.

Relative to coal, the construction of additional natural gas power plants has the potential to both produce excess near-term warming (if methane leakage rates are high) and excess long-term warming (if the deployment of natural gas plants today delays the transition to low-carbon emission technologies).

Box 1.2. Targets for GHG emissions: Absolute vs. intensity targets

Targets for greenhouse gas emissions (GHG) can be defined as absolute targets or as intensity targets.

- An absolute target refers to a target that aims to reduce GHG emissions by a set amount.
- Intensity-based targets are expressed as units of GHG emissions per unit of activity. Activity can be measured at an aggregate level, for example in terms of GDP or per capita GDP, or at a more detailed level based on measures of underlying efficiency of the economy.

Intensity-based targets do not necessarily cap emissions. In fact, even if intensity targets are achieved, emissions may grow as the economy grows. For intensity-based targets to deliver absolute emission reductions the targets should be demanding enough: if the rate of decline in emissions intensity is higher than the rate of GDP growth, then absolute emissions will fall. An alternative approach is to combine intensity targets with absolute targets or caps.

Source: Authors.

Governments should consider prioritising the following actions:

- Undertake a mapping of institutions and agencies that could be involved in addressing methane emissions as well as any pre-existing policies or regulations that address methane emissions or affect indirectly methane emissions.
- Integrate methane emissions reduction into NDC plans.
- Set progressively ambitious methane emissions reduction targets.

Box 1.3. Regulatory measures in Colombia to reduce methane emissions from upstream oil and gas operations

In February 2022, the Colombian Ministry of Mines and Energy introduced flaring and fugitive methane emissions regulations, to reduce emissions from upstream oil and gas activities at a national level. In so doing, they became the first Latin American country to regulate methane emissions from oil and gas. These regulations were developed over a period of five years with significant multi-stakeholder input. The Ministry of Mines and Energy convened expert workshops and undertook a comparative analysis of regulatory requirements globally to reduce emissions on a source-by-source basis.

The new regulations adopt some of the best practices seen in other jurisdictions and requires operators to do the following:

- Carry out a Leak Detection and Repair (LDAR) programme to inspect oil and gas facilities.
- Install vapour recovery units, redirect the gas for utilisation or send gas to flare from existing gas-driven pneumatic pumps or altogether replace them with electric or compressed air driven devices.
- Install vapour recovery units on tanks and separators.
- Redirect emissions from compressors, substitute seals and other measures.
- Carry out reduced emission completions.
- Verify every year, through a third party, that flares are operating efficiently.

Source: (Banks and Miranda-González, 2022[13]).

- Establish a regulatory framework for the measurement, disclosure, reporting and verification of NOC and IOC carbon emissions, using existing reporting templates such as the IPIECA-API-IOGP Sustainability Reporting Guidance, the Oil and Gas Methane Partnership (OGMP) standard, and the Methane Guiding Principles. Governments should support the harmonisation of multiple existing standards for CO_2 and methane emissions reporting.
- Require the public disclosure of methane emissions information, including publication on a website. This added layer of scrutiny may create an additional incentive for companies to comply (IEA, 2021[14]).
- Incorporate both flaring and fugitive methane emissions into the same regulatory instrument. This approach has been taken recently by Colombia (see Box1.5). Traditionally, these issues have been treated separately, which can cause regulatory inefficiencies and gaps and lead to confusion and uncertainty (Banks and Miranda-González, 2022[13]).
- Understand the barriers that may prevent companies, including NOCs, from undertaking actions to drive methane reductions that appear to be cost-effective – for example, a lack of information, infrastructure, investment incentives, or the flow of revenues between governments and NOCs (IEA, 2021[14]).
- Ensure that infrastructure policy is consistent with zero routine flaring and reduced venting objectives and supports the building of pipelines necessary to evacuate gas.
- Introduce methane reduction requirements in the planning stages of projects, requiring new installations or developments to utilise zero-emitting technologies and have plans in place to capture gas and deliver it to the market.
- Consider introducing methane emission reduction requirements in upstream exploration and production contracts or licences (IEA, 2021[14]).
- Require over time the replacement of equipment that is designed to vent methane with technologies that are zero emitting or the use of vapour collection to reroute vented methane back into the pipeline.
- Require detection campaigns with specified frequency (e.g. quarterly), and specify equipment to be used, detection thresholds and time limits for repairs. Using methane regulations allows for the use of alternative leak detection and repair programmes that can achieve equivalent outcomes.
- Treat capital expenditures on equipment to reduce emissions as any other project cost for the purposes of tax deductibility.

Actions requiring international support in contexts where government capacity is low:

- Develop an emissions profile to identify how much methane is emitted and determine the location of the biggest sources, measure to the extent possible and estimate the level of emissions, and identify problem sources and abatement solutions involving industry stakeholders.
- Design robust leak detection and repair programmes (LDAR) based on environmental outcomes that emphasise repairing detected leaks and preventing leaks.
- Establish a comprehensive and transparent production accounting system that includes methane emissions reporting, recordkeeping and disclosure, and third-party verification requirements.
- Develop protocols for incorporating new data such as satellite, flyovers and on-the-ground surveys, into national inventories.
- Consider off-balance sheet financing for upstream and midstream methane emissions abatement, where oil and gas operators contribute to a special purpose vehicle (SPV). The SPV conducts the due diligence, measurement and repairs, and then monetises emissions reductions through direct gas sales, by generating carbon offsets, or through a fee by the operator (IEA, 2021[15]).

- Directly invest in building new infrastructure or adopt policies that allow for the spreading of development costs across multiple firms and end-users (IEA, 2021[14]).
- Consider independent labelling and certification of low-carbon oil and gas with comprehensive and transparent production data and accompanying methane emissions data.

Box 1.4. Methane emissions from the oil and gas industry

The oil and gas industry accounts for 23.1% of global anthropogenic methane emissions, representing the second highest source of anthropogenic emissions after agriculture (39.6%), and ahead of waste (20.5%), coal (12.2%) and other sources, including bioenergy and biomass burning (4.6%).

The IEA estimates that around 80 million tonnes of methane were emitted to the atmosphere from oil and gas operations in 2021. Methane leaks in 2021 from fossil fuel operations, if captured and marketed, would have made an additional 180 billion cubic metres of gas available to the market, an amount similar to all the gas used in Europe's power sector.

Source: (IEA, 2022[16]).

What can the fossil fuel industry do?

Reducing methane emissions across the value chain:

- Participate in voluntary initiatives to reduce methane emissions in the oil and gas sector. Examples of such initiatives include Global Methane Alliance, the Oil & Gas Methane Partnership (OGMP), the Oil and Gas Climate Initiative (OGCI), the Methane Guiding Principles, and the Global Methane Initiative (GMI).
- Systematically improve methane management by applying a management system (e.g. the plan-do-check-act cycle) to the elements of reducing methane emissions (Methane Guiding Principles, 2020[17]).
- Build methane reduction efforts into company culture. For example, through the integration of methane reduction into existing business and operational procedures and the establishment of new learning opportunities relating to emissions reductions for both technical and non-technical staff (Methane Guiding Principles, 2020[17]).
- Establish measurement, disclosure and reporting, and verification procedures for flaring, methane venting, and carbon emissions, satisfying government requirements in the host country and reporting templates such as the IPIECA-API-IOGP Sustainability Reporting Guidance, and the OGMP standard.

Reducing methane emissions in upstream production:

- Incorporate emissions reduction considerations into overall business and operating strategies, including by setting short-term targets towards achieving net-zero, and share information acquired within the company and across the oil and gas industry.
- Identify known sources and potential sources of emissions in an inventory.
- Carry out robust emissions surveys to provide a basis for understanding methane emissions sources and levels to evaluate plans to mitigate emissions. These should include both desktop studies and field surveys (CCAC, 2017[18]).
- Build fugitive inspection and repair capability and skills.
- Quantify methane emissions directly by measuring emission rates and use this information to create or update inventories.

- Acquire an overview of cost-effective readily available abatement options and adopt specific strategies for specific projects.
- If methane needs to be released – prioritise recycling or flaring over venting. Check that flare systems are operating according to design (Methane Guiding Principles, 2020[17]).
- Use smart metering and controls to reduce end-user energy use and emissions (e.g. gas turbines and boilers) (Methane Guiding Principles, 2020[17]).
- Phase-in use of the incumbent and emerging zero or lower emission technology to improve measurement of methane emissions.
- Regularly review the scope, quality and frequency of emissions reporting.

Reducing methane emissions in transmission, storage, and distribution:

- Compile an accurate inventory of emissions from all sources.
- Identify and repair equipment that is not working properly.
- Track emissions and mitigation activities.
- Start with low-cost measures then try implementing those with higher costs. For example, recompress gas instead of venting, install vapour recovery units on crude oil and condensate storage tanks. In the absence of these units, dissolved methane can evaporate and be vented into the atmosphere (IEA, 2020[19]).
- Consider modern, high-integrity materials and jointing technology when constructing downstream distribution networks.
- Systematically reduce methane emissions by minimising potential fugitive and venting sources, perform inspections and prioritise repairs, and consider new technology (e.g. detection, quantification, condition monitoring and predictive maintenance).
- Reduce methane emissions that result from energy use: use smart metering and controls to reduce end-user energy use and emissions, maintain gas-fired equipment to operate according to design, when replacing equipment update with the latest proven energy-efficient models, and consider upgrading.

Box 1.5. Using gas recompression to reduce venting

In line with its net-zero carbon strategy and a specific target to reduce methane emissions by 45% by 2025 compared to 2015 levels, Snam, an energy infrastructure company for transmission network and natural gas storage capacity, has deployed gas recompression systems to reduce venting.

When maintenance is needed on sections of pipeline, operators usually block the smallest possible section of the pipeline and depressurise it by venting natural gas into the atmosphere. For a high-pressure large diameter pipeline, the volume of gas vented may be significant. Large transmission pipelines can pump down, using portable compressors, to lower the pressure in the pipeline before maintenance work and repairs to effectively reduce methane emissions. However, the process takes time and is not suitable for every situation. Snam has deployed mobile compressors that can pull the line pressure down to 0-5 bar, thereby reducing the emissions vented by very close to 100% for maintenance activities in high-pressure large diameter pipelines. These measures have resulted in the reduction of gas venting of 5 360 000 sm3 of gas in 2018 and 380 000 sm3 of gas in 2019.

Source: (Methane Guiding Principles, 2020[20]).

What can government and the fossil fuel industry do together?

- Establish a collaborative process to improve national inventories reports for oil and gas methane emissions by defining the different categories of emissions, reviewing the approach to emission estimation and data compilation, and updating the process after construction of the inventory.
- Share data openly to advance research geoscience and technology improvements and impacts.
- Build on existing initiatives to encourage knowledge-sharing and best practices within the industry (IEA, 2021[14]). Examples include the Global Methane Alliance, the Oil & Gas Methane Partnership (OGMP), the Oil and Gas Climate Initiative (OGCI), the Methane Guiding Principles and the Global Methane Initiative (GMI).
- Build institutional capacity to undertake measurement, reporting and verification activities and to deliver methane emissions reductions.

What can IOCs/NOCs do together to reduce methane emissions?

- Align objectives to ensure a common understanding and commitment to reducing methane emissions in oil and gas operations.
- Transparently share information on methane emissions to identify business opportunities for capturing, producing and selling associated gas.
- NOCs should engage with international initiatives to share knowledge and build capacity, and should also seek to follow international standards to reduce methane emissions across their operations.

1.2.2. Enabling measures and incentives

In order to reduce the carbon footprint of the oil and gas sector, governments should adopt incrementally stronger policies for emissions reduction to incentivise and promote a transition to future lower-emission technologies, and influence the development of domestic gas market reforms.

Without such enabling measures, high natural gas supply may accelerate the phase-out of coal-fired electricity, but will also increase electricity use and slow the decarbonisation process by delaying the use and price-competitiveness of renewable energy technologies. Conversely, flexible demand growth, with higher efficiency and renewable energy deployment, could mitigate fiscal risks and account stress as well as increase energy security.

The pricing of fuel is also essential to incentivise low-carbon pathways.

Governments should consider prioritising the following actions:

- Consider introducing GHG emissions standards/targets for gas production, transport and use.
- Where feasible, set incremental targets for the mandatory adoption of renewable energy sources for power generation.
- Avoid the sale of fuel to the domestic market untaxed, or below export prices, as this can disincentivise energy efficiency and widen inequality (by benefiting disproportionately the rich who use more energy than the poor). This also risks locking in rising fuel demand and locking out clean technologies and infrastructures (Bradley, Lahn and Pye, 2018[1]).
- When fuel substitution is considered, the consumer price of the alternative fuel should be high enough to make investment in infrastructure and processing commercially feasible, yet low enough to ensure it is used instead of less efficient fuels, such as diesel, wood, charcoal and coal (Bradley, Lahn and Pye, 2018[1]).

Actions requiring international support in contexts where government capacity is low:

- Envision reducing black carbon and sulphur dioxide (SO_2) emissions through point source pollution controls.
- Understand the full costs of gas production, processing, transport (pipelines), distribution (city gas networks) and storage (compressed natural gas stations), emissions, water demand and land use, even if not immediately applied to the domestic fuel price (Bradley, Lahn and Pye, 2018[1]).

1.2.3. Utilising associated gas

Associated gas is natural gas that is produced along with crude oil, and typically separated from the oil at the wellhead. Associated gas has often been seen as an inconvenient by-product of oil production: it is generally less valuable than oil per unit of output and is costlier to transport and store. Oil and gas projects that have small gas volumes, are geographically remote, or suffer from a lack of infrastructure or market for gas, will routinely flare or vent the associated gas, emitting large volumes of CO_2, some methane, and other volatile organic compounds (VOCs). As a result, thousands of gas flares at oil production sites around the globe burn approximately 140 billion cubic metres of natural gas annually, causing more than 300 million tonnes of CO_2 to be emitted to the atmosphere (World Bank, 2022[21]).

Flaring of gas not only contributes to climate change and impacts the environment but also wastes a valuable energy resource that could be used to advance the sustainable development and low-carbon transition in producing countries. For example, if the amount of gas which is flared on an annual basis were used for power generation, it could provide about 750 billion kWh of electricity, or more than the African continent's current annual electricity consumption.

Associated gas can be utilised in a number of ways: reinjected for enhanced oil production, transmitted into natural gas distribution networks (i.e. pipelines), used for on-site electricity generation, converted into compressed natural gas (CNG) or liquefied natural gas (LNG), converted from gas to liquids (GTL) to produce synthetic fuel (e.g. methanol), used as feedstock for the petrochemical industry or to produce blue hydrogen, if CC(U)S is applied to the resulting CO_2 emissions.

However, only 75% of the associated gas produced globally is put to productive use, either marketed directly to end consumers via gas distribution networks, used on-site as a source of power or heat, or reinjected into oil wells to create pressure for secondary liquids recovery. The remainder (some 200 bcm in 2018) is either flared (140 bcm) or vented to the atmosphere (an estimated 60 bcm) (IEA, 2019[22]).

Commercial viability is a significant barrier to the utilisation of associated gas, as operators seek to secure long-term reliable off-take agreements with anchor customers for the sale of gas to the domestic market. In many developing countries this will be the power sector due to growing demand for electricity. However, power utilities suffer from grid instability and financial difficulties that can lead to large payment arrears where power utilities are unable to pay for gas "purchased". Furthermore, IOCs may be subject to gas export restrictions, leaving flaring as the only alternative should domestic customers be unable to pay (World Bank, 2022[23]).

Consequently, the capture of associated gas by upstream operators is dependent on gas pricing reforms and competitive downstream energy markets with efficient and transparent legal and regulatory frameworks that provide fair and non-discriminatory access to markets. Many of these enabling measures and regulatory reforms may be outside the mandate of the ministry in charge of oil and gas. Therefore, governments should ensure that an integrated energy sector strategy is implemented to set out the necessary reforms across the gas value chain (World Bank, 2022[23]).

Governments can also set specific gas flaring and venting reduction targets in their NDCs, although few oil-producing countries have done this to date. These targets can be assigned to the government, or, where relevant, to the NOC. For example, in Colombia, Ecopetrol has an interim target to reduce gas flaring by

77% by 2022 (down from 2017 levels), and has linked its targets to Colombia's NDC, which refers to scaling up the utilisation of associated gas (World Bank, 2022[24]).

Box 1.6. Monetising associated gas

In many cases, the monetisation of associated gas can be a financial solution to flaring as associated gas should be viewed as an asset, not an unwanted by-product of oil production. Associated gas is ordinarily re-injected into the field for enhanced oil recovery. Where this is not feasible, there are several options available to operators to monetise associated gas, instead of flaring it into the atmosphere. These include:

- converted to power, with the latter used on-site by the oil operator
- converted to power, with the latter sold to external off-takers
- delivered to an existing pipeline network
- delivered to a gas processing plant
- compressed and sold as compressed natural gas
- liquefied for sale as liquefied natural gas.

Source: (Lorenzato et al., 2022[10]).

Governments should consider prioritising the following actions:

- Develop overall policy for the capture and use of associated gas, with due consideration for the risks associated with continuous reliance on fossil fuels under Pillar 1, Section 1. This policy should specify the role that flare and vent reductions of associated gas play in achieving overall climate policy objectives (World Bank, 2004[25]); (IEA, 2021[14]).
- Ensure that oil producers have the legal right to monetise associated gas, including through gas exports (World Bank, 2022[23])
- Ensure that regulatory agencies have clearly defined responsibilities with no overlapping or conflicting mandates, and that these agencies are properly resourced. The spreading of gas flaring and venting institutional responsibilities across different ministries and in some countries even NOCs, can lead to unclear reporting lines, conflicting mandates, and reduced effectiveness of the regulatory agency. For example, in countries with a dedicated ministry for oil and gas, flaring and venting may fall under the responsibility of the ministry responsible for the environment (Lorenzato et al., 2022[10]). Where regulatory functions are split among different authorities, governments should put in place processes requiring the authorities to cooperate in cross-cutting areas, such as the issuance of flaring permits or the approval of oil field development plans. Interagency co-ordination is essential and can be achieved using dedicated liaison officers (World Bank, 2022[23]).
- Combine monitoring and enforcement powers under one single agency.
- Establish a gas and electricity regulatory agency that efficiently regulates natural monopolies of gas processing, transmission and distribution and implements open access rules to gas networks to foster competition and provide opportunities to market associated gas downstream. Although third-party access can often be secured through contractual negotiations, the substantial bargaining power held by the transmission network's owners may require regulatory intervention (Columbia University, 2016[26]).

- Grant preferential access for associated gas into the national gas pipeline system and preferential access for electricity produced from associated gas to the wholesale market (Lorenzato et al., 2022[10]).
- Establish fit-for-purpose methods for measuring the volume of gas flared and vented (by metering or using engineering estimates) and require IOCs and NOCs to submit this information to the regulator on a regular basis. Engineering estimates can offer an alternative when measurement is difficult or too costly, provided that standardised estimation methods are specified and monitored. Regulators should consider new technologies such as continuous monitoring systems, aerial surveillance, and satellite instruments as independent sources of data. (World Bank, 2022[23]).
- Collect and publicly disclose information on flaring and venting, by requiring oil and gas companies, including NOCs, to publicly disclose such information. Disclosure of information can help strengthen existing regulations and build trust in the industry with the affected communities, civil society and the public (World Bank, 2022[23]).
- Require that routine flaring at existing oil fields ends as soon as possible, and no later than 2030 (World Bank, 2022[21]).
- For new projects, governments should require that field development plans for new oil fields incorporate sustainable utilisation or conservation of the field's associated gas without routine flaring (World Bank, 2022[21]).
- Clearly define in regulation the circumstances under which operators can flare and vent associated gas without prior approval from the relevant regulatory authority, with reporting requirements and sanctions for non-compliance. Examples of such circumstances include safety or unavoidable technical reasons (World Bank, 2004[25]); (IEA, 2021[14]); (World Bank, 2022[23]).
- Include dissuasive and proportionate enforcement mechanisms in relevant regulations to deal with non-compliance of flaring and venting of associated gas: for example, penalties and fines, and revocation of the production/operation license (World Bank, 2004[25]). Any type of mandatory payment (penalty, fine, fee) should be established at a sufficiently high level to make the alternative of investing in flaring and venting reduction more attractive than paying the penalty. However, the payment should not be so high that shutting down oil production becomes the only viable option (World Bank, 2022[23]).
- Encourage the utilisation of associated gas to contribute to the security of supply, by providing for an associated gas profit split between NOCs and IOCs.
- Require that operators on adjacent fields collaborate to capture associated gas where necessary. A portfolio approach that clusters several small flares under the same project is often required to build a minimum of economies of scale and to hedge against the uncertainty and unpredictability of flare profiles (Lorenzato et al., 2022[10]).

Actions requiring international support in contexts where government capacity is low:

- Consider providing fiscal incentives to reduce the flaring and venting of associated gas. Preferential treatment of gas production through lower taxes and royalties compared to oil production may provide a positive incentive to produce gas and develop downstream gas network and markets or LNG facilities for export (World Bank, 2004[25]). When considering the development of options for the commercialisation of associated gas, governments should consider the effects on this new market(s) if oil production is scaled back (IEA, 2020[19]).
- Before granting permission to operators to flare or vent associated gas for economic reasons, require that companies satisfy the regulatory authority that they have investigated all reasonable alternatives to flaring and venting, including reinjection for improved oil recovery or storage, or gas gathering, treatment and sale to downstream energy markets (World Bank, 2004[25]).

Box 1.7. Policy incentives and regulatory requirements to reduce flaring and capture associated gas in Nigeria

Nigeria has reduced its flaring of associated gas from 60% to 6%. This and future reductions are supported by policy changes in Nigeria that include:

1. a requirement for all upstream development plans to include a plan for commercialising or evacuating the associated gas
2. a requirement for production sharing contracts to include a gas utilisation plan
3. a requirement for metering of every new flare point
4. a penalty for the flaring of gas, with proceeds going to environmental mitigation in host communities (the Petroleum Industry Act 2021 also stipulates that the proceeds from flare penalties will be used to carry out environmental remediation).

The efforts of the Nigerian National Petroleum Corporation (NNPC) to reduce flaring have followed from policies, incentives and programmes of the Federal Government of Nigeria, including the enactment of Nigeria's Liquefied Natural Gas Act, the Associated Gas Reinjection Act, and the Flare Gas (Prevention of Waste and Pollution) Regulations. NNPC and its partners are funding some of the flare gas monetisation projects, while others are being carried out in collaboration with third-party off-takers. Nigeria's Ofon Upstream Emissions Reduction (UER) initiative makes use of UER certificates, which can then be sold to fuel suppliers, to be counted towards their emissions reduction. In the Ofon case, the UERs were sold to the Total Lindsey Oil Refinery for approximately EUR 1 million, to be converted into GHG credits. Ofon UERs were externally verified and validated by Nord Cert Gmbh.

Source: (OECD Development Centre, 2021[27]).

What can the fossil fuel industry do?

- Follow international industry standards, while setting improvement targets for flaring and venting reduction as well as standardised monitoring and reporting procedures.
- Join the World Bank's Zero Routine Flaring by 2030 initiative to co-operate to eliminate routine flaring no later than 2030. Join the Global Gas Flaring Reduction Partnership (GGFR) to work to end routine gas flaring at oil production sites. Oil companies with routine flaring at existing oil fields should implement economically viable solutions to eliminate this legacy flaring as soon as possible, and no later than 2030 (World Bank, 2022[21]).
- Investigate commercial uses for associated gas, including on-site electricity generation, conversion to CNG or LNG, and viability of GTL or feedstock for the petrochemical industry.
- Establish an appropriate mechanism for the collection, public disclosure, and reporting on flaring and venting volumes and frequency.
- Share data on established good practices from other jurisdictions. The sharing of data and learning from practices in other oil- and gas-producing countries can enhance and drive the pace of implementation of abatement measures (World Bank, 2022[23]).

What can importing countries do?

- Recognise their shared responsibility for curbing flaring and venting in producing countries. The Imported Flare Gas (IFG) Index is based on the concept that when a country imports crude oil from another country, it is also importing the flaring intensity of the producing country in proportion to the amount of crude oil imported, especially when international agreements and national

commitments on climate mitigation incentivise countries to reduce emissions throughout the life cycle (World Bank, 2021[28]).

- Provide technical and financial support for the deployment of best available technologies for emissions abatement.
- Establish partnerships to build capacity for measurement, verification and reporting of CO_2 and methane emissions.
- Require IOCs operating from their jurisdictions to deploy the best available technologies for emissions abatement wherever they operate.
- Implement "collect and buy" schemes where importing countries agree to purchase associated gas that would have otherwise been flared. Long-term gas purchase agreements for associated gas can incentivise producing countries to invest in technologies and infrastructure to capture associated gas.

What can government and the fossil fuel industry do together?

- Jointly develop transparent and effective standards for the monitoring and reporting of flaring and venting of associated gas (World Bank, 2004[25]); (IEA, 2021[14]).
- Commit to publicly report the flaring of associated gas on an annual basis in accordance with the World Bank's Zero Routine Flaring by 2030 initiative.
- Investigate the potential for a domestic natural gas market in order to monetise any associated gas. For example, some developing countries, in partnership with industry, are looking at financially viable options to build downstream gas network to use associated gas (e.g. the West Africa Gas Pipeline, which aims to reduce gas flaring in Nigeria by exporting associated gas to neighbouring Benin, Togo and Ghana) (World Bank, 2004[25]).
- Join the World Bank's Zero Routine Flaring by 2030 initiative and the Global Gas Flaring Reduction Partnership (GGFR) to work toward the identification of solutions to technical and regulatory barriers to flaring reduction by developing country-specific flaring reduction programmes, conducting research, sharing best practices, raising awareness, increasing the global commitments to end routine flaring, and advancing flare measurements and reporting.

Box 1.8. Gas infrastructure development: The role of transformative public-private partnerships

The development of gas infrastructure can greatly reduce flaring and venting by capturing associated gas. Constructing export terminals, pipeline networks, compression facilities, and reinjection wells, makes it economically feasible to capture and use associated gas that would otherwise be flared or vented.

The development of gas infrastructure can be financed through transformative public-private partnerships between NOCs and private investors. Such partnerships allow parties to pool resources and avoid imposing the full burden of overcoming the infrastructure challenges on individual companies, and can enable flaring reduction projects. Examples of public-private partnerships that have successfully developed infrastructure to capture associated gas include the Angola LNG Project and the El Merk Central Processing Facility in Algeria.

The development of conventional gas infrastructure may not be feasible for all projects, especially where there is a lack of existing infrastructure or where demand for gas is low and there are issues with power supply and transmission. In these scenarios, small-scale LNG facilities (with relatively low investment compared to pipelines or large facilities), LNG distribution by trucks and LNG refuelling stations offer possible solutions to improve gas distribution flexibility.

Source: (Calel and Mahdav, 2020[29]); (Tractebel Engineering, 2015[30]); (World Bank, 2022[23]).

1.2.4. Reducing methane emissions across the LNG value chain

The global LNG industry is rapidly expanding with huge increases in supply and trading, and numbers of exporters and importers, and with several new projects due to come on stream during the early 2020s. LNG projects are projected to account for around 80% of the increase in global gas trade up to 2040 (Stern, 2019[31]). This projected increase in LNG trade may lead to an increase in global GHG emissions, particularly as LNG transport, in general, is more emissions intensive than pipeline transport (IEA, 2019[32]). For many supplying countries, only limited verified emissions data are available, which can be further complicated by disparities in regional and industry practices around flaring, venting, permitted valves and the types of storage tanks or compressors used in LNG processes (Stern, 2019[31]); (Blanton and Mosis, 2021[33]).

Emissions can occur across the LNG life cycle – during liquefaction, shipping, and regasification. The liquefaction of gas is an energy-intensive process, as the gas needs to be cooled to -162°C, and the energy required for this process can equate to 11-13% of the gas arriving at the liquefaction terminal (Stern, 2019[31]). Emissions from liquefaction derive from fuel combustion for electricity, natural gas venting and also fugitive methane leaks (Abrahams et al., 2015[34]). Emissions can also be present during transportation and can include boil-off gas from cargo tank to engine and methane slip during fuel combustion. Emissions intensity varies across different LNG ship sizes and types of propulsion, and can be further blurred where, in an increasingly liquid LNG market, cargos may change direction/intended destination several times prior to final delivery (Stern, 2019[31]). The emissions intensity of the regasification stage of the LNG life cycle is less clear. There is a wide variation in energy required for regasification due to differences in ambient air temperatures and availability of seawater for heating. In some cases, regasification facilities are co-located near power plants, which can minimise the direct emissions from energy required to regasify LNG (Abrahams et al., 2015[34]).

Table 1.2. Sources of emissions in the LNG value chain

Phase	Upstream Liquefaction			Midstream Transportation by ship			Downstream Regasification		
Cause of emissions	Fugitive emissions	Venting	Incomplete combustion/ methane slip	Fugitive emissions	Venting	Incomplete combustion/ methane slip	Fugitive emissions	Venting	Incomplete combustion/ methane slip
Source of emissions	Components (valves, flanges, connecters etc.); compressor seals	Flaring; tank storage; vessels and truck loading; maintenance; failure/ emergency; start-up/ shutdown activities	Flaring; stationary combustion devices (e.g. engines, boilers)	Components (valves, flanges, connecters etc.)	Tanks; compressors; gas freeing for dry-dock; start and stops	Engines (e.g. methane slips)	Components (valves, flanges, connecters etc.);	Flaring; vessels and truck loading; vessels unloading; maintenance; failure/ emergency; pneumatic controllers	Flaring; vessels and truck loading; vessels unloading; maintenance; failure/emergency; pneumatic controllers
Emissions intensity across LNG value chain*	Upstream (8.25%)			Midstream (4%)			Downstream (0.25%)		

Note: *Of the entire LNG value chain, only 12.5% of emissions occur during liquefaction, shipping, and regasification. Other emissions occur during upstream gas production, processing and transportation (12.5%), and downstream (75%). This table covers emissions specific to LNG (liquefaction, shipping, and regasification). For an overview of emissions in the entire oil and gas value chain, see Table 1.1.

Source: Adapted from (Blanton and Mosis, 2021[33]) and (Stern, 2020[35]).

Typical LNG projects may take 5 years to build and have an operating life of at least 25 years – in many cases extending beyond 2050. Consequently, developing country producer governments should consider how the introduction of new GHG reduction requirements by importer countries may impact new LNG

projects over their operating life. These regulations may dictate how long LNG can be sold as unabated methane, and potentially increase costs and lower expected returns from new LNG projects (Stern, 2019[31]). Developing country producer governments should also recognise that several of the largest LNG importers (e.g. France, Japan, South Korea, Spain and the United Kingdom) have pledged to become carbon-neutral by 2050, and by 2060 in China's case (Blanton and Mosis, 2021[33]).

Governments should consider prioritising the following actions:

- Stay abreast of policy developments on LNG emissions in importing countries affecting the choice of suppliers (Stern, 2019[31]). It is likely that GHG emission regulations will be introduced by importing countries during the life of LNG projects that continue/commence operating post-2030.
- Introduce requirements for LNG project operators to measure emissions during liquefaction, shipping, and regasification (where possible) (Stern, 2019[31]).

Actions requiring international support in contexts where government capacity is low:

- Consider whether importing countries plan to introduce GHG emission reduction requirements for new LNG projects when assessing the commercial viability of LNG projects.
- Introduce strict decarbonisation requirements for new LNG projects. For example, in Western Australia, the Gorgon LNG project only received regulatory approval once CC(U)S was integrated into the project to capture the CO_2 (Stern, 2019[31]).

What can the LNG industry do?

- Establish a measurement, disclosure and reporting, and verification framework for emissions from liquefaction, shipping, and regasification and provide for complete transparency of emissions data and the methodology used to compile them (Stern, 2019[31]); (Methane Guiding Principles, 2020[36]).
- Disclose aggregated emissions data in line with recognised international standards, for example the International Organization for Standardization (ISO) framework or the International Group of Liquefied Natural Gas Importers' MRV and GHG Neutral Framework. Methodologies for emissions measurement, emissions ratios, and accounting practices differ across companies and jurisdictions, so the provision of data in ISO format can ensure better comparability of GHG emissions across the LNG life cycle (Blanton and Mosis, 2021[33]); (GIIGNL, 2021[37]).
- Prevent emissions during liquefaction, shipping and regasification whenever possible and reduce those emissions that cannot be prevented (Methane Guiding Principles, 2020[36]).
- Identify and repair equipment that is not working properly (Methane Guiding Principles, 2020[36]).
- Introduce electrification into the liquefaction process using renewable energy in place of natural gas in order to reduce its energy intensity. Electrification trains and integration of liquefaction projects with CC(U)S have already resulted in emissions reductions (IEA, 2019[32]); (Dauger, 2020[38]).
- Consider progressively replacing natural gas feedstock with biogas and biomethane feedstock (depending on availability) (Stern, 2019[31]); (Dauger, 2020[38]).
- Participate in voluntary initiatives to reduce methane emissions in the LNG sector. One such example is the International Group of Liquefied Natural Gas Importers (GIIGNL).

Box 1.9. Minimising emissions during regasification

Since 2013, Enagás, a Spanish natural gas transmission company that operates Spain's gas grid and also owns four liquefied natural gas regasification terminals in the country, has implemented a number of best practices to reduce emissions at three LNG regasification plants in Spain:

- **Leak detection and repair (LDAR) programmes.** These are conducted every year at the LNG terminals that Enagás operate in Spain (Barcelona, Cartagena, Huelva) to identify and reduce fugitive emissions. This includes the use of a portable detector (a point sensor) on a daily basis, during start-ups and during maintenance.
- **Mitigation of emissions from venting.** This includes eliminating pneumatics powered by gas, optimising tank pressure, monitoring rod packing (on the boil off gas compressor), LNG truck loading vapour exchange, purging hoses and LNG arms with nitrogen prior to disconnection, and dry disconnecting couplings in LNG truck loading facilities.
- **Reducing boil-off gas (BOG) venting.** During the design phase of their three LNG terminals, Enagás implemented BOG recovery units to recover, compress and send the BOG to the recondenser to be converted into LNG. In 2015, Enagás installed high-pressure BOG compressors to inject non-recoverable BOG into the grid during loading and unloading operations and zero or low send-out modes.

The introduction of these best practices has had a significant impact on emissions from Enagás LNG regasification plants in Spain. Since 2013, total methane emissions have been reduced by 89%, fugitive emissions have decreased by 55% and emissions from venting by 98%.

Source: (Methane Guiding Principles, 2020[36]).

What can importing countries do?

- Introduce emission requirements on deliveries of imported LNG as part of their own GHG reduction targets and engage with producers to reduce life cycle emissions from LNG (Stern, 2019[31]) (Blanton and Mosis, 2021[33]).
- Introduce requirements for electrifying the regasification process using renewable energy and integrate CC(U)S for CO_2 storage, where appropriate (Stern, 2019[31]).
- Support the research and development of emissions monitoring along the LNG value chain and encourage the disclosure of emissions calculations and offsets (Blanton and Mosis, 2021[33]).

1.2.5. Reducing methane emissions from coal mining

According to the IEA, in 2021 the global energy sector was responsible for emitting around 135 million tonnes (Mt) of methane into the atmosphere. Of those 135 Mt of methane emissions, an estimated 42 Mt were from coal mine methane – more than oil (41 Mt), extracting, processing and transporting natural gas (39 Mt), bioenergy (9 Mt) and leaks from end-use equipment (4 Mt). The United States Environmental Protection Agency (US EPA) estimates that the coal-mining industry is responsible for 11% of global methane emissions from all human activities (U.S. EPA, 2019[39]). By way of example, coal-related methane emissions from China, the world's largest coal producer and emitter of coal mine methane, are equivalent to the total CO_2 emissions from international shipping (IEA, 2022[16]). The amount of methane emissions from coal mines is likely to be higher than IEA estimates as they do not include emissions from abandoned coal mines due to difficulties in sourcing reliable data. However, recent

estimates indicate that abandoned coal mines could account for almost one-fifth of methane emissions from worldwide coal production (IEA, 2022[16]).

Methane occurs naturally in coal seams and the surrounding strata, and is emitted during the mining process. Underground mines are the single largest source of coal mine methane emissions in most countries, as they are typically much deeper than surface mines and the methane content per ton of coal mined increases with increasing depth (GMI, 2011[40]). Furthermore, methane must be removed from underground coal mines, as it is explosive in nature and poses a safety hazard to coal miners. Large-scale ventilation systems move massive quantities of air through the mine but also release large amounts of very low-concentration ventilation air methane (VAM) into the atmosphere (GMI, 2011[40]). VAM accounts for the largest source of coal mine methane emissions globally. In some instances, VAM is supplemented by a degasification system consisting of a network of boreholes and gas pipelines that may be used to capture methane before, during, and after mining activities to keep the methane concentration within safe limits (U.S. EPA, 2015[41]). Methane emissions do not necessarily stop when the mine halts production, as abandoned or closed mines can continue to emit methane from ventilation pipes or boreholes.

Table 1.3. Sources of emissions in the coal value chain

Phase	Upstream Coal mining and processing		Midstream Transportation		Downstream End-use	
Activity	Drilling, blasting, excavation	Washing, separation, drying	Truck, rail, ship	Stock piling	Electric power generation	Industrial processes
GHGs	Methane (CH_4), Carbon dioxide (CO_2)	Methane (CH_4), Carbon dioxide (CO_2)	Methane (CH_4), Carbon dioxide (CO_2)	Methane (CH_4), Carbon dioxide (CO_2)	Carbon dioxide (CO_2), Nitrous oxide (N_2O)	Carbon dioxide (CO_2), Nitrous oxide (N_2O)
Emissions intensity across the value chain	Upstream and midstream (10%)				Downstream (90%)	

Source: Adapted from (Pandey, Gautam and Agrawal, 2018[42]); (Delevingne et al., 2020[43]); (IEA, 2019[22]).

There are a number of challenges to the mitigation and reduction of coal mine methane emissions. These include accessing appropriate technology to assess resources, install drainage systems, and select appropriate end use technologies (U.S. EPA, 2015[41]). Commercial utilisation of coal-bed methane is possible, but presents technical and economically viability issues in the absence of policy incentives. As a result, methane drained from coal mines is mostly vented, and there are limited efforts to capture fugitive methane emissions (Delevingne et al., 2020[43]). Further challenges include a lack of adequate infrastructure to transport the gas, clear establishment of property rights to the same gas, and access to capital or financing (U.S. EPA, 2015[41]). Lastly, as countries continue to produce coal, coal mine operators tend to extract coal at increasingly greater depths where, on average, the methane content per tonne is higher (Kholod et al., 2020[44]). However, there are also significant opportunities to reduce methane emissions in the near term by deploying existing technologies and monetising coal mine methane. Methane captured from coal mining can be used in the coal production process, for electricity generation or sold as natural gas. In situations where coal mine methane cannot be effectively captured, the methane may be flared (as opposed to vented), as methane is destroyed by combustion and converted to CO_2, a far less potent GHG (Pandey, Gautam and Agrawal, 2018[42]).

Governments should consider prioritising the following actions:

- Establish an appropriate mechanism for the collection and dissemination of credible and unbiased data on coal mine methane emissions, including technical and market information (GMI, 2011[40]).
- Implement regulations and policies to govern coal mine methane capture and use. Ensure that the property rights of the gas are clearly allocated and understood (GMI, 2011[40]); (U.S. EPA, 2015[41]).

- Provide incentives for the deployment of new technologies in small and medium-sized mines.
- Implement regulations to ensure that the liability of coal mine operators for methane emissions continues after the mine has been abandoned/closed.

Actions requiring international support in contexts where government capacity is low:

- Introduce policies and regulatory regimes to incentivise or require the use of technologies to capture VAM (IEA, 2022[16]).
- Introduce requirements for coal mine operators to capture methane using degasification wells and drainage boreholes prior to the start of production (IEA, 2022[16]).
- Implement a programme to remediate abandoned coal mines. For example, in the United States, the Abandoned Mine Land programme provides funding for remediating thousands of currently leaking, abandoned coal mines in order to reduce methane emissions. This programme has the benefit of employing tens of thousands of dislocated energy workers in affected communities across the country (Office of Domestic Climate Policy, 2021[45]).
- Initiate dialogues and exchange programmes across developing and advanced economies to share international good practices for coal mine closures.

What can the fossil fuel industry do?

- Explore options for using coal mine methane in the coal production process (coal drying, heat source for mine ventilation, etc.) (U.S. EPA, 2015[41]).
- Explore options for using coal mine methane for on-site power generation. Coal mining is an energy-intensive process, which requires a high electricity load to run equipment including mining machines, conveyor belts, desalination plants, coal preparation plants and ventilation fans. Methane-fired power generation technologies such as gas engines, gas turbines and fuel cells can be used for on-site power while also reducing energy consumption during the coal production process (Pandey, Gautam and Agrawal, 2018[42]).
- Explore options for commercialising coal mine methane for electricity or heating – for example, district heating, boiler fuel, town gas or sale directly into natural gas pipeline systems (U.S. EPA, 2015[41]).
- Explore options for using coal mine methane as a chemical feedstock to produce synthetic fuels and chemicals – for example, methanol (Pandey, Gautam and Agrawal, 2018[42]).

What can governments and the fossil fuel industry do together?

- Transparently share data to advance research geoscience and technological improvements, and to build capacity.
- Engage with international public-private partnerships such as the Global Methane Initiative (GMI) to facilitate project development and to advance methane recovery and use at underground coal mines throughout the world (GMI, 2011[40]).
- Jointly explore options for commercialising coal mine methane, including in a cluster development with several coal mines/operators. Commercialisation may include: power generation, district heating, boiler fuel, or town gas, or sale directly into natural gas pipeline systems (U.S. EPA, 2015[41]).
- Jointly explore the feasibility of flooding abandoned underground coal mines in order to stabilise the hydrostatic pressure on the coal seams which will significantly reduce methane emissions. Systems will need to be put in place to monitor hydrogeological and geotechnical aspects of the mine (Kholod et al., 2020[44]).

1.2.6. Integrating renewables into upstream extractive projects

In order to meet climate objectives, electricity generation for industrial use would need to be fully decarbonised, using electricity from centralised grid or off-grid, supplied by renewable energy sources. This process will in turn depend on the existing and potential supply of decarbonised electricity (and hence the availability of renewable sources, hydrogen or synthetic hydrocarbon sourced net zero emission liquids and gases). Depending on its emissions intensity, the use of grid-based electricity can increase the efficiency of oil and gas and mining operations. This is already the case in some upstream operations, for instance, at the Johan Sverdrup field in Norway, where renewable electricity from the grid is used.

However, many oil and gas operations in developing and emerging economies are in remote locations, disconnected from power plants, where the grid-based supply is not always reliable. Therefore, an alternative approach is to deploy, for instance, decentralised renewable energy sources with storage systems, or off-grid nuclear power reactors (small modular reactors), where cost-competitive. Such initiatives have started to become more widespread, and include a 10 MW Sonatrach-Eni project to power an Algerian oil field with solar PV, or a new 88 MW wind facility to supply electricity to offshore platforms in the Norwegian Sea. Small modular reactors (SMRs) are attracting interest as a low-carbon alternative energy source in resource extraction and mining. In Canada, the oil sands industry is considering SMRs as potential power and heat source (Governments of Ontario, New Brunswick, Saskatchewan and Alberta, 2022[46]), with a demonstration project foreseen to be operational by the mid-to-late 2020s (Global First Power, 2020[47]). Meanwhile, the Russian Federation is planning to use floating and land-based SMRs in power supply for extractive industries (RAOS JSC, 2019[48]). SMRs generally have a power output of between 1 megawatt electric (MWe) and 300 MWe (compared to approximately 1 000 MWe for large reactors). Their components can be manufactured in a factory and transported and assembled on-site, their modularity enabling capacity to be expanded according to the required energy demand. The energy output from SMRs can be used not only to power resource extraction at mining sites, but also for heat supply for residential and industrial applications, including district heating, desalination, and industrial processes.

The IEA has estimated the potential size of integrating renewables into upstream oil and gas operations based on the costs and emissions savings of installing different-sized hybrid solar PV, wind and battery storage systems at new oil and gas facilities. The assessment suggests that it is technically possible to reduce upstream emissions by over 500 Mt CO_2 by installing decentralised renewable systems when new resources are first developed.

Governments should consider prioritising the following actions:

- Where feasible, mandate the adoption of renewable energy sources for power generation.
- Consider the potential contribution of SMRs in decarbonising mining activities and other industrial sectors as part of a portfolio of technological solutions.

Actions requiring international support in contexts where government capacity is low:

- Depending on the context, consider introducing a carbon tax, or cap and trade systems, to be eventually integrated with carbon offsets, and phase out inefficient fossil fuel subsidies that disincentivise investments in low-carbon technologies (see also Pillar 3, Section 3.3.1).
- Engage with international organisations, such as the Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA), to develop a better understanding of SMRs.

What can the fossil fuel industry do?

- Scope the possibilities for the cost-effective use of renewables in existing and new oil and gas projects.

- Understand the economics and technical requirements (e.g. back-up supply in case of power outage) for such an investment.
- Prioritise the use of renewable electricity in upstream operations over fossil fuel sources, where renewable sources are a cost-effective alternative.
- Advocate and apply for government support through available national and sub-national programs to mitigate financial risk associated with early adoption of SMRs.
- Build relationships between SMRs developers and potential customers for further collaboration toward demonstration and deployment.

1.2.7. Deploying carbon capture (utilisation) and storage technology

CC(U)S refers to the process of capturing carbon dioxide (CO_2) before it enters the atmosphere, transporting it, and either storing it underground (i.e. in a geological reservoir) or recycling it for industrial usage.

Fossil fuel producer countries may consider the deployment of CC(U)S technologies to reduce emissions in the upstream oil and gas sector as well as other energy intensive and hard-to-abate industrial sectors, such as the cement and fertiliser industries. In addition, the deployment of CC(U)S can help avoid job losses in industries where continued production depends on emissions abatement and allow for a smoother transition to a net zero economy.

Different applications of CC(U)S imply different costs. These costs are largely determined by the initial concentration of the CO_2 captured, the availability and proximity of storage capacity and transport infrastructure and the existence of a robust business case. For example, one projection finds that in natural gas processing and fertiliser production, concentrated streams of CO_2 can be captured and stored at costs as low as USD 15-25 per tonne of CO_2, depending on location. Coal fired power plants retrofitted with CC(U)S have delivered at costs of around USD 65 per tonne of CO_2, and studies show that these costs could come down to USD 45 per tonne for new projects (IEA, 2020[49]); (International CCS Knowledge Centre, 2018[50]).

There is considerable potential for cost reductions. Such potential is linked to learning-by-doing effects as CC(U)S is scaled up for different types of applications; reduction of capital and operating costs due to economies of scale and optimisation of operations and maintenance; digitalisation and technology spill-overs from other industries, and improved business models where costs are shared through CC(U)S hubs with broad industry participation (IEA, 2020[49]). The large-scale roll out of CC(U)S is not solely within the sphere of influence of producing countries, but also heavily relies on progress towards climate objectives in consumer markets, in terms of achieving the critical mass required to create demand, technology development and financing. However, perceived levels of risk remain relatively high, driving up financing costs (Global CCS Institute, 2020[51]), and for this reason, government support is essential.

There may be significant opportunities for fossil fuel producer countries to scale up the deployment of CC(U)S, as more than half of the investment required for industrial CC(U)S would need to be located in developing countries (IEA, 2012[52]). However, governments should also consider the risks of relying on assumptions about the timing and costs of global CC(U)S deployment. Implementation of CC(U)S faces technological, economic, institutional, ecological-environmental and socio-cultural barriers, and current rates of CC(U)S deployment are below those in modelled pathways limiting global warming to 1.5°C or 2°C. Many existing CC(U)S projects have been designed for enhanced oil recovery, and only 8 of the 26 existing global CC(U)S projects are dedicated to the long-term storage of CO_2. Furthermore, the IPCC has also stated that the global deployment of CC(U)S technologies should be limited to 3.8 Gt CO_2 per year (under a scenario of medium feasibility concerns), which may constrain global scale-up (IPCC, 2022[53]).

Box 1.10. Examples of government support for CC(U)S deployment

Canada: In 2021, the Government of Canada launched the development of a federal CC(U)S Strategy to enable the CC(U)S industry to realise its GHG reduction and commercial potential on the path to a net-zero economy. In 2022, the government announced that they would invest CAD 319 million over seven years into research, development and demonstrations to advance the commercial viability of CC(U)S technologies. These funds will support businesses, academia, non-profits, government and federal laboratories on the path to net-zero emissions by 2050.

European Union: The Innovation Fund (EUR 10 billion from 2020-30) provides funding programmes for the demonstration of innovative low-carbon technologies and processes in energy-intensive industries, including products substituting carbon-intensive ones. Examples include carbon capture and utilisation, the construction and operation of carbon capture and storage (CCS) and innovative renewable energy generation and storage.

The Netherlands: The Sustainable Energy Transition Scheme (SDE++) is intended to stimulate the production of clean and sustainable energy. CC(U)S and blue hydrogen are also eligible. It is financed by surcharge on the energy bills of citizens and companies.

United Kingdom: The Carbon Capture and Storage Infrastructure Fund (GBP 1 billion) is intended to support deployment of CC(U)S in a minimum of two clusters by the mid-2020s, and four clusters by 2030 at the latest, with an ambition to capture 10 Mt CO_2/year by 2030. In is intended to provide support for capital expenditures on CO2 transport and storage networks, and industrial carbon capture projects.

Source: (IEA, 2022[54]); (BEIS, 2021[55]); (Directorate-General for Climate Action, 2022[56]).

Governments should consider prioritising the following actions:

- Provide the national geological survey authority, or equivalent government entity, including NOCs, with the capacity to undertake geological mapping to identify and assess CO_2 storage sites, and establish a national register or atlas, enabling the licensing and commercialisation of CC(U)S activities. This process does not need to be resource-intensive, as geological surveys can base storage mapping activities largely on existing geological information generated by oil and gas exploration and production.
- Determine whether highly concentrated large-point source emitters of CO_2 are relatively close and well connected to potential storage sites.
- Allocate CC(U)S projects to companies that already have the required capacity with regard to geological knowledge, relevant operational experience, and infrastructure capacity to develop and operate CC(U)S infrastructure.
- Develop a CC(U)S investment-friendly tax regime (see Box 1.13).
- Where incentives for CC(U)S are in place, ensure they reflect a fair sharing of the risks and costs between governments and investors.

Table 1.4. CC(U)S Regulatory Framework – key issues

Broad regulatory issues	Classifying CO_2
	Property rights
	Competition with other users and preferential rights issue
	Transboundary movement of CO_2
	International laws for the protection of the marine environment
	Providing incentives for CC(U)S as part of climate change mitigation strategies
Existing regulatory issues applied to CC(U)S	Protecting human health
	Composition of the CO_2 stream
	The role of environmental impact assessment
	Third-party access to storage site and transportation infrastructure
	Engaging the public in decision making
	CO_2 capture
	CO_2 transportation
	Scope of framework and prohibitions
	Definitions and terminology applicable to CO_2 storage regulations
CC(U)S-specific regulatory issues	Authorisation of storage site exploration activities
	Regulating site selection and characterisation activities
	Authorisation of storage activities
	Project inspections
	Monitoring, reporting and verification requirements
Emerging CC(U)S regulatory issues	Corrective measures and remediation measures
	Liability during the project period
	Authorisation for storage site closure
	Liability during the post-closure period
	Financial contributions to post-closure stewardship
	Sharing knowledge and experience through the demonstration phase
	CC(U)S ready
	Using CC(U)S for biomass-based sources
	Understanding enhanced hydrocarbon recovery with CC(U)S

Source: (IEA, 2010[57]).

Actions requiring international support in contexts where government capacity is low:

- Establish CC(U)S regulatory frameworks, including independent third-party verification of storage sites, provisions for monitoring, environmental impact assessments, consultation mechanisms, and requirements for post-closure stewardship of projects, including liability and provisions for long-term monitoring, to provide the private sector with the necessary confidence to invest (Global CCS Institute, 2020[51]).
- Consider working with neighbouring countries to develop a regional framework for the sequestration, transport and storage of CO_2, drawing on the experience of the London Protocol and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). This would help remove legal barriers to a regional cluster-based CC(U)S approach.
- Undertake an in-depth cost-benefit analysis to assess capture and storage efficiency and integrity, as leakage undermines economics, public acceptance, and environmental benefits.
- Establish capacity within the public sector, or through partnerships with private specialist firms, to conform to relevant ISO standards (27914:2017; 27915:2017; 27916:2019) for carbon dioxide capture, transportation and geological storage at milestones in the CC(U)S project life-cycle: screening and selection of storage sites, qualification of site, application for permits, design and development of project, and operation and closure.

- Develop CC(U)S pilots and then demonstration projects to foment the research and deployment rates needed for CC(U)S to take off in developing countries (Almendra et al., 2011[58]).
- Play a co-ordinating role to establish CC(U)S hubs across high-carbon industrial sectors to achieve scale and create demand for CO_2 storage. The development of CC(U)S hubs in industrial areas, where CC(U)S transport and storage infrastructure is shared among various industrial users, can reduce capture and storage costs through economies of scale. This, in turn, reduces the costs for industrial facilities of incorporating CC(U)S into their production process, and could attract new investments, while maintaining existing facilities under increasingly climate-constrained conditions (IEA, 2019[59]).
- Consider emission standards and labelling or certification of low-carbon products.
- Provide long-term predictability for investors considering investing in CC(U)S. This may include a price on carbon sufficiently high to push industry players to join forces to invest in CC(U)S, or tax credits such as the 45Q in the United States, which provides the price visibility for investing in CC(U)S.
- Where feasible, provide grant support, government investment, operational subsidies (tax credits, contracts-for-difference, feed-in tariffs), demand-side measures (public procurement), CC(U)S-specific market mechanisms (tradable certificates and carbon storage units), and funding for research and development.

Box 1.11. Carbon taxation and the deployment of CCS in natural gas production in Norway

Carbon taxation can help deploy CCS in natural gas production. In 1990, during the planning phase of the Sleipner project, located in the Norwegian part of the North Sea, it became clear that the natural gas contained about 9% of CO_2, exceeding customers' specifications of a maximum 2.5% share. Therefore, the CO_2 content needed to be reduced before the natural gas could be sold. Rather than venting the separated CO_2, Equinor, the operator of the field, decided to invest in CCS technology. In 1991, the Norwegian government introduced an offshore CO2 tax in an effort to reduce emissions. This tax would have applied to any CO_2 released from gas extracted from Sleipner. The CO_2 tax was one of the triggers for operator Statoil's plans to separate CO2 offshore and inject it into deeper geological layers. Due to the Norwegian CO_2 emissions tax, it became more economical to store the CO_2 once captured than venting it.

Source: (OECD Development Centre, 2019[60]).

What can the fossil fuel industry do?

- For storage purposes, share relevant geological information, including the capacity of depleted reservoirs, including the results of geophysics and geochemical assessments, with national geological survey authorities and NOCs.
- Inform governments where gaps in geoscience knowledge may exist that inhibit investment in the deployment of CC(U)S.
- Support technology transfer to NOCs or other relevant government entity in charge of CC(U)S deployment.
- Introduce feasibility studies into industrial hubs to better understand the economic viability of CC(U)S applications including linkages to broader economic development opportunities such as hydrogen production (see Pillar 3, Section 3.2).
- Leverage horizontal cross-sector industry collaboration in industrial hubs to lower high upfront capital costs and enable the development of potential pilot projects that benefit industry stakeholders.

Box 1.12. Example of public-private collaborative approaches for CC(U)S technology deployment: Shell Quest, Alberta, Canada and Longship, Norway

Quest CCS project, Canada

Public-private collaborative approaches in Alberta have led to achievements in the deployment of CC(U)S technology. The Shell Quest CCS project received CAD 120 million from the Government of Canada and CAD 745 million from the Alberta government to sequester CO_2 emissions from oil sands operations in Alberta. The Shell Quest plant has sequestered 5 million tonnes of carbon dioxide emissions and has reported savings in operating costs, with the facility operating at CAD 25 tonne of stored CO_2 instead of the anticipated CAD 40 per tonne. Alberta remains the leading provincial candidate to deploy CC(U)S technologies, with the Alberta Carbon Trunk Line (ACTL) project opening in 2020. Canada's recognition of CC(U)S as technologically and commercially viable has been outlined in the federal budget, with tax incentives for companies that invest capital in CC(U)S projects.

Longship CCS project, Norway

The Longship CCS project will capture and store the carbon emissions of Norcem's cement factory (confirmed) and Fortum Oslo's Varme waste incineration facility (planned, pending full financing). Longship CCS plans to demonstrate that the deployed CC(U)S technology is functional for larger industrial plants and can set a new standard for future industrial projects. "Northern Lights", the storage part of the Longship project, is a joint project between Equinor, Shell and Total, financially supported by the Norwegian government through Longship. The Northern Lights project will transport liquid CO_2 from capture facilities to a terminal on the Norwegian North Sea coastline. From there, the CO_2 will be pumped through pipelines to a geological reservoir beneath the seabed. Longship builds on Norway's experience from the Sleipner CCS Project, operational since 1996 as a result of Norway's carbon tax for the oil and gas sector, implemented since 1991.

Norway has established a framework of research and financing entities to support the deployment of CC(U)S through partnerships with private companies. This includes the development, construction, and operationalisation of the Longship CCS project. The framework consists of three main components: Gassnova, CLIMIT and TCM. Gassnova was established by the Norwegian authorities in 2005 to further the development of technologies and knowledge related to CC(U)S. Gassnova also serves as the adviser to the government on this issue and has been tasked with administrating the research and financing programme CLIMIT, and with ensuring the testing and developing of CC(U)S technologies at the Technology Centre Mongstad (TCM). CLIMIT and TCM are key elements for the realisation of Europe's first industrial-scale project for carbon capture and storage, Longship CCS. CLIMIT was set up in 2005 by the Norwegian Ministry of Petroleum and Energy, to support the development of CC(U)S technology for gas power plants. The scheme was expanded in 2008 to include power generation based on all fossil fuels, and in 2010 industrial emissions were included. CLIMIT's primary objective is to contribute to the development of technology and solutions for CC(U)S by providing financial support to projects that will: develop knowledge, expertise, technology and solutions that can contribute towards cost reductions and international deployment of CC(U)S.

Test Centre Mongstad (TCM) is the world's largest test centre for developing CO_2 capture technologies, and a leading competence centre for carbon capture. TCM was established to test, verify and demonstrate different technologies related to cost-efficient and industrial-scale CO_2 capture, and also provides advisory services to carbon capture projects. TCM offers technology developers and project developers' opportunities to reduce technological and financial risk, by testing and verifying carbon capture technology ahead of full-scale application. TCM is owned by the Norwegian State, through

Gassnova (73.9%), together with the industrial partners Equinor (8.7%), Shell (8.7%) and Total (8.7%). Equinor is the operator of the facility.

Source: (Bakx, 2020[61]); (CCS Norway, 2022[62]).

1.2.8. Utilising CO_2

Carbon dioxide (CO_2) is a major contributor to climate change. However, CO_2 can also be a valuable input to a range of processes and products including the production of fuels, chemicals and building materials. Interest in this quality is reflected in increasing support from governments, industry and investors, with global private funding for CO_2 use start-ups reaching nearly USD 1 billion over the last decade (IEA, 2019[63]).

Utilisation processes are designed to convert CO_2 into higher-value products (e.g. fuels, plastics) or into stable products for long-term storage (e.g. concrete, minerals). CO_2 can also be used to produce methanol, which in turn, can be used to produce energy or as a component of automotive fuel (see also Pillar 3, Section 3.6). The fertiliser industry is the largest consumer of CO_2, with around 130 Mt CO_2 per year used in urea manufacturing. This is followed by the oil sector where 70-80 Mt CO_2 is used annually for enhanced oil recovery (EOR), which equates to around 5% of the total crude oil production in the United States. CO_2 is also used in the production of food and beverages, the fabrication of metal, in cooling, fire suppression and greenhouses to stimulate plant growth (IEA, 2019[63]); (Hepburn et al., 2019[64]).

While some technologies are still at an early stage of development, CO_2 use can support climate goals where the application is scalable, uses low-carbon energy and displaces a product with higher life-cycle emissions. However, CO_2 use does not necessarily reduce emissions, and quantifying climate benefits is a complex process, requiring a comprehensive life cycle assessment of its impacts as well as an understanding of market dynamics (IEA, 2019[63]); (Hepburn et al., 2019[64]).

Governments should consider prioritising the following actions:

- Ensure policy and investment decisions for CO_2 use applications are informed by robust life-cycle analysis that provides improved understanding and quantification of the climate benefits and risks associated with continuous reliance on fossil fuels (IEA, 2019[63]; Hepburn et al., 2019[64]).
- Identify opportunities for the use of CO_2 to create petrochemical products. For example, several companies have built pilot plants producing methane and methanol from CO_2 and hydrogen. Commercial production of CO_2-derived methanol and methane could be possible in markets where both low-cost renewable energy and CO_2 are available, such as Chile, Iceland and North Africa (IEA, 2019[63]).

Actions requiring international support in contexts where government capacity is low:

- Identify and enable early market opportunities for CO_2 use that are scalable, commercially feasible and can deliver emissions reductions. The use of CO_2 in building materials is one such opportunity as the CO_2 remains sequestered well beyond the lifespan of the infrastructure itself (IEA, 2019[63]); (Hepburn et al., 2019[64]).
- Consider introducing public procurement guidelines for low-carbon products. This can create an early market for CO_2-derived products with verifiable CO_2 emissions reductions, and promote innovation and investment (IEA, 2019[63]).
- Establish performance-based standards for products such as building materials, fuels and chemicals to facilitate the uptake of CO_2-derived alternatives (IEA, 2019[63]).

- Support research development and demonstration for future applications of CO_2 use that could play a role in a net-zero economy, including as a carbon source for aviation fuel – a sector that is difficult to decarbonise (IEA, 2019[63]; Hepburn et al., 2019[64]).
- Consider putting a price on carbon. Carbon pricing can act as an incentive to capture CO_2 and use it (or sell it for use) in the manufacture of products or services, provided this is the cheapest compliance strategy for the emitter. Carbon pricing of around USD 40 to USD 80 per tonne of CO_2, and increasing over time, may be sufficient to scale-up CO_2 utilisation (IEA, 2019[63]; Hepburn et al., 2019[64]).

What can the fossil fuel industry do?

- Undertake research, development and demonstration to test the climate benefits of CO_2 use applications, including chemicals and aviation fuels (Hepburn et al., 2019[64]).
- Consider using CO_2 for enhanced oil recovery in existing fields. Naturally, recoverable oil in a reservoir typically represents about 20% of the resource, but injecting CO_2 can stimulate additional production of up to 13%. Companies should evaluate which reservoirs may be suitable for CO_2 enhanced oil recovery (Ward, 2020[65]).

1.3. Addressing the technology gap

Extractive-based developing and emerging economies are confronted with a large technology gap, which needs to be addressed to avoid hampering their transition to a low-carbon future. According to the World Bank, low-income countries account for just 0.01% of low-carbon technology exports and 0.3% of imports, whereas between 2010 and 2015, high-income countries produced 80% of all low-carbon technology innovations (Pigato et al., 2020[66]). To ensure a just and equitable low-carbon transition, it is necessary for developing countries to have access to low-carbon technologies, based on technology transfer and innovation, capacity building, and finance so they can reap the benefits from a sustainable, resilient and inclusive recovery and integrate existing low-carbon value chains or create new regional ones.

Without targeted policy support and long-term financing, extractive-based developing and emerging economies will continue to face an investment preference for high-carbon technologies, given the capital sunk into pre-existing fossil fuel value chains and the high-carbon industries created around them (Pigato et al., 2020[66]).

However, extractive-based developing and emerging economies need to seize opportunities from the low-carbon technology sector, which would provide a new driver for sustainable economic growth and greener job creation. Getting policy, regulation and pricing right is crucial to a country's attractiveness for low-carbon finance and technology transfer.

1.3.1. Creating an enabling environment to incentivise the deployment of low-carbon technology

Governments should consider prioritising the following actions:

- Phase-out inefficient fossil fuel subsidies that hinder investments in new low-carbon technology, including by shifting public resources away from NOC spending on the highest-risk oil and gas projects (see also Pillar 3, Section 3.3.1).
- Consider the potential of a long-term commitment to carbon pricing to guide investment decisions taken by both public and private sector actors, and reduce the risks of stranded assets and stranded jobs (see also Pillar 3, Section 3.3.1).
- Consider the revenue potential of carbon pricing, to support domestic resource mobilisation efforts. Developing and emerging economies would be able to raise revenue equivalent to approximately

1% of GDP on average if they raised carbon rates on fossil fuels to a benchmark of EUR 30 per tonne of CO_2 (OECD, 2021[67]) (see also Pillar 3, Section 3.3.1).

- Reform fuel excise taxes to better align with the climate costs of fuel. Fuel-based carbon taxes are the most common form of carbon taxation in many countries. In countries that lack the administrative capacity to manage an emission trading system or a carbon tax, excise taxes that reflect the targeted price on carbon can be an effective policy instrument to make polluters pay for these externalities. In order to incentivise reduced emissions during production, fuel excise taxes would also have to be charged on the share of natural gas that oil and gas companies use for their own production process – to run generators, for use in refineries, etc. (see also Pillar 3, Section 3.3.1).

Actions requiring international support in contexts where government capacity is low:

- Build capacity to measure and monitor emissions and apply carbon pricing to analysis and decision making. Institutions that manage and operate in the upstream – including ministries of energy and power, upstream regulators and NOCs – can help manage emissions (Bradley, Lahn and Pye, 2018[1]).
- Use a carbon price in studies for public investment projects, including for environmental impact assessments, to ensure that the right decarbonisation incentives are in place.
- Consider providing public funding (grants, loans and concessional debt) to reduce the risks of basic research and demonstration projects, combined with tax credits for private involvement in low-carbon technology demonstration projects.
- Mitigate the distributional effects of tax reforms, ensuring that the poor will be able to access clean and affordable energy. Consider using part of the revenues from carbon price reform to meet social objectives (see also Pillar 3, Section 3.3.1).
- Consider the potential of carbon pricing to help tackle informality and lower the relative tax burden on the formal sector. Unlike many direct taxes, where firms and individuals can avoid taxation by operating in the informal economy, energy taxation and carbon taxes can be more difficult to avoid since even informal firms must buy energy from the formal sector.
- Ensure that carbon pricing does not generate unsustainable biofuel switching, which could lead to deforestation or is otherwise unsustainable. Implement and enforce policies that ensure the sustainability of biofuels, as outlined in Pillar 3, Section 3.2.4.

Trade policy

- Foster technology trade among countries, including through the reduction of tariffs to lower technology trade barriers and providing subsidies to encourage more technology trade.
- Consider the introduction of a differential tax treatment for the import of energy intensive equipment coupled with restrictions on the production of high-carbon products to guide the market and promote the development of local high value-added and low-carbon industries.

Energy policy

- Use NOC and government licensing and set procurement standards to steer the domestic market in low-carbon products and services. Set incentives for industry to meet emission targets, such as making licensing and procurement contingent on industry hitting such emissions targets.
- Establish the right price regimes to incentivise cleaner, more efficient practices, and gradually taxing higher-emissions fuels and use the revenues to invest in low-carbon development (including public goods), as discussed in Pillar 3, Section 3.3.

Fiscal policy

- Consider introducing wellhead carbon taxes to reduce emissions from oil and gas projects, as well as from coal mining. These taxes are collected from producers rather than consumers of fossil

fuels and unlike emissions-based carbon taxes, wellhead taxes are not rebated when fuel is exported. Hence, they generate a revenue stream for producing countries. Wellhead taxes also offer a possible alternative solution to carbon border adjustment taxes (Peszko et al., 2020[68]).

Box 1.13. Wellhead taxes, carbon pricing, and carbon border adjustment taxes

Wellhead taxes

As proposed by the World Bank, wellhead taxes can provide an alternative to carbon border adjustment taxes (CBATs). Wellhead taxes have not yet been tried out, but could become a relevant alternative if countries or trade blocks introduce CBATs.

The main differences between wellhead taxes, carbon taxes, and carbon border adjustment taxes is their placement along the energy value chain, and the distribution of the proceeds.

Wellhead taxes are collected from producers “at the wellhead”, so that consumers of fossil fuel products both in the producing and the importing country pay for the emissions associated with the extracted oil, gas or coal. Wellhead taxes shift the carbon tax base from importing countries, where a carbon tax would be levied on consumers of fossil fuel products, to exporting countries, where the wellhead tax is levied on producers. If the carbon price used to determine the wellhead tax is the same as the carbon price applied in the importing country, fossil fuel consumption will be equally costly in both countries. In its “extreme” version, the wellhead tax is collected from producers at the wellhead only, with all of the proceeds remaining in the exporting country. In more realistic versions, various revenue-sharing ratios would be bilaterally or multilaterally negotiated between fossil fuel exporters and importers through agreements on the harmonised tax rates. This can be calculated so that the exporting country retains (roughly) the share of wellhead taxes paid by its citizens, while the importing country would retain the share paid by consumers.

In principle, wellhead taxes can provide an incentive for industry and citizens to shift to renewable energy sources, which are not subject to this tax, However, as they are levied at a considerable distance from the end consumer, it can be hard for this instrument to change end consumer behaviour. Furthermore, since wellhead taxes are not levied directly on GHG emissions, they address only energy-related emissions. Wellhead taxes will therefore not provide incentives for curbing process emissions from industry. In cement production, for example, emissions resulting from chemical processes can be as much as 60% of total emissions. Wellhead taxes will also not address other non-energy related emissions, for example in agriculture. Thus, for non-energy related emissions, wellhead taxes would need to be complemented with other measures.

As an alternative to carbon pricing (carbon taxes or emissions trading schemes), wellhead taxes are easy to estimate and levy.

Carbon pricing

Carbon pricing differs from wellhead taxes in that it is a direct price on GHG emissions. This means that a carbon price, whether in the form of a carbon tax or an emissions trading scheme, can in principle be imposed on any type of emissions source, in any sector. The proceeds from carbon pricing, levied on consumers on fossil fuels, go in entirety to the country where the tax is levied. Compared to wellhead taxes, carbon pricing is more complex to administrate. At the firm level, carbon pricing requires capacity to measure and report emissions. At the government level, carbon pricing requires capacity to monitor and verify firms’ compliance and accuracy of reporting.

Carbon border adjustment taxes

Carbon border adjustment taxes, or mechanisms, consist in the importing country (or trade block) of imposing a carbon price on the imported product, based on an estimate of the emissions embedded in the product and the difference between the carbon price in the exporting and the importing country. The tax is paid at the border by the importers, and all of the revenues from the CBAT go to the importing country.

When a carbon price is imposed in the exporting and importing country, fossil fuel producers and other energy-intensive industries are charged for their emissions in both countries. There is no need for a CBAT if the carbon price in the two countries is the same and is implemented equally efficiently in both countries. If the exporting country has a lower carbon price, companies in the importing country will lose competitiveness, necessitating a partial CBAT.

Source: (Peszko et al., 2020[68]).

1.3.2. Fostering sustainable technology transfer

Sustainable technology transfer is a multifaceted process that goes far beyond the transmission of technological hardware, and covers the transmission of knowledge, experience and skills to deploy, operate, maintain, adapt, improve and reproduce the transferred technology. It follows that technology transfer requires system-wide, process-driven thinking to foster a process of learning and interactive collaboration among different stakeholders (e.g. governments, private sector entities, financial institutions, non-governmental organisations (NGOs) and research/education institutions). The deployment and diffusion of new technologies will depend on countries' pre-existing technological capabilities, size of market and productive capital base, which underpin the large capital investments needed to produce and eventually exporting low-carbon technology, as well as the ability of countries and sectors to build new human, physical, institutional, organisational and financial capabilities, particularly for complex technology. The transfer of technology will also depend on: 1) the ability of technology providers and third-party organisations to identify impactful projects and suitable partners in host countries; 2) the creation by host governments of policy, regulatory, and legal frameworks that reduce risks and attract private and public investors; and 3) the ability of firms in host countries to understand, select, adapt and replicate viable technologies that are suited to domestic circumstances and needs (Pigato et al., 2020[66]).

While some recommendations are targeted at IOCs and NOCs, it is recognised that other players in the value chain (e.g. service companies, local companies) must be considered to identify broader opportunities to accelerate and implement sustainable technology transfer.

Bearing in mind that there are different types of NOCs (operators and non-operators) with different mandates, capabilities and resources, which will have a bearing on outcomes, governments should provide the necessary enabling conditions and long-term incentives to effectively promote sustainable technology transfer from IOCs to NOCs in order to reduce emissions and improve efficiency of upstream, midstream and downstream operations.

Governments should consider prioritising the following actions:

- Uphold good governance and the rule of law, and provide political stability through a predictable and transparent legal, regulatory and economic environment.
- Incorporate technology transfer obligations into contractual arrangements, such as licensing between business partners, joint ventures and co-operation agreements.
- Consider providing for a share of operational management and staff positions for the NOC, as the shareholding partner, in order to promote the development of both technical and managerial skills.

Capacity building is a key issue for technology transfer to recipient emerging and developing countries and their NOCs, and should be taken into account at an early stage in project planning, by providing for NOC management and staff positions in the cooperation project or joint venture.

Actions requiring international support in contexts where government capacity is low:

- Adopt a climate and emissions reduction strategy, including emissions reduction targets and caps. Where relevant, this should include natural gas and associated gas, in particular to provide clarity to investors and facilitate systemic and industry-wide solutions, as opposed to individual company or project approaches.
- Review existing legal instruments for the petroleum sector, including the introduction of obligations for operators to deploy industry best practices and best available technological solutions for decarbonising operations. For example, any field development plan should incorporate plans for decarbonising operations and managing the risk of stranded assets.
- Assess the available human, physical, financial, and organisational capital as well as the up-front costs of low-carbon technologies.
- Assess the need for complementary investment in infrastructure, such as pipelines for associated gas or storage, and power grids and transmission networks for effective renewable energy deployment.
- Provide fiscal incentives and fast-tracking decision-making processes, such as tax exemptions or subsidies, for investments in feasibility studies for low-carbon technology deployment, in order to de-risk investments.
- Share the costs and risks for technical and capital-intensive carbon reduction technologies by adopting a systemic approach that stimulates the creation of multiple partnerships across the value chain.
- Assess the readiness for a market for decarbonised products.

What can IOCs do?

- Identify opportunities for technology transfer that reflect the country context and proactively engage with government.
- Incorporate technology transfer into the design and implementation of projects.
- Consistently deploy best available technologies and practices in their operations across different countries, going beyond applicable regulatory requirements.
- Offer free carry equity to the NOC. Free carry equity allows capital constrained NOCs to deploy low-carbon technology that they may otherwise not be able to deploy. Due consideration should be given to increased exposure to risk of continuous reliance on fossil fuels, since the value of the carry will be drawn from the government take of revenues, potentially putting public capital at risk of stranding.

What can IOCs and NOCs do together?

- Ensure that projects generate acceptable returns for all parties and that risk/rewards sharing arrangements are reflected in the terms of the licence or production sharing agreement.
- Establish an IOC/NOC peer-to-peer learning process, whereby the most experienced NOCs and IOCs share insights around emissions management, carbon pricing and markets, and the integration of energy efficiency measures and renewable energy within the industry, as well as the reform of long-term commercial strategies and national mandates.
- Ensure management commitment within the IOCs and NOCs to drive technology transfer.
- Involve local energy companies, service providers and original equipment manufacturers (OEM) in the deployment of technology transfer solutions.

- Second NOC staff to more experienced NOCs or IOCs to familiarise themselves with low-carbon technologies.
- Share data on GHG emissions (e.g. methane and CO2) among IOCs and NOCs to enable appropriate deployment of technology.
- Channel technology transfer through joint ventures and leverage state participation as a conduit for transferring know-how and best practice among several operators.

What can development finance institutions do?

- Provide technical support for the development of an enabling regulatory framework for the uptake and transfer of low-carbon technologies.
- Fund pre-investment feasibility studies for low-carbon technology deployment to provide the basis for evidence-based investment decision making.
- Assist NOCs and their governments in negotiating contracts, including technology transfer and cost/risk-sharing clauses.
- Promote and finance technology transfer-related projects.
- Deploy guarantees to reduce the risk for private investors and attract private investments and commercial financing to support decarbonisation in developing countries. The guarantor agrees to pay part or the entire amount due on a loan, equity or other instrument in the event of non-payment by the obligor or loss of value in the case of investment. Such schemes provide risk mitigation with respect to obligations due from government and government-owned entities – such as NOCs to private investors.

Box 1.14. Fostering sustainable technology transfer in Nigeria: Putting associated gas to productive use

Background

In October 2020, the NNPC and Sterling Exploration and Energy Production Company (SEEPCO) signed an agreement for the development and commercialisation of gas from the Oil Mining Lease 143. The agreement on associated gas processing and commercialisation seeks to help reduce gas flaring and its environmental hazards, and to promote gas production and utilisation in the domestic market. NNPC had encouraged SEEPCO to monetise not only associated gas but also non-associated gas, but this was postponed until the joint development agreement could be signed.

Project structure

The gas processing plant is structured as a lease-to-own contract, with original equipment manufacturers (OEMs) providing full financing for the equipment. The main OEMs are Exterran and GCI, which between them provide the main components of the plant. Exterran provides the dehydration unit, the heat exchanger, the sub-cooling unit, and the mechanical refrigeration; GCI has delivered the compressors and generators, as well as the debutaniser, the de-methaniser, and de-propaniser.

The rate of down payment on OEM financing will be determined by the productivity of the plant and the price of natural gas. At current production and price levels, SEEPCO and NNPC expect to take joint ownership of the project within seven years after the project becomes fully operational in the second quarter of 2021. SEEPCO will then own 83% of the equity, whereas NNPC will own 17%, corresponding to its initial share of the project in the form of free carry. In return for the free carry, NNPC provides expertise and knowledge of the local Nigerian context. Among other things, NNPC took care of permitting and liaising with local and federal authorities, agreements with landowners, as well as communication with communities affected by the construction of installations and pipelines, and with

other local stakeholders. SEEPCO pays the land lease, and other expenses not directly related to the OEM equipment.

Knowledge transfer

NNPC and SEEPCO contemplated knowledge transfer from the start of project planning, and decided to embed knowledge transfer into the managerial structure of the processing plant. As such, the processing plant is staffed jointly by NNPC and SEEPCO managers and staff, with the general manager coming from SEEPCO, and three deputy managers distributed between NNPC (two deputy managers) and SEEPCO (one deputy manager). To determine training needs, SEEPCO conducted a SWOT analysis of NNPC and SEEPCO teams, based on nominations of candidates by each of the companies. One conclusion from the SWOT analysis was that neither of the two companies possessed the required profile for the general manager position, and a general manager was hired externally. Training was organised as a top-down exercise, with representatives from Exterran and GCI providing on-site as well as classroom training, for the SEEPCO general manager and the NNPC and SEEPCO deputy managers. The onsite training took NNPC and SEEPCO managers and staff through the project stages of commissioning and ramping up, to full productive capacity, over a period of about six months. The OEMs provided two different teams for the commissioning period and the operational period, respectively. At the plant, the OEM teams provided on-the-job training for the manager and three deputy managers. These 4 were in turn responsible for training 12 staff each, 10 of them local and 2 expatriates in each training group.

Exterran and GCI will maintain on-site staff for one year. NNPC, SEEPCO, Exterran, and GCI will then hold a two-way assessment to decide whether the joint NNPC-SEEPCO operational team is ready to take over plant operations, after operational and maintenance routines are well established among NNPC and SEEPCO staff. This will enable Exterran and GCI representatives to move offsite, permitting them to reduce their costs. There is no definitive deadline for OEMs to move off-site, and the consortium will undertake quarterly reviews to determine whether an extension of OEM on-site presence is necessary. SEEPCO and NNPC plan for a major capacity-building review in 2025, with intermediate annual reviews, and will take account of continuous technological developments in natural gas processing. SEEPCO and NNPC also have sought to further transparency and openness between themselves as partners, and to facilitate integration of NNPC and SEEPCO staff activities at the shared processing plant into a single operational structure.

Climate benefits

The climate benefits of the processing plant come from the avoidance of flaring, so that gas that would have been flared can now be used for electricity production at a 1500 MW plant now under construction. Then remaining natural gas will be delivered to customers in gas-based industries, fertiliser production, and other commercial customers. As these customers would otherwise have used non-associated gas, the total emissions resulting from gas delivered to these customers is reduced.

Whereas carbon capture and storage for CO_2 resulting from natural gas processing could be contemplated in the future, this option has not yet been considered.

Transfer technology lessons

Transfer technology lessons from the NNPC-SEEPCO case study include:

- **Transparency:** private oil companies gain from being transparent about their emissions with governments, NOCs, and other partners. In the case of SEEPCO, gas that SEEPCO vented and flared was identified by NNPC as a business opportunity for capturing, producing and selling not only associated gas, but also non-associated gas.

- **Partner knowledge and experience:** it is important to work with partners that have the required capacity. Capacity development can go both ways – from IOC to NOC, but also from NOC to IOC or independent producers. This is particularly the case where the NOC is a large and well-established company with a broad set of competencies, and the private counterpart is a smaller company with a narrower set of capabilities. In this case, NNPC helped SEEPCO enter the midstream space.
- **Commercial mind set:** it is important to design well-functioning business models across the natural gas value chain, with functional partnerships along each level of the chain.
- **Bringing in regulators early:** collaborative arrangements need to involve regulators in the process at an early stage. Early attention to regulatory issues is likely to reduce regulatory compliance costs at later stages, and cumulative compliance costs throughout the lifecycle of the project.
- **Customer base:** off-take agreements must be ready when the plant starts producing.

Source: Adapted from the interventions by NNPC and SEEPCO to the Sixteenth Plenary Meeting of the Policy Dialogue on Natural Resource-based Development on 1 July 2021.

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Pillar 2 Sustainable fossil fuel exit strategies and just transition plans

This Pillar provides guidance on a managed phase down/out of fossil fuels and delivery of a just transition for affected communities, industries, and regions. It focuses on identifying and understanding transition risks and developing strategies to respond to them, structuring dialogue mechanisms between government, employers and employees as well as wider stakeholder engagement to define equitable strategies for the phase-down/out of fossil fuels, and offsetting negative impacts through the roll out of social protection schemes and labour market policies. Pillar 2 also outlines strategies to ensure any new fossil fuel infrastructure is transition ready, enabling repurposing for low-carbon re-use to avoid risks of high-carbon lock-in and stranded assets. It also provides guidance to support fossil fuel-based developing countries close the financing gap, including through mechanisms to de-risk green projects, developing a pipeline of robust and investible low-carbon projects, and innovative mechanisms to raise finance for the low-carbon transition.

2.1. Understanding transition risks

Fossil fuel producer emerging and developing economies are among the most vulnerable to risks arising from the low-carbon transition. Many face severe fiscal and economic contractions as a result of the COVID-19 pandemic, have high poverty levels, and are already finding the simultaneous requirements of investing in debt servicing, health service provision and decarbonisation immensely challenging. Fossil fuel producer countries are likely to be increasingly vulnerable to transition risks depending on the carbon intensity of their economies, the importance of fossil fuel exports to macroeconomic stability and government revenue, and the role of subsidised fossil fuels or cheap access to fossil fuels in keeping basic products and services affordable for poorer households. For many fossil fuel producer developing countries, delivering universal access to affordable, reliable electricity and clean forms of fuel remains a central priority to achieve inclusive economic growth, and will depend on their resource endowments and availability of renewable sources of energy.

The low-carbon transition presents a range of opportunities for fossil fuel producers to build more inclusive, resilient economies which work better for their citizens. Diversification away from fossil fuels can promote macroeconomic stability, reducing import dependency on petroleum products and reliance on volatile commodity prices. Transition to green forms of energy and other low-carbon sectors also offers the chance to create jobs, build new value chains that are integrated into the global economy and with more value added retained locally, stimulate the non-fossil fuel private sector, broaden the tax base and create a healthier environment with less air pollution and reduced public healthcare costs.

However, taking advantage of these opportunities entails careful management of a range of interconnected transition risks, which could undermine the low-carbon transition, and requires building support among citizens to minimise socio-economic disruptions. Fossil fuel producer economies will need to find a way to generate revenues to invest in alternative low-carbon sectors for the long term, while continuing to pay for imports and service debts in the meantime. This will need to be done in the face of projected declining global demand for fossil fuels and the likely adoption of stricter import conditions requiring the abatement of fossil fuels emissions, potentially constraining market access. Amid declining revenue, increased price volatility and devaluation of fossil fuel assets, governments will have to walk a delicate balance between generating revenue and investing in non-fossil fuel sectors including enabling access to affordable and ready capital for investment in low-carbon projects. Meanwhile, they are likely to need to adjust their balance of trade. Challenges will surround whether or how much to invest in the fossil fuels sector while in transition and how to limit stranded assets.

The low-carbon transition also requires strong investment growth in mineral supplies to keep up with the pace of demand. The IEA estimates that to hit net-zero globally by 2050, six times more mineral inputs will be required in 2040 than today (IEA, 2021[1]). Clean energy technologies, like electric vehicles, solar panels and wind turbines, rely on the supply of critical minerals such as copper, graphite, lithium, nickel, cobalt and rare earth elements. Factors such as the high geographical concentration of production, long project development lead times, declining resource quality, growing scrutiny of environmental and social performance, the potential for substitution and high exposure to climate risks will affect the availability and reliability of supply of critical minerals used for clean energy technologies.

Box 2.1. Critical minerals: Managing risks and capitalising on opportunities

Uncertainties around the supply of critical minerals represent a central threat to achievement of the global low-carbon transition. Metals including cobalt, copper, graphite, iron ore, lead, lithium, nickel, manganese, platinum, rare earth metals (including cadmium, molybdenum, neodymium and indium), silver, steel, titanium and zinc, are key to manufacturing technology that is core to the low-carbon transition, such as solar and wind facilities and battery storage. Many critical mineral value chains are likely to undergo transformational growth in the coming decades as the low-carbon transition gathers pace, representing an important opportunity for developing countries to capitalise on their resource endowments (AfDB, 2022[2]).

Critical minerals markets are relatively small, and extraction and processing facilities are unevenly spread across the world. The overwhelming majority of rare earth metals, for instance, are currently sourced from and processed in China. This raises the possibility that supply chain disruptions and fluctuations in prices could slow down the low-carbon transition. This is a concern both for developed and developing countries whose transition plans will be equally reliant on sourcing critical minerals.

For many emerging and developing economies, unexploited reserves of critical minerals could present a transformational opportunity to take advantage of growing demand for commodities, underpinning economic development and financing the low-carbon transition. For example, Argentina, Brazil, Chile, and Peru, are well positioned in terms of copper, iron ore, silver, lithium, nickel, magnesium and zinc, while many countries in Africa have significant reserves of platinum, manganese, chromium and bauxite.

However, taking advantage of these opportunities can be fraught with risk. Investments in extraction and processing can be significant in terms of upfront capital costs, and with long project development timelines – sometimes up to ten years – with no direct incomes for mining companies. The fact that many critical minerals are frequently extracted as by-products means that extraction at scale is often challenging. Profound uncertainty as to what the future make-up of the global energy mix will look like also adds to risk. For instance, a sudden technological breakthrough could reduce demand for certain critical minerals. An example of this might be the discovery of a cheaper alternative to lithium for batteries, potentially leading to wasted investments and stranded assets. In fact, significant substitution potential already exists. For example, battery cathode materials can be adjusted to reduce cobalt use and copper use cabling can be replaced with aluminium. Moreover, identification of “winning” critical minerals will also be contingent on trade-offs in the global energy mix, for example the balance between solar and wind generation. Notwithstanding positive demand projections, it is unclear whether these will translate into sustained high prices and revenue flows. This will depend on supply and demand forces, which are highly elastic and therefore may well result in a first-mover’s advantage. Against this backdrop, it is important that governments make their critical minerals sectors responsive and attractive by providing infrastructure and a sound regulatory environment.

In addition, ongoing efforts to increase the recycling of critical minerals from waste electrical and electronic equipment (i.e. urban mining) might reduce pressure on future primary supply demand, while eliminating waste from electrical and electronic equipment (WEEE) and creating additional employment opportunities. Efficient life cycle management and the recycling of waste into secondary critical raw materials facilitates maintenance of the value of products, materials and resources for as long as possible in the economy, while minimising the generation of waste. The average global end-of-life rate of recycle (EOL-RR) of many metals is in many cases far lower than their potential for re-use. Notwithstanding, current recycling deficiencies, the IEA estimates that by 2040, critical minerals recycled from clean energy technology waste (e.g. batteries and wind turbines) could reduce primary supply demand for copper, lithium, nickel and cobalt by around 10%. However, estimates of expected

recycled quantities of critical minerals are somewhat uncertain and are contingent on several factors. The future amount of recycling will depend on governmental regulation and investment in smarter product design to stimulate recycling activities. It will also be necessary to deploy new recycling technologies and practices for energy transition metals and develop the ability to recover materials stored in complex and diluted waste streams

Lastly, current extraction of many critical minerals is often associated with human rights abuses, environmental degradation and transparency issues. Direct and indirect impacts on land use including deforestation with hazardous legacies, have all been historical aspects of mining that still affect many countries today and merit serious reconsideration of policies and practice. Processing of magnesium and lithium is very energy intensive and can contribute significantly in terms of a country's GHG emissions, while waste elements from thorium and mercury are hazardous and can be hard to dispose of safely.

Given these uncertainties and risks, emerging and developing economies should carefully monitor recycling trends and factor these in when considering potential opportunities, build partnerships with consuming countries to ensure responsible sourcing practices, and shape sustainable supply chains from extraction to waste management (see Pillar 3, Section 3.2.3).

Source: (IEA, 2021[1]; World Bank Group, 2017[3]); (Tercero Espinoza et al., 2020[4]); (Sykes et al., 2016[5]); (Gielen, 2021[6]); (UNEP, 2013[7]); (Bradley, 2020[8]).

The political economy of fossil fuel-based economies can also entail transition risks, with vested interests interfering with the progress of policy reform. Governance structure is often concentrated around the presidency, the ministry of energy/resources and state-owned enterprises. All areas of government involvement, including policy design, licensing, regulation, enforcement, commercial participation, tax administration, management and spending of revenues present major corruption risks, and many fossil fuel-producer countries have limited capacity to mitigate and prevent corrupt practices. Corruption can distort governance decisions and undermine economic performance. Consequently, there is a risk that fossil fuel-producer countries may become trapped in resource dependence as corruption and rent-seeking behaviour are key disincentives for these countries to transition to a low-carbon economy (OECD, 2015[9]).

Moreover, fossil fuel subsidies, whose elimination is key to decarbonisation, are seen in many producer countries as underpinning the social contract between the state and its citizens. Plans to eliminate them, without adequate support measures can face resistance and lead to civil unrest. In general, mitigating the negative impacts of the low-carbon transition on poorer households, for example, by providing compensation or exemptions when prices go up, also represents a significant transition risk, and if managed poorly, can lead to widespread opposition to low-carbon policies, which could derail decarbonisation plans and inclusive economic growth.

Misaligned incentives, given mismatches in timing between the high short-term costs of diversifying away from fossil fuels and profitability of continuing to invest in established industries and sectors, and the long-term benefits of systemic decarbonisation, exacerbate transition risks. There are no quick fixes to overcoming these tensions. Doing so will require governments to provide short-term benefits for citizens, while mitigating negative impacts on poorer households, and, at the same time, articulating a compelling long-term vision of the benefits of decarbonisation which can outlast election cycles and changes in government administrations.

Geopolitical tensions and energy security concerns can also exacerbate transition risks, resulting in considerable volatility and supply disruptions in energy markets, as well as disruptions in minerals and metals supply with implications for the deployment of low-carbon technologies. Periodic shortages in crude, refined products and gas supply could lead to higher and more volatile prices, which could undermine the progress of the transition if people believe ambitious transition policies will affect energy affordability and

security. Additionally, the likelihood that global production will be concentrated in fewer hands could increase transition risks, giving greater geopolitical influence to a few number of petro-states with low-cost, low-carbon production in the medium term. Similarly, the concentration of capacity to cheaply manufacture components for new technologies in few countries could stall progress of the transition if their supply is interrupted, as could concentration of production of low-carbon fuels, such as hydrogen and ammonia, in fewer countries, with important knock-on effects in hard-to-abate sectors.

Further risks may arise in the renewable energy sector. Investment in renewable energy is forecasted to grow significantly as countries seek to meet their commitments under the Paris Agreement. IRENA's Roadmap on Global Energy Transformation forecasts that the share of renewable energy in the power sector will increase from 25% in 2017 to 85% by 2050 – mostly through growth in solar and wind power generation (IRENA, 2018[10]). This investment will come at a significant cost, and according to the IEA, to reach net-zero emissions by 2050, global clean energy investment will need to more than triple to around USD 4 trillion per year by 2030 (IEA, 2021[11]).

The significant scaling up of renewable energy investment can create opportunities for corruption, and these risks are likely to be higher in developing and emerging economies due to local conditions of corruption and instability (Rahman, 2020[12]). These risks include the oversight role played by governments, discretionary decision-making power, government subsidies, the issuance of green certificates, and access to national power and distribution grids. For example, the scaling up of renewable energy may be incentivised by feed-in tariffs to provide investors with guaranteed sales through power purchase agreements (PPAs), and corruption risks may occur in the selection of investors for these projects. Wind energy projects require rights to access public or private land, and these processes often involve discretionary power for government officials and politicians. Lastly, specific corruption risks may arise in jurisdictions where state-owned enterprises (SOEs) have a role in renewable energy generation as either a provider or regulator.

Inflationary risk looms large over the low-carbon transition, exacerbated by disruptions caused by the pandemic, Russia's invasion of Ukraine and soaring commodity prices. Developing countries will be hit hardest by these shocks, particularly those which are dependent on imports of crude, refined products and natural gas. Given that food and fuel make up a higher proportion of household income in developing countries than in advanced economies, the impact of sharply increasing prices will be acute. Rampant inflation will also have negative implications for the cost of finance in developing countries, with low-carbon projects on the margins of economic viability likely to be squeezed out.

Meanwhile, tackling low energy access rates will require governments to reflect on options to overcome intermittency and absorption capacity issues. These include striking the right balance between on-grid and off-grid solutions; assessing the need for complementary investment in infrastructure, power grids and transmission networks for effective renewable energy deployment at scale; and evaluating demand for pipelines for associated gas or storage, where appropriate, and other basic infrastructure to digitalise payment collection from consumers. Governments should also reflect on implications deriving from the changing landscape of energy generation and distribution, with more demand-side and passive (storage) solutions (as opposed to supply-side solutions), which call into question the need for constant power supply to ensure energy security and reliability.

For many fossil fuel producer emerging and developing countries, navigating such risks will require substantial investment in raising technical and institutional capacity across multiple layers of government. Transition risks tend to be interconnected, hard to predict, and if left unaddressed, can spiral out of control. For example, public protests against fossil fuel subsidy reform can generate widespread scepticism of climate policies, which undermines the progress of the transition. As such, governments need to build new mechanisms that are innovative and flexible, and which allow them to deal with the substantial uncertainty accompanying the low-carbon transition.

Governments should consider prioritising the following actions:

- Consider stress testing approaches at a macro, sectoral and micro-level to improve management of transition risks. Stress testing can be used to model impact and likely consequences of sudden technological developments, supply chain issues or the introduction of new policies. This approach consists of a variety of useful techniques to help governments understand the implications of unexpected shocks and put in place contingency plans to mitigate any negative impacts. The Netherlands has run stress testing against technological and policy risks and provides a useful blueprint for approaching this process (Vermeulen et al., 2018[13]).
- Consider taking an integrated and centralised approach to transition risk management, by setting up an agency or commission to be responsible for the identification, assessment and management of risks and co-ordination of national planning responses. In some countries, this role might be undertaken by a centralised government body, for example, a prime minister's office, with a broad mandate across government.
- Provide for multi-stakeholder consultation prior to policy changes and allow adequate time for those affected to prepare for changes before enactment. Unexpected policy changes are a key source of transition risks, and consulting with affected companies and citizens to understand how they will be impacted and devising potential mitigation measures can help to reduce adverse impacts.
- Consider economic diversification at the earliest possible opportunity and take an integrated approach to transition planning. This should incorporate short- and long-term diversification of products and exports, for example, through development of green hydrogen, linking them with NDCs and long-term decarbonisation targets, such as net-zero targets, just transition plans and dialogues. It is also key to integrate economic diversification plans with programmes to improve energy efficiency and promote investments in renewable energy, in parallel to establishing criteria based on pricing and emissions targets to guide the necessary retirement of fossil fuel assets (See Pillar 3, Section 3.2).
- Undertake a cross-government capacity needs assessment, identifying capacity gaps and possible solutions to achieve the low-carbon transition. Needs assessments should take place at national, subnational, sectoral, regional and institutional level, and also seek to identify weaknesses in co-ordination between government institutions, with the end objective of developing approaches to close gaps. The United Nations Paris Climate Change Committee on Capacity Building provides a step-by-step toolkit for governments to go about undertaking capacity gap assessments across a range of sectors and institutions, with illustrative case studies and guidance on developing strategies to address gaps (PCCB, 2022[14]).

Actions requiring international support in contexts where government capacity is low:

- Strengthen ministry, utility and regulator capacity in power sector design, regulation and management, as key factors in mitigating energy security risks and making the right choices in terms of technology selection, expansion of electricity access and encouraging private investment in the power sector. Further priority capacity considerations relating to regulation investment attraction and management in the power sector are covered in Pillar 3, Section 3.4.
- Given the interconnected nature of transition risks, governments can aim to identify catalytic interventions, which can result in broader and long-lasting impacts (Collins, Florin and Sachs, 2021[15]).
- Undertake geological mapping to better understand critical minerals resource endowments. Many developing countries, particularly in Africa, lack geoscience data relating to resources. Geological mapping represents a key step in understanding opportunities to access global or build new regional critical minerals value chains (World Bank Group, 2017[3]).

Producing and consuming countries should:

- Increase collaboration in the research and development of technologies to ensure the global sustainable supply of critical minerals and sustainable supply chains, from extraction to waste management, in order to underpin a just low-carbon transition.
- Share experience on how to systematically identify, assess and mitigate transition risks, and determine best practice and lessons learned for emerging and developing countries to deal with uncertainties related to the low-carbon transition.
- Pursue policies and regulation that encourage recovery and processing of scrap material to reduce demand for primary supplies of critical minerals (Kettle and Wlazly, 2021[16]).

2.2. Just transition planning in fossil fuel-intensive sectors and regions

Keeping global temperatures within a 1.5 °C increase on pre-industrial times in line with the Paris Agreement will require the unprecedented global phase-down/out of fossil fuel production and consumption. Most studies agree that there will be net gains in employment created by the energy transition, but at a local level, communities and regions dependent on fossil fuel intensive industries will bear the brunt of job losses and their knock-on socio-economic impacts.

Coal mine and heavy industry closure in Europe and North America during the last 50 years has often resulted in regional economic decline, poverty and persistent legacies of marginalisation and grievance. Economic planning for industrial reconversion has largely failed to listen to those most affected and put in place measures to mitigate economic and social harm to communities and workers.

Governments need to safeguard the rights, protect the livelihoods and actively involve the most adversely affected communities and workers throughout the low-carbon transition (Rosemberg, 2017[17]). This is best achieved through a transparent and inclusive planning process. The process through which different interest groups are consulted and feed into policy formulation plays a critical role in determining whether a given approach to transition is considered “just” (Green and Gambhir, 2020[18]; Zinecker et al., 2018[19]).

Fossil fuel-producer developing countries face different challenges compared to advanced economies and will need to establish a transition pathway based on their national specific circumstances and understanding of risks. As opposed to advanced economies, the labour class is highly diverse and fractured, job losses are primarily induced in the informal sector, welfare is often underfunded or non-existent, state capacity is lower and economic development remains the highest priority (Chandra, 2020[20]).

There is no set template for how a transition should be planned and managed, especially in fossil fuel-based developing economies. Local conditions play an important role in defining which kinds of policies can best mitigate negative impacts on communities and workers.

Transition planning should be informed by territorial assessments to identify regions within a country that will be most negatively affected by the transition in terms of economic and social impacts. When it comes to identifying these regions, the eligibility criteria of the EU Just Transition Fund for EU member states to access transition finance offers potential guidance. The EU Just Transition Fund allocates funding to affected regions based on two criteria: expected job losses and expected transformation of production processes of carbon-intensive industrial facilities. These criteria are assessed through regional rates of employment in coal mining and GHG-intensive industries as well as regional rates of GHG emissions from industrial facilities (European Commission, 2020[21]).

Planning a just transition requires clear policy direction, effective co-ordination between multiple agencies and layers of governments, and strong technical capacity at all levels of government, as well as the adoption of an integrated approach. For example, at a national level, the labour ministry will need to lead

on design and implementation of social protection and labour market measures, while planning and finance ministries have a key role to play in terms of budget allocation. Regional and provincial government, particularly in countries such as China and India where there is substantial devolution of authority, may also be central protagonists in the planning process. In all contexts, local and municipal administrations, which will lead in the formulation and implementation of local labour market and economic regeneration programmes and are well placed to engage with local groups, should play an integral role, despite often lacking the capacity and resources to effectively deal with local structural transformation.

Where possible, governments should communicate early and clearly the deadline for achieving fossil fuel phase-out or incremental targets for their progressive phase-down, their intention to mitigate negative impacts on affected groups, and the mechanism through which social dialogue will take place (TRACER, 2020[22]).

Past industrial restructuring processes are instructive in providing a set of principles which can guide transition management, helping to build consensus, smooth implementation and ensure appropriate policies are selected to safeguard rights and livelihoods and promote green growth (Strambo, Aung and Atteridge, 2019[23]).

Tripartite social dialogue between the state, industry and worker representation, is a minimum requirement (Gambhir, Green and Pearson, 2018[24]; UNFCCC, 2016[25]; ILO, 2015[26]; Zinecker et al., 2018[19]; Harrahill and Douglas, 2019[27]). In parallel, wider stakeholder engagement should take into account the needs and views of communities affected by the low-carbon transition. Evidence suggests that transition processes which embrace genuine co-determination, in which worker and community groups have a meaningful influence in decision making, is a key success factor in generating buy-in for transition plans and smoothing implementation (Green and Gambhir, 2020[18]).

Given this complex array of stakeholders, many governments have taken the approach of establishing a dedicated just transition agency or commission to act as a high-level decision-making body, co-ordinating inputs from relevant government bodies, as well as external actors such as unions. Establishing clear roles and responsibilities within this structure is an important component of ensuring efficient co-ordination (Stanley et al., 2018[28]).

However, lack of strong technical capacity required for meaningful participation of community and worker groups, as well as local governments, represents a significant gap that needs to be considered when designing effective participatory governance arrangements (UNFCCC, 2016[25]; Strambo, Aung and Atteridge, 2019[23]). At the same time, there is concern that stakeholder consultation and consensus-building processes may slow down the speed of the low-carbon transition and lower ambitions. Some institutions overcome this concern by using ambition-raising scenarios to challenge current targets or to determine the preferred transition pathway that informs national energy plans (IRENA, 2021[29]).

Box 2.2. Weaker institutions, informal labour and fiscal constraints: The challenge of applying just transition best practice in developing country contexts

Overwhelmingly, just transition case studies are derived from wealthier, industrialised countries, particularly Australia, the EU, North American countries and the UK. Fossil fuel phase-out in these contexts, normally associated with broader reconversion and competitiveness trends, rather than climate change imperatives, has been fraught with challenges, in many cases, often failing to result in economic regeneration and employment creation.

In developing countries, the number of people dependent on fossil fuels for their livelihoods tends to be higher than in OECD countries, while government institutions are weaker and funding to invest in

affected communities is less available. In these contexts, safeguarding livelihoods and creating jobs in sectors not linked to fossil fuels is likely to be doubly challenging.

Some estimates, for example, put the number of people dependent on coal in India at between 10 million and 15 million. Many of these people work informally around coal mines and depend on the sector for their livelihoods, for example coal picking or artisanal coal mining for sale, or rely on coal pickings for fuel. In South Africa, the coal sector provides some 200 000 formal jobs, each supporting an estimated three dependents per job, not including informal workers around coal sites. Coal accounts for 88% of electricity generation, and generates billions of dollars in export revenue each year.

In many developing countries where unemployment levels are high, wages generally low, and there are no, or few social welfare protections, every job is doubly important in terms of the people it supports. This is particularly the case given that those impacted by climate change tend to be those who are most vulnerable. Moreover, the prevalence of informal labour means that the extent of those who will be adversely affected can be hard to ascertain.

Lessons learned from just transition case studies in the Global North can be instructive for developing countries facing the need to rapidly decarbonise. However, tailored advice and guidance, case studies and research that focuses on approaches that work in developing countries, and above all, finance, are key to supporting emerging and developing countries in managing the decarbonisation process in such a way that those affected are not pushed further into poverty and inequalities in society are not exacerbated.

Source: (Chandra, 2020[20]); (Strambo, Burton and Atteridge, 2019[30]; WRI, 2021[31]).

Allowing sufficient time for gradual and progressive change is important. Previous transitions, such as the phase-out of the coal and steel industries in Germany's Ruhr Valley, have taken more than a decade to negotiate and implement (Strambo, Aung and Atteridge, 2019[23]; EBRD, 2020[32]). The combination of multiple measures, including worker-focused policies (e.g. early retirement, relocation of workers to other jobs in the energy sector, and training and skills certification programmes), substantial state investment, empowerment of local actors through unions, forward-looking long-term structural policies, and the prioritisation of secondary and tertiary education led to the transformation of the region from dependence on fossil fuels to a knowledge and tourism-based economy.

As a testament to the relative success of Germany's Ruhr transition, the average annual growth rate of the region has been a modest, though positive 1.3%, unemployment has remained quite low, and mass outward migration and long-term economic decline have largely been avoided. In terms of employment, between 1961 and 2011, production industries, composed mainly of coal and steel, but also some other sectors, declined from 1 426 000 workers – about 62% of the region's workforce – to 496 000 workers by 2011, representing a loss of almost a million jobs. At the same time, jobs in the service sector grew from 876 000 to 1 824 000, meaning the overall number of jobs remained more or less the same (Taylor, 2015[33]; WRI, 2021[34]). However, on average, workers transitioning from the coal sector to the non-coal sector found jobs with lower pay and lower levels of job security (Haywood, Koch and Janser, 2021[35]).

Early planning can give workers and communities time to accept change, allow for social dialogue to take place, and enable companies to gradually reduce their workforce through retirement, attrition and recruitment freezes (Atteridge and Strambo, 2020[36]; EBRD, 2020[32]). Economic diversification and fostering growth in new, job-creating industries can take years to bear fruit, requiring the ability to adapt. Planning for the long term is therefore key to success. Any just transition plan needs to be sufficiently resilient to survive contextual changes, for example, transition to a new government administration following an election, as well as sufficiently adaptable to respond to changes in context or to be adjusted when they prove not to be working or ineffective (Popp, 2019[37]).

Governments should consider prioritising the following actions:

- Provide strong leadership on the necessity of fossil fuel phase-down/out, committing to a tripartite approach to achieving consensus. Seek to build cross-party consensus on just transition integrated planning, funding and appropriate policies, with the intention that measures and policies put in place to help workers and communities be sustained over multiple election cycles to avoid them failing or running out of funding.
- Commit to and communicate a schedule for coal, oil and gas gradual phase-down, and ultimately, phase out, establishing social dialogue and stakeholder engagement mechanisms to agree with worker, industry and community groups on just transition pathways.
- Communicate openly and transparently not only on the environmental and economic need to phase-down and ultimately phase out fossil fuels, and the associated negative effects on workers and communities, but also on the advantages and opportunities presented by the transition to a green economy. Avoid masking the negative impacts of the transition, and instead be open and honest with people about what the challenges are, and how they can be overcome. Avoid communicating about the need to phase-down fossil fuels in GHG emissions reduction terms only, focusing on other aspects of the transition to a more sustainable and greener economy, such as new more sustainable ways to access, produce and consume energy, the reduction in health risks and environmental hazards, and new employment opportunities.

Actions requiring international support in contexts where government capacity is low:

- Conduct territorial assessments to identify regions within a country that will be most negatively affected by the transition in terms of economic and social impacts.
- Strengthen the technical capacity of actors participating in just transition social dialogues and broader stakeholder engagement, particularly worker, community and local government representatives.

Development finance institutions should:

- Consider establishing a global Just Transition Fund, making finance available to support just transition planning and policy measures in developing countries, as well as the provision of technical assistance to build social dialogue mechanisms, and plan for and implement a just transition (ITUC, 2017[38]).
- Increase funding for just transition projects under dedicated climate finance funds.
- Establish a dedicated just transition technical forum where policy approaches, lessons learned and peer learning on a just transition can be discussed, encouraging governments and other actors to share their learning and understanding of what works in different contexts (ITUC, 2017[38]).
- Build on existing just transition case studies from developing countries, such as from the Climate Investment Funds (CIF, 2021[39]), and conduct additional ones in an effort to build a comprehensive body of just transition case studies tailored to the needs of developing countries, in order to guide governments embarking on the process.

2.2.1. Structuring social dialogue and stakeholder engagement mechanisms

Inclusive social dialogue and stakeholder engagement mechanisms offer effective means to build consensus around available policy options and to identify acceptable pathways to a just transition, which can be agreed on by governments, unions, industries and community groups. Many governments have taken the approach of establishing just transition commissions or agencies to manage the social dialogue process and to co-ordinate inputs from government and external actors. The mandates of these bodies vary depending on local conditions and government objectives. However, regardless of scope, evidence suggests that social dialogues which are genuinely predicated on principles of tripartism and co-

determination are more likely to result in successful consensus building and ultimately lasting outcomes for affected communities and workers (UNFCCC, 2016[25]; Zinecker et al., 2018[19]; ILO, 2015[26]).

Stakeholder mapping is an important part of the social dialogue planning process. Governments should recognise that policy responses are likely to be more sustainable and implementable when there is substantive local input in the planning process, particularly from local administration and civil society stakeholders. Where this is more challenging, for example, if dialogue is national in focus, governments must decide how decision making and planning will cascade down to local authorities (Popp, 2019[37]). Spain's recent system of signing region-specific Just Transition Agreements provides a good practice example (see Box 2.2) (Government of Spain, 2019[40]).

Governments should also consider how involved they will be in the social dialogue process. Some have established a commission's mandate and then removed themselves from proceedings, as in the case of the German Coal Commission, while others have decided to play a leading role in discussions and policy formulation - a model followed by South Africa's National Planning Commission (NPC).

Establishing governance arrangements, timeframes and processes, as well as levels of representation for participants, is equally important in the design of social dialogue mechanisms. Governments should transparently map out the processes for arriving at recommendations, being clear as to the level of influence participants will have on final decision making, for example, through voting rights or discretion of commission chairs, and how results from the process will be approved and implemented by the government.

Some social dialogue processes have been criticised for allowing policy dialogue to recommend just one set of outcomes, rather than multiple policy responses, ultimately constraining government options when it comes to selecting transition pathways.

The scope and number of participants can also have an important bearing on the ability of social dialogues to come up with clear and actionable recommendations. South Africa's Social Partner Dialogue for a Just Transition, led by the National Planning Commission (NPC), for example, has involved broad-based consultations with local and national actors on a range of complex topics, such as distributional justice and the nexus of land use, water and energy. This has stimulated significant discussion as to what a just transition means for South Africa, but has made it hard to draw out actionable recommendations based on which the country can begin to move away from a dependence on coal (Popp, 2019[37]; EBRD, 2020[32]).

Box 2.3. Lessons learned from three approaches to structuring social dialogue and stakeholder engagement mechanisms in the coal sector

The German Coal Commission

Established in 2018, the German Coal Commission convened 31 representatives from industry (5), trade unions (3), environmental associations (3), the scientific community (5) the energy sector (4), representatives of regional groups (7), government administration (1) and parliament (3) to agree a phase-out timetable for coal-fired power plants. The German government, which strongly prioritised consensus, tasked the Commission with negotiating a recommended phase-out date between participating groups, as well as investments in affected areas and compensation for operators of power plants. Each participant was given a vote, with the exemption of parliamentary representatives.

The German government provided the Commission with a clear mandate, but then stepped back from the process, and assigned an office attached to the Federal Ministry of Economics and Energy to support the achievement of negotiated outcomes. Between June 2018 and January 2019, the Commission held ten plenary meetings, with the first part of the period focusing on gathering inputs from experts, and the second focused on negotiating its final recommendations. These were presented

to the federal government in January 2019, having been approved almost unanimously by Commission participants at 27:1 (not including parliamentary representatives).

The Commission's recommendations included a phase-out of all coal by 2038, with a review in 2032 to ascertain whether a 2035 phase-out date would be feasible. They also recommended the closure of 12 GW out of 43 GW of coal capacity by 2022, a further reduction of 17 GW by 2030, EUR 40 billion in transition measures in lignite mining regions over a 20-year period and compensation for coal plant operators.

The German Coal Commission has been praised as an example of government bringing together representation from a broad set of actors to build consensus on challenging issues related to the transition.

However, it has also been criticised by environmental NGOs, who would have preferred a 2030 deadline, and argued that the phasing out of coal between 2035 and 2038 was not in line with Germany's commitments under the Paris Agreement and could potentially dissuade other countries from setting earlier phase-out dates. Critics also argue that by allowing the Commission to chart a recommended approach, rather than asking it to provide multiple phase-out options, the government was able to avoid taking a politically difficult decision in line with Germany's established climate commitments.

Critics further argue that tasking the Commission to negotiate agreements on multiple fronts – a final phase-out date, compensation for regions and compensation for coal power plant operators, among other elements – was a strategic mistake, because it encouraged participants to prioritise certain outcomes (postponing the phase-out date and higher levels of compensation) and to use other elements as bargaining chips, rather than considering the transition as a whole.

Presidential Climate Change Commission, South Africa

Dialogue on the just transition in South Africa has been underway since 2011, when the Congress of South African Trade Unions (COSATU) issued its Policy Framework on Climate Change. This framework called for the government to take a lead on addressing South Africa's GHG emissions while simultaneously addressing socio-economic issues, including the need to create green jobs and ensure universal access to electricity and clean water.

The National Planning Commission (NPC), which leads the just transition process has undertaken numerous consultations and assessments since 2011. A full chapter was included on the just transition in South Africa's National Development Plan in 2012, and the concept was referenced in its 2015 NDCs. In 2017, the government launched a National Employment Vulnerability Assessment (NEVA) to assess the employment impacts of reducing coal production and use in the power sector. In 2019, the NPC completed a Social Partner Dialogue on Pathways for a Just Transition, bringing together government, unions, civil society and industry. In December 2020, the government established the Presidential Climate Change Coordination Commission (P4C) to oversee the process.

However, despite strong government focus and engagement from labour unions, South Africa is still working to define an actionable just transition pathway. The challenges of transitioning away from coal are undoubtedly considerable. South Africa is the world's fifth biggest coal exporter, and the sector is therefore an important source of foreign currency. Coal accounts for 88% of electricity generation, and provides 200 000 jobs, representing about 1% of total formal employment, with each job estimated to support about three other people. Strong labour unions have legitimate concerns about the impact of energy transition on its members' livelihoods, and vested interests have also mobilised against change.

The South African just transition process has also struggled in other areas, due to lack of capacity to manage transition planning effectively. Moreover, the approach to social dialogue and broader stakeholder engagement has been very broad and high level, focusing on socio-economic challenges

in general and process. The Social Partner Dialogue on Pathways for a Just Transition generated consensus on high-level issues, such as the need for social dialogue, anti-corruption and participatory decision making, but produced few conclusions regarding actual measures and policies to enable and support a just transition for those most affected. The process has also failed to effectively involve subnational governments and other local organisations, particularly in the Province of Mpumalanga, where 80% of coal mining takes place, in order to define a practical route away from dependence on coal mining.

Spain's Just Transition Agreements

The Spanish government's approach to negotiating closure of its remaining coal mines between 2019 and 2020 has been praised as an example of an all-encompassing approach to just transition planning, and has been described by union leaders as a best practice model for a just coal transition. It also illustrates how government can take a national approach to the issue, while also dealing with regions to ensure policy responses are context-specific.

To comply with EU requirements to remove financial support from uncompetitive coal mines by 2018, the Spanish government negotiated a deal with employers and workers unions - Comisiones Obreras (CCOO), Unión General de los Trabajadores (UGT) and Unión Sindical Obrera (USO) – and the coal-mining association – Federación Nacional de Empresarios de Minas de Carbón (Carbounión), – for a EUR 250 million package to cover investments in coal-mining regions over a ten-year period. This covered a range of policy measures, including early retirement, active labour market measures including upskilling and use of existing skills for environmental rehabilitation planning, and local investment.

In February 2019, the government introduced the Integrated National Energy and Climate Plan (2021-2030). Building on national-level agreements with unions, it negotiated regional-level Just Transition Agreements with the involvement of as many stakeholders as possible, including local authorities, companies, business organisations, schools, universities, NGOs, environmental associations and other interest groups, and involved local-level impact assessments and employment trends. The Just Transition Agreement for Asturias, for example, where 550 jobs are expected to be lost, has involved consultations with 67 representative groups across councils and local authorities, regional governments, employer organisations, unions, businesses, environmental organisations, and education and research institutions.

Just Transition Agreements include roadmaps and just transition calendars, as well as detailed monitoring and evaluation indicators, for example, number of jobs created or businesses supported. A Just Transition Institute has also been created to support the drafting of Just Transition Agreements, and the Public Employment Service's Occupations Observatory has been tasked with undertaking regular analyses on employment trends and job creation opportunities.

Source: (Litz, Graichen and Peter, 2019[41]); (Taylor and Makszimov, 2021[42]); (Reitzenstein and Popp, 2019[43]; Robins and Rydge, 2019[44]); (COSATU, 2011[45]; WRI, 2021[46]); (Burton, Caetano and McCall, 2018[47]; Strambo, Burton and Atteridge, 2019[30]); (EBRD, 2020[32]); (Government of Spain, 2019[40]; WRI, 2021[31]).

Governments should consider prioritising the following actions:

- Consider establishing a just transition commission to co-ordinate structured dialogue between government, industry, worker representatives and community groups, to build cross-sectoral consensus around fossil fuel phase-down/-out schedules, and possible pathways to ensure the transition is just, leaving no one behind.
- Commit to genuine co-determination and tripartism in social dialogue processes.
- Map relevant sub-national government, industry, worker and community actors who should be involved in the tripartite decision-making process, as well as community groups (including

Indigenous and identified vulnerable groups) who should be consulted through parallel stakeholder engagement processes. Recognise that failing to properly involve relevant actors in the policy-making process in a meaningful way will undermine the transition and its acceptance by local governments as well as worker and community groups.

- When establishing a just transition commission, consider carefully its mandate, scope, and how results of social dialogue and parallel stakeholder engagement will feed into just transition planning and be communicated with stakeholders, in line with success factors outlined in Box 2.3. Governments should consider how recommendations from a just transition commission feed into and complement its transition plans, for example, negotiating phase-down/-out schedules, offering options for different transition pathways for governments to choose from and providing options for policy responses.
- In designing just transition commissions, social dialogue and stakeholder engagement mechanisms, undertake a political economy analysis to identify challenges, obstacles and opportunities (Zinecker et al., 2018[19]).
- Define with participating groups how recommendations from the consultation process will be incorporated into just transition planning.
- Consider how agreements and recommendations emerging from the just transition commission or dialogue can be made binding, for example, through signing just transition agreements between unions or worker representative groups, industry and government, or through legislation.
- If establishing national-level social dialogue and stakeholder engagement mechanisms, consider how recommendations can be cascaded to local regions to ensure policies reflect context-specific conditions.

Subnational governments should consider prioritising the following actions:

- Develop a communication strategy to ensure that local communities and workers understand the social dialogue and stakeholder engagement processes, the differences between the two, how results will be used and how they can contribute to the process.
- Identify local actors to participate in the social dialogue and stakeholder engagement processes.
- Identify vulnerable groups and work to incorporate their interests and views into stakeholder engagement consultations.
- Participate in local-level impact assessments and studies to ensure that analysis accurately captures local conditions, strengths and opportunities, and that local stakeholders feed into this process.

Civil society organisations and trade unions should:

- When operating at the local level, consider partnering with international civil society organisations (CSOs) to increase their capacity to participate in social dialogue and stakeholder engagement.
- Consider how to represent vulnerable people and groups in just transitions discussions, on the basis that local representation does not necessarily guarantee that vulnerable people will be safeguarded. Additional steps need to be taken to ensure these people's interests are represented in line with the recommendations included in Box 2.4.
- Work to publicise social dialogue and stakeholder engagement plans including how results will be used at a local level, ensuring that affected communities understand the process that is taking place, how it will affect them and how they can participate. Work to educate local groups about the issues at stake and collect their viewpoints and perspectives to feed into social dialogue and civic engagement processes.
- Leverage local know-how, networks and knowledge to ensure that impact assessments and analyses undertaken as part of the social dialogue and stakeholder engagement processes are

contextually accurate and represent local-level challenges affecting workers and communities. Impact assessments undertaken by non-local actors may not be sufficiently granular to represent local interests.

- Hold social dialogue and stakeholder engagement mechanisms to account, ensuring they abide by stated terms of reference and governance arrangements, and call for the publication of findings and recommendations at all stages.

Development finance institutions should:

- Provide technical assistance and guidance to governments to establish social dialogue and stakeholder engagement mechanisms, as well as mediation support.
- Provide technical assistance to non-governmental actors to increase their capacity to meaningfully participate in social dialogue and stakeholder engagement, particularly in terms of representing local groups.

Box 2.4. Success factors in establishing a just transition commission

There are three main ways to structure a just transition commission:

- Independent advisory councils provide evidence-based advice to inform policy formulation, and can also act as independent watchdogs monitoring government progress against stated objectives.
- Just transition commissions can also be housed in existing government departments, such as a Ministry of Planning. This can mean that just transition planning is closely integrated with broader government planning, as well as making it more likely that a commission has access to adequate resources. However, its close connection with the government can mean that its independence is sometimes perceived as having been compromised in the eyes of the public (even if this is not necessarily the case).
- Lastly, stakeholder engagement platforms can serve as a conduit for the viewpoints of citizens, industry, unions and other groups into the formulation of government plans and policies. If a just transition commission is structured as either an independent advisory council or as part of a government department, it is essential that a well-structured policy dialogue process also be set up.

In addition to the established mandate and purpose of a just transition commission, several other factors can be important in determining whether it has an impact:

- Establishing recurring and regular touch points and processes through which the commission can provide input into government policy formulation, in an iterative manner, is key to ensuring recommendations are not side-lined. Ideally, government would be required to formally respond to a commission's suggestions and recommendations, as is the case, for example, with the UK's Committee on Climate Change. This approach significantly increases influence over policy making.
- Commissions which have mixed representation comprising government and non-government representatives are more likely to be perceived as unbiased, and their recommendations considered as objective by stakeholders. This can help generate buy in and build consensus for potentially unpopular policies.
- Adequate resourcing makes a big difference in enabling a commission to effectively fulfil its function. The better resourced a commission, the greater its ability to provide evidence-based policy recommendations, and to hold government policies to account on in terms of progress made on policy implementation through undertaking in-depth evaluations of government action,

and effective engagement with stakeholders through well-designed communications campaigns.

- A commission's mandate should be clearly defined, including regular reporting cycles and a clearly articulated purpose and set of objectives.
- Structuring a voting system with an uneven number of total votes can avoid deadlock on important decision making.
- Lastly, visibility is important to generating public buy in for transition policies and pathways. Ensuring that a commission has an up-to-date website, available publications and a regular presence on social media can be an important success factor and can serve to promote accountability.

Source: (Evans and Duwe, 2021[48]).

2.2.2. Assessing impact in affected areas and designing a comprehensive policy response

Consideration of how fossil fuel phase-down/out will impact local areas and communities, including any associated unintended consequences, and the choice of policies and measures to mitigate them is one of the most challenging aspects of transition planning. This process should begin as soon as possible to enable the discussion and implementation of mitigation measures before lay-offs take place (TRACER, 2020[22]). Quantitative scenario modelling can be useful in determining timeframes and the location of job losses caused by fossil fuel phase-down/out, as well as job creation resulting from economic diversification and growth in new areas such as renewable energy (IRENA, 2021[29]; UNFCCC, 2016[25]; Zinecker et al., 2018[19]).

However, in developing countries where informality is high and data may not be readily available, a more granular and localised approach to impact assessments is needed. Qualitative methodologies, including use of surveys and interviews, should be used to build detailed pictures of the impact of closure at the local level to inform policy making. These methodologies should also be used to assess the extent of informal labour market coverage of social protection measures. In addition, impact assessments of the labour market should also extend direct employment to also consider informal, induced and indirect jobs, for instance, companies selling services to the households of coal miners, as well as the quality of jobs created in terms of income, security and working conditions (ILO, 2015[26]; UNFCCC, 2016[25]). The European Commission Joint Research Centre (JRC), for example, estimates that the coal, peat and oil shale production in the EU, employs more than 200 000 direct workers, with 140 000 indirectly related jobs also reliant on the industry (Mandras and Salotti, 2021[49]).

Impact assessments should also try to understand the extent and adequacy of existing social protection mechanisms, opportunities for economic regeneration based on local strengths, and environmental restoration requirements. In addition, political economy analysis represents a useful tool to identify potential roadblocks. Planning should also review existing regulations and sector-specific agreements, for example, labour regulations, to identify the existence of any factors that might hinder the transition process (Stanley et al., 2018[28]).

The OECD's Key Indicators of Informality based on Individuals and their Household (KIIbIH) database is available to support policy makers looking to address informality in the labour market and to expand social protection coverage. The KIIbIH database uses household survey data to provide comparable indicators and harmonised data on informal employment, and the well-being of informal workers and their dependents across 42 countries across North and sub-Saharan Africa, Eastern Europe and Central Asia, Asia and the Pacific, and Latin America and the Caribbean. Whereas other publicly available harmonised statistics on

workers in the informal economy only take into account the individual characteristics of the workers, the KIIbIH database uses household surveys to provide more comprehensive information on the socio-demographic and economic status of workers and their households.

Box 2.5. Safeguarding vulnerable groups and gender dimensions of the just transition: Leveraging opportunities to address inequalities through just transition plans

Safeguarding vulnerable groups

Safeguarding the livelihoods of and affording opportunities to vulnerable groups, such as people with disabilities, the elderly, indigenous communities, youth and migrant workers, is an important component of ensuring a just and equitable transition that leaves no one behind. Indeed, low-carbon transition plans should offer an opportunity to redress existing local injustices and inequalities.

Transition policies can affect vulnerable groups in a multitude of ways. This includes exclusion from benefits such as job opportunities arising from the transition, and increasing costs of goods and services such as transport and electricity bills owing to green policies.

Six key principles can assist governments and others involved in just transition planning processes to mitigate these negative impacts:

1. Take steps to identify vulnerable groups and do not assume that the mere establishment of a just transition commission or stakeholder engagement process means that these groups will be consulted and represented. Consider identifying local champions with which to work to ensure that these groups are identified, properly consulted and understand how to participate in consultations.
2. Tailor policy measures to ensure they cater to and can be accessed by vulnerable groups as well as women. This might, for example, necessitate childcare facilities so that women can participate in consultations or courses, running workshops in remote locations, or making materials relating to the transition accessible in other languages or through alternative formats.
3. Understand that green policies are likely to result in higher costs which disproportionately impact the most vulnerable and poorest. For example, green policies such as carbon pricing and cuts to fossil fuel subsidies can cause energy, fuel and transport prices to increase. These impacts can be mitigated through carefully designed mitigation measures, including cash transfers to vulnerable groups.
4. Ensure that policies are tailored to respond to the needs of women and vulnerable groups based on their inclusion in consultations. For example, active labour market policies might seek to increase the participation of women in the renewable energy workforce.
5. Establish monitoring and evaluations systems to assess the impact of policies on vulnerable groups and make changes to improve measures where policies are proving ineffective.
6. Empower marginalised stakeholders by establishing local-level platforms to formally engage with them and build their capacity to influence transition outcomes.

In 2022, the Extractive Industries Transparency Initiative (EITI) launched “Engaging communities in a just transition”, a two-year project funded by the Ford Foundation. The project aims to shed light on how the energy transition is impacting livelihoods in communities living near mining and energy projects, and seeks to amplify the voices of local stakeholders in public debate and policy discussions. The project is being implemented in Colombia, Ghana and Indonesia. The project also explores the obstacles that local communities face in accessing and using information on the mining and energy projects impacting their lives – including in relation to subnational revenue flows, community investments, and environmental and social impacts. The project will engage a broad range of

stakeholders through dialogues and capacity development training to identify the best means to ensure the interests of communities are better represented in the energy transition.

Mainstreaming gender in low-carbon transition planning

Women are disproportionately affected by climate change and environmental degradation, particularly in poorer and rural communities, where they are more likely to lack access to finance and resources, and decent work. They also bear the brunt of many of the physical impacts of climate change and environmental degradation. Women, for example, are more likely to die of indoor pollution than men, while also being more exposed to unsafe water and sanitation – all aspects which have been exacerbated by the COVID-19 pandemic – and highlighting the links between environmental degradation and well-being. The burden on women can also be significant during fossil fuel closure and can often leave them as the sole breadwinner in a household, doubling their burden on top of existing unpaid work such as child-care.

Despite playing prominent roles in climate and environmental activism, women are also underrepresented in decision-making roles on climate and the environment. Women also tend to be excluded from many of the opportunities and benefits that will accrue from the transition. Despite quality jobs being created in innovation and green energy, among other areas, women are often overrepresented in low-skilled, low-paid, assembly jobs. This is reinforced by the fact that many jobs created by the transition tend to require an educational background in STEM (science, technology, engineering and maths) subjects, in which women and girls are underrepresented. Women, for example, account for 15% of workers in technology development roles, 10% of employees in power generation and 8% in general engineering technology roles in OECD countries.

Key actions to mainstream gender in low-carbon transition planning include improving the availability of disaggregated data on the gender implications of the low-carbon transition in order to improve policy making, better integrate women into decision-making processes and leadership roles relating to the environment and the low-carbon transition and encourage women and girls' uptake of STEM subjects. Gender dimensions should also be mainstreamed into all climate and gender policy making, and considered at all stages, ensuring that women are adequately incorporated into consultation processes.

Source: (CSIS and CIF, 2021[50]); (EITI, 2022[51]); (OECD, 2021[52]).

Based on these assessments, policy formulation should aim to balance reactive (social protection, compensation and environmental restoration) measures, with proactive (active labour market and economic regeneration measures) approaches. The policy response should be context specific, and policy options should be discussed and negotiated through the social dialogue and stakeholder engagement mechanisms established for the just transition.

Strong technical capacity and resourcing of local and municipal government is needed throughout the planning and implementation process. This is key to undertaking civic engagement with local groups, developing financing plans for affected regions, and developing proposals to capture funding for just transition measures. Just transition policies which are accepted by worker and community groups should be designed from the local level up, and local government must play a central role in this process. Efficient administration and delivery of social protection and active labour market measures are also key to retaining community trust in the transition process. Peer-to-peer engagement between local government actors can facilitate lessons learned, and national or regional government and international development partners can set aside funding to raise local government capacity through technical assistance (Green and Gambhir, 2020[18]; TRACER, 2020[22]).

Affordability and securing funding sources should be prioritised throughout the planning process. Planners should work with ministries of planning and finance and other relevant bodies (e.g. the international

co-operation ministry to obtain international development assistance) to identify and secure funding. This might include allocating funds from the central budget, mobilising funding through green finance mechanisms such as just transition bonds, international financial assistance or applying to existing funds which allocate funding for the just transition. As discussed in Pillar 3, Section 3.3.1, carbon pricing offers the possibility of raising substantial revenues which can be used to finance just transition programmes and to ease impacts on workers (Botta, 2019[53]).

Regular and transparent communication with affected communities and groups is important to build trust and facilitate civic engagement. Poor communication between government and affected groups, as happened for instance during the closure of UK coal mines in the 1980s, can undermine social dialogue efforts and lead to conflict. Information campaigns can help to reduce misinformation and provide those affected with means to participate in dialogue. At a minimum, information campaigns should avoid overpromising, should communicate the intent to provide social protection and labour market support, and outline the approach to social dialogue (Stanley et al., 2018[28]).

Lastly, just transition planning should also look to establish monitoring and evaluation mechanisms, enabling transparent assessment of whether just transition policies are working or not. Results indicators should be publicly available, and where possible, inform adjustment of measures to improve performance.

Box 2.6. Impact assessments: The importance of going beyond quantitative approaches and building a granular picture of impact at a local level

Understanding the impact of fossil fuel phase-down/out on employment and livelihoods, particularly in developing country contexts, requires a multidimensional approach to labour market analysis and impact assessments.

Traditional approaches to labour market analysis struggle to accommodate the large-scale informality so prevalent across fossil fuel industries in developing countries, particularly in coal mining. In India, for example, formal, direct employment in coal mining through Coal India, accounts for a relatively small proportion of total employment in the coal sector. Other data, such as average age of fossil fuel employees – a key factor in assessing the potential for early retirement schemes in just transition planning – can also be hard to come by in many cases, pointing to a need for an alternative approach to impact assessment in the context of the transition.

Failure to understand and account for informal employment, as well as the role such jobs play in supporting households and communities, can result in gross miscalculations as to the impact of fossil fuel phase-down/out, as well as misguided development of policies that do not take into account the full impact of closure.

These issues, as well as the heterogeneity of fossil fuel regions, point to the need for a blended approach to impact assessment, mixing traditional quantitative approaches with qualitative methodology. This should draw on region-specific knowledge, interviews and surveys, and should leverage networks of CSOs and NGOs which know communities well to paint a picture of local conditions that fully captures the impact fossil fuel phase-down/out will have on people's livelihoods

Source: (Chandra, 2020[20]).

Governments should consider prioritising the following actions:

- From an early stage, while setting clear policy direction on fossil fuel phase-down/out with timelines, communicate the intention to safeguard livelihoods through social protection and active labour market measures, and provide an outline of how social dialogue and parallel stakeholder

engagement will contribute to shaping a just transition away from fossil fuels. Recognise that it will take time to build consensus around just transition pathways.

- Map which national, regional and local government actors should be involved in the just transition planning process, considering how to effectively engage relevant departments and agencies on specific issues.
- Ensure relevant national-level ministries have clearly defined roles and responsibilities in formulating just transition plans. National governments should consider how these roles feed into the broader process of transition planning, including through the establishment of a just transition commission or agency. It is important that a broad range of public institutions and agencies are involved in the planning process, including those in charge of enhancing technical and scientific capabilities.
- Consider how to operationalise efficient communication and co-ordination between multiple layers of government involved in just transition planning, to avoid delays and ensure local initiatives can be allocated funding.
- Develop a stakeholder engagement strategy, outlining how it will work and engage with government and external actors, in terms of research and policy formulation, as well as social dialogue and stakeholder engagement to agree on just transition pathways for affected regions.
- Consider the scope and objectives of impact assessments on affected areas, ensuring analysis goes beyond quantitative analysis, utilising qualitative research tools, including interviews and surveys, to develop a granular picture of expected impact and differences at a local level.
- Ensure labour market impact assessments go beyond direct jobs, considering informal labour, indirect and induced jobs, and job quality in impacted areas. Impact assessments should also consider the socio-economic implications of unemployment on households.
- Undertake assessments of potential impacted areas and associated risks to enable broad-based policy making across multiple policy areas, including social protection measures, active labour market measures, economic regeneration and environmental restoration. Decide which government departments will be responsible for policy formulation in given areas and how this will interact with other policy options, and ensure the mechanism allows for a balanced approach to policy making blending both reactive and proactive measures.
- Throughout the planning process, consider how just transition policies and measures will be financed, balancing affordability and value for money. Involve closely planning and finance ministries in this process.
- Establish monitoring and evaluation mechanisms, ensuring lesson learning and sufficient adaptability to build on success and eliminate failures.

Actions requiring international support in contexts where government capacity is low:

- Incorporate into the planning process the mapping of industrial opportunities for workers throughout the value chain, including data relating to likely employment opportunities that can match labour supply and demand, as far as is possible.
- Consider where just transition policy measures should be uniform nationally, for example, setting early retirement thresholds or compensation rates for miners, and where locally driven solutions are preferable, for example, by developing approaches to environmental restoration.
- Consider alternative fundraising options to pay for the just transition, including carbon taxes and green finance. Work with central banks and finance sector regulators to establish frameworks to raise finance through mechanisms such as green bonds, as discussed in Pillar 2, Section 2.4.3.
- Explore with international development partners options for multilateral and bilateral funding to finance just transition measures, and to provide technical assistance to facilitate just transition planning and implementation.

- Consider establishing a national just transition fund to pool finance for just transition projects in affected areas, capitalised by carbon taxes to finance retooling, reskilling and reschooling programmes for affected workers, as well as contributing to a pension/dislocation fund for those that cannot be retrained.

Subnational governments should consider prioritising the following actions:

- Work with national and local government to undertake regional assessments to assess the impact of fossil fuel phase-down/out on employment and livelihoods.
- Consider how to improve availability of data on employment (often informal) and social protection in producing areas.
- Take a subnational or district-by-district approach to socio-economic impact assessment through surveys and interviews with local people, with the understanding that conditions in one district may be very different from neighbouring districts and, that it is important to develop as full a picture as possible of socio-economic conditions, and numbers and type of employment for the process of transition planning. This is particularly important to understand the extent of informality in labour markets and the differentiated impacts of fossil fuel phase-down/out on different people. Where possible, identify local CSOs that possess a strong granular knowledge of local areas and consider partnering with and funding them.
- Develop strategies to transparently communicate with worker and community groups on the transition. These should focus on providing accessible information (e.g. through radio, community leaders, etc.), publishing plans for the transition, outlining the parameters of the social dialogue and stakeholder engagement process, and conveying the government's intent to provide social protection and labour market policies to mitigate the impacts of fossil fuel closure.
- Seek to understand who are the most vulnerable among groups impacted by transition planning, and how the perspectives of these groups can be incorporated into policy making processes, ultimately with the intention of safeguarding their rights and livelihoods.
- Consider how best to provide inputs into regional economic planning and environmental restoration strategies, recognising that local governments are best placed to identify regional strengths and opportunities and to design projects which are best suited to community needs.

Actions requiring international support in contexts where government capacity is low:

- Review capacity and finance gaps in planning and implementation for just transition policies, focusing in particular on the capacity to undertake civic engagement, impact assessments, administration of social protection and labour measures, strategic planning and bidding for just transition funding.
- Consider allocating additional funding to involved local and municipal government agencies. Funding can be used to raise technical capacity through technical assistance in areas such as civic engagement, communication, undertaking research and analysis, and administration of social protection and labour market support mechanisms. Funding can also be allocated to pay for studies and strategy development, as well as for local administration to recruit staff to posts necessary for transition planning and implementation.
- Consider partnering with relevant universities who can provide capacity building to regional and local government on innovative research techniques to understand the granular impacts on localised areas.
- Strengthen government capacity to undertake monitoring and evaluation of progress against just transition plans. This is important to build consensus for the low-carbon transition and to ensure policy makers are accountable to the public. Whether a monitoring and evaluation function is embedded in government or within an independent watchdog, it must be well resourced and credibly independent, and its findings and recommendations should be readily accessible to the public.

Civil society organisations should:

- Participate in social dialogue and stakeholder engagement, ensuring the interests of vulnerable groups are integrated into discussions.
- Leverage local networks to ensure people in affected areas understand the social dialogue process taking place, the probable impact on their livelihoods and the scale of coming change. Help them to participate in the process and plan for the future.
- Take a lead on district/localised-level analysis of labour markets and community impacts, leveraging local knowledge, networks and connections to build an accurate picture of the local impact of closure to feed into social dialogue and policy making.
- Monitor the implementation of just transition strategies.
- Consider forming partnerships with international NGOs to strengthen capacity to assist local groups in participating in social dialogue related to the transition.

The fossil fuel industry should:

- Communicate early and transparently on closure, providing workers time to adjust and, where possible, find new employment.
- Plan to reduce the size of the workforce gradually in advance of closure through recruitment freezes and retirement to reduce the number of staff being made redundant at closure.
- Adjust/develop internal strategies to integrate climate risk, mobilise financial flows and influence boards to adopt just transition strategies and plans (Robins and Rydge, 2019[44]).
- Ensure that industry-delivered training plans for workers are tailored to local opportunities and conditions as well as the ambitions of individual employees. This might include, for instance, training programmes targeting skills necessary for employment in specific industries, such as renewable energy, or plans tailored to provide more general skills and competencies, such as management classes for micro, small and medium enterprises (MSMEs). These plans should be implemented in collaboration with local institutions, civil society and universities.

Development finance institutions should:

- Consider paying for or implementing regional or local-level impact assessments which take a granular, qualitative approach to understanding the impact of closure on local workers and communities.
- Provide technical and financial/funding assistance to national, regional and local governments, and educational and vocational training institutions on the planning, design and implementation of just transition measures.
- Support developing country governments to incorporate just transition plans into NDCs and long-term decarbonisation plans consistent with their low-carbon development strategies.

2.2.3. Promoting skills transferability and quality jobs through active labour market measures

The ILO estimates that 18 million net jobs will be created by 2030 and that 43 million renewable energy jobs will be needed by 2050 under a scenario aligned with the Paris Agreement. These include opportunities in the mining and renewable energy sector where growing demand for critical minerals could create new jobs for fossil fuel workers. Of all the jobs that will be created in the energy sector by 2030, some 13 million will be for medium-skilled workers (ILO, 2018[54]; IRENA & ILO, 2021[55]).[1] There is a big overlap between the skills utilised in fossil fuel sector jobs and those needed in renewable energy jobs, and in that regard, many new jobs created in the energy transition will be highly transferable with only minor upskilling and reskilling required.

However, challenges remain, as these jobs may not be created in the same region and may be characterised by a high degree of informality, a lack of collective bargaining and inadequate social protection measures. Additionally, the renewable energy sector will only be able to absorb some of the fossil fuel jobs eliminated by the low-carbon transition. Labour market planning, therefore, should put in place measures at the earliest possible opportunity to identify synergies and job profiles, and to leverage transferable skills across a range of both traditional and low-carbon sectors.

One of the major challenges that government will face when undergoing a low-carbon transition is how to enable workers in sunset industries to find new jobs and livelihoods. Fossil fuel industries may be significant direct or indirect employers at a local, regional and national level. Governments need to consider the labour mobility of their workforce in order to deliver a just transition, but also take steps to increase the portability of skills across the energy and other sectors of the economy. Some sets of skills and expertise from occupations in fossil fuel industries are applicable to careers in climate-friendly sectors as there are overlaps between conventional and renewable energy industries. Green industries can borrow from existing expertise; for example, the Norwegian solar cell industry was able to develop by drawing on familiar know-how, scientific knowledge and technology from the oil and gas sector – in particular from the process industry used in new petroleum fields. The skills of electrical engineers, electrical technicians, electricians and information technology specialists employed in operating fossil fuel power stations can all be adapted to operating renewable power plants (UNFCCC, 2016[25]).

Skills synergies between the offshore wind and offshore oil and gas industries can be utilised as both these industries use the same port facilities and have similar supply chains. Offshore oil platform engineers, for example, could potentially be deployed in the installation of offshore wind turbine foundations. Other transferable expertise includes surveying and offshore installation, the design and manufacturing of support structures, and large-scale installation and operation and the maintenance of offshore assets (IRENA, 2021[29]; Pinker, 2020[56]). There are also similarities in occupational profiles between oil and gas drilling and geothermal development (Gambhir, Green and Pearson, 2018[24]). In addition, oil and gas expertise is valuable in the development of CC(U)S projects. Many of the job opportunities that will arise in the CC(U)S sector will also be able to make use of the subsurface skills and experience of workers from the oil and gas sector. These opportunities include near-term employment needs associated with CO_2 storage exploration, as well as the more intensive phase of characterisation and development of new storage facilities (IEA, 2020[57]).

Similarly, expertise from the coal industry can be harnessed to support the low-carbon transition. Coal sector workers can find new opportunities in renewables, and recent years have seen many instances of targeted recruiting of coal miners for work in the solar and wind sectors (IRENA, 2021[29]). For example, thermal plant operation skills can be transferred to renewable plant operation, or an operations engineer in the coal industry could retrain to work as a manufacturing technician in the solar industry. In addition, explosive workers, ordinance handlers and blasters in the coal industry could capitalise on their technical safety experience and obtain additional training to become commercial solar technicians (Pearce, 2016[58]).

The needs of workers currently employed in hard-to-abate sectors, such as cement and steel, also need to be considered during the transition. While these sectors will experience fewer job losses than fossil fuels industries, workers will need to be provided with skills and training to adjust to new norms. Many will need support through the process of the transition, particularly younger workers who are often more vulnerable.

Governments should also consider the quality of jobs created through the low-carbon transition, including decent pay, respect for fundamental rights at work (including the effective right to organise and bargain collectively, gender equality and workplace democracy), decent working conditions and provision of social protection in line with the ILO's Decent Work Agenda (ILO, 2015[26]). Jobs in extractive industries are often high quality, and there is a risk that displaced workers will be moved into roles without adequate protections in place.

Labour market policies should also take into account informal workers dependent on fossil fuel industries, recognising their capacity to organise collectively and participate in social dialogue processes. It is important that labour market policies related to education and training, employment services, partnerships with educational institutions and relocation support, are joined up with robust social protection provision and effective public services, to support workers through retraining and reskilling, Meanwhile, universal social protection floors are needed to safeguard others who will be impacted by fossil fuel industry closure (EBRD, 2020[32]; Johnstone and Hielscher, 2017[59]).

Governments should consider prioritising the following actions:

- Undertake research to take stock of existing skillsets in the fossil fuels sector as well as expected job opportunities in the renewable energy and other low-carbon sectors and to better understand the impact of under-utilisation of skills on achieving a just transition (Scottish Government, 2021[60]).
- Ensure a cross-governmental approach to skills transfers by involving all relevant government departments in the planning process (ministries of energy/mining, industry, labour, finance, education, social welfare, etc.).
- Review certification and regulation to ensure they are fit for purpose and do not inhibit the transfer of employees to similar roles. For example, a certified offshore oil and gas worker may already meet many of the requirements for an offshore wind turbine worker (e.g. health and safety) without extensive additional training.
- Review regulatory frameworks and national policies governing labour standards and mechanisms for implementation to ensure jobs created through the low-carbon transition adhere to the standards defined by the ILO's Decent Work Agenda (ILO, 2022[61]).
- Link active labour market policies, such as training, reskilling and careers counselling, with social protection measures to ensure that workers have sufficient time and resources to retrain and are incentivised to look for new work. Workers who are nearer retirement age and for whom there is little point in reskilling will need to be provided with support until they can access a pension.

Actions requiring international support in contexts where government capacity is low:

- Build well-resourced, efficient and competent local employment services that can have a significant impact on facilitating fossil fuel workers to transfer into new roles.
- Invest in labour ministry capacity to undertake labour market assessments and modelling to underpin the design of active labour market policies as a key measure in identifying relevant skill-sets for re-skilling programmes to target.
- Following the identification of transferable skills, dedicate funds to the reorientation and reskilling of the workforce. For example, the Scottish government's Transition Training Fund offers grants for the retraining of oil and gas workers who have lost their jobs or are at risk of redundancy (IRENA, 2021[29]).
- Introduce incentives for industry to assist in reskilling workers through tenders and consenting processes. Tenders for renewables projects are often determined by price alone, but to support just transition outcomes, governments can include additional criteria in respect of wage levels, social protection benefits for employees, approach to rights at work and overall employment numbers (including gender breakdowns), alongside financial penalties for companies who fail to fulfil these requirements.
- Consider introducing gender requirements into public procurement to address gender inequality in the low-carbon transition. Currently, women are underrepresented in jobs in the energy sector. Access to training is essential to empowering women in the low-carbon sector, and universities and other training institutions can play a key role in training and preparing women to take on future positions.

- Consider including binding clauses in public procurement contracts to incentivise skills transfers from fossil fuel sectors to renewable energy sectors.
- Where regions face mass unemployment, as part of a broader package of measures, consider establishing an employment guarantee scheme which provides unemployed workers with a guaranteed number of paid days per year. This can provide support to poorer households while furthering socio-economic, climate or environment objectives. For example, India's Mahatma Gandhi National Rural Employment Act guarantees 100 days of work at a set rate for one member of poorer households. The scheme covers 70 million people, with a third of jobs reserved for women. Participants in the scheme work on water, environmental and climate adaptation projects (GIZ, 2019[62]).
- Where migrant workers are impacted by low-carbon transition policies, government to government collaboration may be necessary to limit the impacts of unemployment on foreign workers. The impacts of transition policies on migrant workers needs to be incorporated into impact assessments from an early stage.

Industry should:

- Consider re-deploying employees internally as well as funding or co-funding training programmes to support the re-deployment of workers, in instances where oil and gas companies diversify into broader energy companies. Electric utilities can retrain their coal-fired power plant workers for positions involving utility-scale solar farms (Pearce, 2016[58]). The transition may be smoother where companies support multi-skilling within their labour force as this gives workers greater flexibility to adapt to future changes in the labour market (Atteridge and Strambo, 2020[36]).
- Consider diversifying their core business model based on the existing skills of their employees. For example, when the oil sector began to decline in California in the 1990s, many local, offshore, oil-related firms adapted by diversifying into related sectors, such as scuba diving equipment, marine electronics, or sales and rental of environmental impact measurement tools. In Germany, following the decline of coal mining, heavy industry firms such as RAG and Thyssenkrupp developed new activities in related fields, including plant engineering, environmental technology and control services (Atteridge and Strambo, 2020[36]).

Governments, the fossil fuel industry, and educational institutions together should consider prioritising the following actions:

- Jointly identify solutions related to re-skilling in the context of the transition. By bringing these entities together, it would be possible to encourage the development of solutions well-tailored to the needs of the job market (industry), and provide tailored training solutions that match these needs (educational institutions) and are adequately resourced and funded (government and industry). Alignment between governments, industry and educational institutions, and information sharing regarding the evolution of the job market will enable more efficient interventions.

Actions requiring international support in contexts where government capacity is low:

- Create a detailed and publicly available database with labour market information pertaining to fossil fuel workers, such as skills profiles, demographics, locations and employers. This can serve as a baseline of labour market information, and can match supply and demand for skills by enabling workers to connect with potential new employment opportunities (ILO, 2016[63]; Pinker, 2020[56]). This database could be managed through an international organisation, or by government at the national level.
- Collaborate on training and re-skilling initiatives to maximise the existing skillsets of employees in the fossil fuel sectors and enable the transfer of those employees to new low-carbon sectors. For example, in New Zealand, a collaboration among various energy companies and Te Pūkenga, the New Zealand Institute of Skills and Technology, led to the development of an action plan to train

and upskill energy sector workers, to ensure that this highly skilled workforce is not vulnerable to labour market restructure as New Zealand transitions to a lower-emission economy (Energy Resources, 2021[64]).

- Consider employee transfers within the fossil fuels sector where appropriate. For example, following the closure of the Hazelwood Coal Fire Power Station and Mine in Victoria, Australia in 2017, the local authority set up a scheme whereby impacted workers could transfer to other power generators. The local authority provided early retirement packages to workers in those other power generators to create employment opportunities for impacted workers from the Hazelwood Coal Fire Power Station and Mine (Premier of Victoria, 2017[65]).

2.2.4. Mitigating negative impacts through universal social protection and compensation measures

Expanding basic social protection to all can mitigate the negative socio-economic impacts of the low-carbon transition, particularly in countries with high levels of informal labour. As part of a coherent policy package, supplementary social protection and compensation measures can be provided to fossil fuel workers to mitigate the short-term impacts of redundancy and support them to reskill and find new jobs.

Governments should work towards providing basic safeguards, including unemployment relief, a state pension and access to healthcare, for all citizens, regardless of historic employment contributions. The view that only advanced economies are able to provide universal social protection is misplaced. The UK had comparable GDP per capita to Botswana and Indonesia when it first introduced social protection. Recently, several emerging and developing economies, including Kenya, Namibia, Nepal and South Africa, have introduced tax-financed pensions, ensuring basic coverage for all citizens in old age (ILO, 2021[66]).

Fossil fuel producer governments need to identify new financing mechanisms to expand social protection and pay for effective public services, given the central role of fossil fuel revenue in financing such expenditure. According to the ILO, lower middle-income countries and low-income countries need to invest 5.1% and 15.9% of GDP per year, respectively, to close the financing gap on social protection. Short-term financing options include revenue recycling from carbon taxation, bond issuance and reallocating wasteful public expenditure.

Box 2.7. How can governments finance the expansion of social protection?

ILO Recommendation 202/2012 encourages governments to invest more and better to expand social protection to all citizens. Multiple options to achieve this goal:

- **Expanding social protection through benefits linked to employment-related contributions:** This can generate revenue and encourage the formalisation of informal workers. Additional non-contributory safeguards will be required for people who do not work. Long-term, blended contributory and non-contributory coverage is the best way to ensure a financially sustainable system.
- **Domestic revenue mobilisation through fiscal reorganisation (see Pillar 3, Section 3.3), and revenue mobilisation through new taxes such as a carbon tax or taxes on specific goods.** In Ghana, for instance, unions have called for a levy on gold, while Nigerian unions have called for a luxury goods tax to fund expansion of social protection floors.
- **Eliminating illicit financial flows:** targeting bribery, money laundering and tax evasion would free up substantial resources to finance social protection schemes.

- **Reallocating wasteful public expenditure to social protection:** Costa Rica and Thailand, for instance, have both redirected military spending to fund universal healthcare programmes.
- **Bond issuances to finance basic services and infrastructure:** For example, in 2017 Colombia issued a social impact bond. South Africa has issued municipal bonds to finance basic services and infrastructure.

Source: (ILO, 2021[66]).

Additional social protection packages may be provided to fossil fuel workers to provide financial support after redundancy. Financial packages should be agreed in advance of closure, and need to be negotiated between government, industry and unions through an established social dialogue process. Financial packages should also be integrated with labour market measures to motivate and support workers to re-skill and re-train and should not be a disincentive to looking for new jobs. Older workers who are near retirement age and for whom there is little point in reskilling can be provided with transition packages to support them to an age when they will qualify for a pension.

A strategy which emphasises high levels of compensation for workers without considering job creation and local regeneration, risks resulting in long-term economic decline, and potentially increases in societal issues such as apathy, alcoholism or migration. Spain's use of substantial voluntary redundancy and early retirement packages for workers affected by coal power plant closures in Asturias, for example, has led to outward migration from affected areas, as younger people seek opportunities elsewhere (Bridle et al., 2017[67]).

Box 2.8. **Spain's coal sector restructuring programme (1990**-2018): Prioritising early retirement and generous compensation measures

Faced with an uncompetitive coal mining sector and EU state aid rules which required the elimination of subsidies to coal, the Spanish government since the 1990s has implemented a number of coal mining restructuring plans. These have aimed to raise the competitiveness of the sector by reducing the workforce and closing some mines.

Through implementation of these plans, coal's share of primary energy production fell from 31% in 1990 to 4.7% in 2014. Employment in the sector has also reduced significantly, from about 32 000 jobs in 1993 to 3 715 in 2014.

In managing this restructuring process, the Spanish government has relied heavily on early retirement and voluntary redundancy compensation to encourage acceptance of its policies and to prevent economic decline in affected areas. Strong links between miners and powerful unions, such as Comisiones Obreras (CCOO), as well as union influence on Partido Socialista Obrero Español (PSOE), which governed Spain during much of the implementation period, have been credited with bringing compensation and early retirement to the forefront of negotiations. Generous compensation was a key condition for unions' acceptance of any job losses.

Eligible workers accepting voluntary redundancy received compensation of EUR 10 000, plus an additional amount for every year worked, with those suffering from Silicosis receiving an extra EUR 24 000. Early retirement for those eligible – workers over the age of 54 having worked more than ten years in the most recent iteration of the programme – has included 70% of gross wages for the previous six months worked.

Assessments as to the success of these policies have been mixed. The Spanish government's agreement to union demands for generous compensation measures has been credited with generating overall acceptance for policies that ultimately sought to drastically reduce the number of jobs in the coal industry.

It has also been seen as a major factor in maintaining the economic health of affected communities, given that spending by former mine workers did not fall substantially when unemployment hit.

However, across Spain, these policies have been criticised for being too expensive, with early retirement wages two to three times higher the national minimum wage. Moreover, they have largely failed to stem the flow of outward migration from affected areas, and social issues such as divorce, depression and alcoholism have risen in former mining communities.

Source: (del Río, 2017[68]; Bridle et al., 2017[67]).

Governments should consider prioritising the following actions:

- Recognise that a just and equitable, people-centred transition should be premised on universal basic social protection. Low-wage informal workers and their dependents will not be insulated from the negative impacts of the transition without universal social protection floors covering public pensions, healthcare and basic income security. This is key in contexts where there are large numbers of informal workers with no social protection provision and where individual workers on low wages often support multiple other dependents. Governments can set a target to provide universal basic social protection, regardless of historic employment contributions, and establish social protection standards in national legislation.
- Review the adequacy of existing social protection mechanisms and model the costs of expanding basic protections to all citizens, particularly public pensions, healthcare, unemployment relief and financial support to poor households.
- Identify new financing mechanisms to expand social protection measures, as outlined in Box 2.8. In the long term, social protection mechanisms need to be financially sustainable, and should look to blend contributory revenue from wealthier citizens with tax revenue.
- In legislation or social protection policy, make the link between climate change and social protection policies, ensuring that climate change is acknowledged and outlining how policies have been designed to deal with negative impacts.
- Prioritise the provision of effective public services, especially education, healthcare and public transport, as critical to achieving a people-centred transition that prioritises human capital and enables citizens to capitalise on new opportunities.
- Consider additional support packages for fossil fuel workers whose jobs will be eliminated by the low-carbon transition. Compensation packages should be defined in advance of closure through established social dialogue processes between government, industry and employee associations. It is crucial that financial support is integrated with active labour market policies, providing workers with the support they need to retrain, reskill and find new employment. Eligibility can be contingent on participation in schemes to find new work. Packages should not be so large to deter workers from re-entering the job market.
- For older workers who are unlikely to find new work, or for whom reskilling is not an option, consider transition packages which can support them to an age when they will qualify for a pension.
- Recognise that in many cases, informal workers unionise and are able to bargain effectively. They should be incorporated into discussions relating to provision of social protection packages in response to fossil fuel phase-down/out.
- Consider strategies to encourage the formalisation of artisanal and small-scale mining, including through uptake of good practices in extraction and ventilation, and training on health and safety.

Actions requiring international support in contexts where government capacity is low:

- Consider the practicalities of enrolling in social protection schemes to ensure effective coverage. Undertake communication and education campaigns to ensure people fully understand the eligibility requirements and know how to access benefits and services. Review system design and administration to simplify enrolment and access. Consider automatic enrolment.
- Consider the role of local governments in providing counselling, mental health support, employment and financial management guidance in areas affected by closure.
- Consider the broader social implications of fossil fuel phase-down/out on communities, for example, increases in cost of fuel or electricity. Devise approaches to offset these impacts on the poorest in society through cash handouts or exemptions.

Box 2.9. Takaful and Karama: Prioritising education and healthcare at a time of economic crisis in Egypt

From 2014, the Egyptian government embarked on an ambitious economic reform programme, involving refloating the currency, reducing fossil fuel subsidies and introducing a new value added tax (VAT). To mitigate the impact of these reforms on the country's poorest people, the government introduced two cash handout programmes with USD 400 million in World Bank funding.

Takaful, or Solidarity, is a conditional cash handout programme providing EGP 325 (approximately USD 20.50) per month to poor families. To receive the money, families have to demonstrate that their children between the ages of 6 and 18 have an 80% school attendance rate, as well as meeting other criteria, such as participation in nutrition awareness sessions and regular visits to health clinics for children under 6. Households are provided with extra support for additional children. Karama, or Dignity, is an unconditional cash transfer programme providing EGP 450 (about USD 28.60) per month to Egyptians over the age of 65, those with disabilities and orphans.

Takaful and Karama were developed in parallel with the government's economic reform programme on the basicprinciple that no Egyptian should be left worse off because of the necessity to undertake difficult macro-level reforms. The development of human capital, and the idea that the health and education of the country's young people should be prioritised despite the country's economic crisis, is also central to the design of Takaful.

Since 2014, 2.3 million households, equivalent to 10 million people, have benefitted from support through the two programmes, and the Egyptian government, with the assistance of the World Bank, recently introduced a new pilot programme, Forsa, or Opportunity, exploring options to get people off cash handout programmes and into work.

For developing countries considering the implications of fossil fuel phase-down/out on their poorest people and informal workers, this case study offers a useful model on how to approach the safeguarding of livelihoods and prioritise human capital alongside the necessity of economic restructuring, which would otherwise result in suffering and hardship among the poorest and most vulnerable.

Source: (World Bank Group, 2018[69]).

Subnational governments should consider prioritising the following actions:

- Consider how vulnerable groups will be impacted by the transition, consult with them and establish plans to safeguard their interests and livelihoods to avoid the just transition exacerbating existing inequalities.

- Assess social protection and compensation options, including costs and potentially negative impacts. Recognise that social protection and cash handouts can play a key role in sustaining livelihoods and local economies, particularly in areas where there are high levels of poverty, but understand that from a long-term perspective, social protection can lead to other problems and may not be sustainable from a finance point of view.
- Develop plans to understand the scale and implications of informality in the labour market and approaches to deal with this, including social protection mechanisms, such as cash handouts, which can be used to directly target the poorest and most vulnerable people.

2.3. Decommissioning and repurposing fossil fuel assets and infrastructure

Increasingly cost-competitive low-carbon technologies, energy security concerns and the acceleration of international climate policy will likely quicken the pace of fossil fuel phase-down/out to 2050. The number of fossil fuel-intensive assets reaching the end of their commercial lives earlier than anticipated could increase in a low-price scenario, and countries will need to bring forward decommissioning and retirement schedules to meet their GHG emissions targets. Failing to plan for a managed closure process poses significant environmental and financial risks for governments, including the possibility of stranded assets. Effective decommissioning planning and management, including opportunities for materials recycling and re-use, is also relevant for renewables infrastructure, particularly offshore wind turbines.

Repurposing can enable governments to capture value from ageing assets which would otherwise need decommissioning at high cost. It can also reduce the overall capital expenditure (CAPEX) requirements of the low-carbon transition by utilising existing infrastructure. Gas pipelines, for example, can be built or repurposed to transport CO_2 or hydrogen fuel, and oil and gas reservoirs can store sequestered CO_2 via CC(U)S. Coal-fired power plants can be converted to renewables generation, offering also ancillary services to stabilise the grid if combined with battery storage.

However, asset repurposing can be expensive, technically challenging and will only be viable in certain conditions. While exploring opportunities for repurposing, therefore, governments should also plan for the phased decommissioning of carbon-intensive assets in a way that is compatible with their long-term emissions reduction commitments. Key priorities include clarifying decommissioning liabilities in the oil and gas sector, and developing selection criteria through which to determine which carbon-intensive facilities should be retired and when. Throughout this process, regular and constructive engagement with industry, and robust environmental and socio-economic safeguards, will be critical in facilitating the gradual closure of high-emitting assets.

Box 2.10. The potential scale of stranded assets: A growing risk for fossil fuel-based economies

Analysis undertaken by the International Renewable Energy Agency (IRENA) provides two scenarios for understanding the future scale of fossil fuel asset stranding. A REmap scenario assumes the acceleration of renewable energy deployment from the date of publication of the report (2017) to 2050, and a delayed action scenario assumes policy action to accelerate the energy transition is delayed until 2030, but then accelerates to 2050.

IRENA's analysis estimates that the total value of stranded assets across the upstream energy, power generation, industry and buildings sectors will be USD 20 trillion under the delayed action scenario, compared with USD 10 trillion in the REmap scenario by 2050. This includes USD 7 trillion in the upstream energy sector under delayed action against USD 3 trillion under REmap. Power generation will see USD 1.9 trillion in stranded assets under the delayed action scenario, compared with

USD 0.9 trillion in the REmap. This is mainly attributed to continued investment in coal-fired power plants in developing countries through to 2030, which will then require stranding.

IRENA's report also notes large variance across countries and sectors In China and India, for example, power generation accounts for between 25% and 45% of stranded assets, reflecting their large reliance on coal-fired power generation and the relatively young age of their coal fleets. Meanwhile, Australia, Brazil, Canada, Indonesia, Mexico, Russia and South Africa will experience significant stranding of upstream assets, while the EU, Japan and US would see a high degree of stranded assets in the buildings sector.

Recent research calculated the risk ownership of 43 439 oil and gas production assets across 1.8 million companies worldwide, and showed that much of the losses from fossil fuel stranded assets would fall on private investors, particularly pension funds and financial markets mainly in OECD countries, as the ultimate owners of these assets. This means that advanced economies have an important stake in ensuring a well-managed phase-down in production in all countries across the world, as they could face significant financial market consequences or have to provide large bailouts to equity investors such as pension funds.

Source: (IRENA, 2017[70]; Semieniuk, Holden and Mercure, 2022[71]).

2.3.1. Managing accelerated decommissioning in the oil and gas sector

Oil and gas decommissioning is technically challenging, entailing significant environmental and safety risks, as well as costs that could run into billions of dollars. Many emerging and developing economies are relatively new oil and gas producers with limited experience in decommissioning. Gaps in regulatory frameworks, a lack of clarity over decommissioning liabilities, and weak government capacity and expertise to oversee the process, can present significant environmental, health and safety risks for oil and gas producer countries, as well as potentially severe economic consequences if decommissioning costs are passed to the taxpayer.

The low-carbon transition could accelerate the number of oil and gas projects requiring decommissioning over the next two decades, as demand for oil and gas is projected to decline in the medium to long term. Governments should prioritise addressing gaps in the regulatory framework, understanding the costs and schedule of decommissioning requirements, and clarifying decommissioning liabilities for all projects (Ogeer, 2022[72]). Otherwise, they risk being overwhelmed, particularly if their experience of decommissioning is limited.

The upstream decommissioning process is generally similar for onshore and offshore facilities, albeit with some key differences. Onshore decommissioning, involving plugging and capping wells, securing and dismantling facilities, recycling steel and land reclamation, is more straightforward and less expensive. However, the requirements are complicated by a need to co-ordinate with multiple local authorities, regional governments and environmental agencies, and the need to adhere to overlapping non-sector specific regulations. The default requirement for onshore decommissioning tends to be full removal of all oil and gas apparatus and land reclamation. Decommissioning of offshore facilities is altogether more complex, challenging and controversial, often involving vast fixed steel platforms, concrete gravity structures and floating production systems. Offshore decommissioning is governed by sector specific regulations, normally requiring operators to submit a Decommissioning Plan for approval. For both onshore and offshore decommissioning, well plugging and abandonment represents around 50% of the total cost. It is therefore crucial that onshore scrapping and recycling facilities are in place before any physical decommissioning takes place.

There has only been limited decommissioning of offshore pipelines around the world, and the process is often overlooked in regulations. Pipelines require flushing and cleaning, and available decommissioning options include removal, trenching, backfilling or remediation through rock cover. Key considerations include whether or not leaving a pipeline in situ will interfere with other users of the seabed, particularly fishing trawlers, and whether attempts to remove them would have adverse safety or environmental impacts given the structural integrity of the pipeline and water depth. Angola, for instance, requires the removal of all pipelines in water depths of less than 400 m, unless otherwise justified. Shore-based pipelines can present additional challenges owing to overlapping regulatory requirements and because they are more likely to interfere with other users of the seabed. Major pipelines connected to multiple projects can have complex owner-operator regimes. In this case, phased decommissioning may be required to account for staggered field depletion. Depending on national regulations, pipeline size, and whether they serve multiple fields and operators, pipeline decommissioning can be considered as part of its own decommissioning plan, or as part of that of a field (IOGP, 2021[73]).

The United Nations Convention on the Law of the Sea (UNCLOS II, 1982) and the International Maritime Organisation (IMO)'s Guidelines and Standards for Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone (EEZ), are the most widely used international standards for offshore decommissioning. In 2017, the International Standards Organisation (ISO) issued ISO16530-1: Petroleum and Natural Gas Industries Well Integrity - Part 1: Life Cycle Governance, which defines criteria for permanently abandoning a well.

From a national standpoint, Norway and the UK have the most advanced decommissioning requirements, given the scale at which decommissioning has taken place in the North Sea. Both follow a risk-based evaluation process requiring approval of a decommissioning plan by the relevant national regulator. Key steps include supporting studies incorporating recent environmental surveys and the technical feasibility of different decommissioning options, a comparative assessment of different options (though this may not always be required when removal is the preferred option) and an environmental appraisal. These documents support the development of the decommissioning plan, the layout and contents of which are defined in national guidelines, as well as a monitoring framework for after decommissioning takes place. Public consultations are considered key to the process. Most other countries which are in the process of developing decommissioning requirements are adopting a similar risk-based evaluation approach.

Box 2.11. Ring-fencing funding for decommissioning through financial assurance mechanisms, clarifying liability and adapting bankruptcy legislation

A key issue for governments is to clarify decommissioning liabilities and to secure the availability of required funds to avoid costs being transferred to taxpayers. Decommissioning costs should be considered at the design phase of a project, and several financial mechanisms are available to ensure funds for decommissioning are available at the end of a project's life:

- Parent company guarantee, where an operator's corporate parent guarantees the cost of decommissioning.
- Letter of credit, which is a form of third-party guarantee to cover decommissioning costs.
- Surety bond, consisting of a guarantee by a third party that assumes responsibility for payment if an operator cannot fulfil its payment obligations.
- Trust or escrow fund, whereby the operator is required to deposit cash into the fund at a predetermined rate, up to the full cost of decommissioning by the end of the project's life.
- Standby trust fund, only partially funded as a back up to a letter of credit or surety bond.

- Decommissioning Security Agreements (DSAs), where participants can agree to deposit cash, or another type of security, such as a letter of credit, into a trust to cover decommissioning costs, in case of overlapping liabilities.

However, financial assurance mechanisms have not been universally applied across all projects, with the attendant risk that costs will be borne by the taxpayer if an operator cannot fulfil payment obligations or disappears. Moreover, there is a lack of standardised guidance on how decommissioning costs should be calculated, resulting potentially in costs far in excess of the amount of funds ring fenced. Additionally, transfer of interests between entities can create confusion as to who is actually liable.

NOCs often face specific decommissioning issues. Countries using Production Sharing Contracts (PSCs) tend to be particularly vulnerable to lack of clarity around decommissioning liabilities. An asset is normally transferred to the state, usually the NOC, when the PSC expires on the basis that the asset will continue to produce. Many PSCs do not consider decommissioning liability, meaning that the NOC will eventually be left to cover the cost.

Increased oil price volatility has also made the operating environment more hostile for oil companies. Bankruptcies of companies with smaller balance sheets are likely to become more common, increasing the risk that decommissioning costs will be transferred to the state. The number of bankruptcies in the US and Canada, for instance, increased by 50% in 2019, and by a further 62% in 2020. Moreover, as international oil companies (IOCs) divest themselves of and sell oil assets to smaller players, this is likely to further increase the risk of bankruptcies.

These issues have led to an increase in orphaned wells, or abandoned oil and gas projects with no legally responsible entity, but with persisting environmental issues and ongoing decommissioning costs. In Alberta, Canada, the government raises a levy on existing operations to cover the decommissioning of orphaned wells to ensure the associated costs are not transferred to Albertans. Additionally, in April 2020, as part of its COVID-19 relief package, the Government of Canada committed to spending USD 1.7 billion to clean up abandoned and orphaned wells in Alberta, Saskatchewan and British Columbia. The programme was designed to support Canada's energy sector to maintain jobs, creating 5 200 in Alberta alone, as well as to support companies to avoid bankruptcy.

Financial assurance mechanisms can help governments guard against the risk of operators going bankrupt. In some cases, such as in the UK, regulators have sought to establish liability in perpetuity, meaning that if the existing operator cannot fulfil payment obligations, liability transfers up the chain to previous owners. However, this can risk acting as a disincentive to repurposing, as operators may be unwilling to hand over an asset if they will retain liability once it is repurposed. Additionally, adapting bankruptcy laws to ensure decommissioning is given priority creditor status can help governments recover as much of the decommissioning costs as possible when an operator goes bankrupt and there are no financial assurance mechanisms in place.

Source: (Ogeer, 2022[72]); (Anderson, 2020[74]).

Governments should consider prioritising the following actions:

- Develop an inventory of all wells, facilities and associated installations which will require decommissioning, including costs, timeframes and an assessment of each project's environmental and safety risks. This should include an analysis identifying projects that lack a liable entity, where liability is unclear (e.g. because of transfer of assets) or where the operator is at risk of bankruptcy. Governments can build a picture as to the potential scale of the decommissioning risk and a preliminary picture of decommissioning options for each asset. Based on this, they can begin to define solutions to financing gaps in partnership with industry (Ogeer, 2022[72]).

- Complete a diagnostic on the legal and regulatory framework to identify decommissioning gaps and weaknesses. Particular focus should be given to who has liability for decommissioning in different circumstances, for example, bankruptcy and asset transfer, including residual risks. In some countries, for example the UK, regulators have opted for liability in perpetuity to cover changes in asset circumstances (Ogeer, 2022[72]).
- Ensure the regulatory framework incorporates decommissioning requirements for oil and gas operations based on the principle of polluter pays (Ogeer, 2022[72]).
- Ensure the design of any new oil and gas projects includes high-level information on decommissioning, in particular on financial security to cover liabilities. Regulators should ensure well-formulated and costed decommissioning plans are developed during the production phase (Ogeer, 2022[72]).
- Ensure the government has access to full and credible data relating to environmental and safety risks and costs for decommissioning, allowing it to effectively evaluate decommissioning options for each asset (Ogeer, 2022[72]).
- Require operators to undertake ongoing environmental and data reporting throughout the life cycle of the project to ensure decommissioning costs and options are based on current information and have evolved based on changing project circumstances (Ogeer, 2022[72]).
- Clarify the kind of environmental monitoring that has to take place following decommissioning (groundwater, hydrocarbons presence, species diversity, etc.) based on risk assessment. Set requirements for implementation, including for the length and frequency of monitoring (Ogeer, 2022[72]).

Actions requiring international support in contexts where government capacity is low:

- Introduce financial assurance mechanisms to ensure taxpayers do not end up paying for decommissioning. These include parent company guarantees, letters of credit, surety bonds decommissioning trust funds/escrow funds, and Decommissioning Security Agreements (DSAs). Such mechanisms should cover the full amount of costs, and should be capable of accommodating transfer of assets to a new operator (Ogeer, 2022[72]).
- Regulatory approval of planned divestments and asset transfer to a new entity should ensure the financial mechanism or financial assurance covers decommissioning costs, including in event of bankruptcy. The financial capability of the buyer should be taken into account, including their ability to meet future decommissioning liabilities and their access to adequate financial security.
- Adapt bankruptcy legislation to ensure government decommissioning claims are treated with priority creditor status to maximise the amount of money that can be recouped in the event an operator goes bankrupt and adequate financial securities are not in place. Bankruptcy policy should also ensure that if the existing operator becomes insolvent, leading to the regulator calling upon a predecessor in the chain of title, financial liability for decommissioning is still retained by the insolvent company, even if the physical decommissioning is performed by the predecessor or a different party. Often companies restructure and emerge from bankruptcy, and under these circumstances they should reimburse the relevant party for the physical decommissioning work that was performed as a result of the existing operator's (temporary) default.
- Assess risks relating to temporary suspensions. In a low-price environment, it is likely operators will prefer to suspend production, rather than plug and abandon wells, given this represents 50% of the cost of the decommissioning process. However, this approach could risk the creation of large numbers of orphaned wells if a number of companies were to go bankrupt during the same period. Moreover, the longer a well is idle, the more likely it is that decommissioning will become more costly and unsafe. Governments can mitigate this risk by establishing a time limit for suspended wells, also referred to as the "idle iron" approach, whereby a requirement exists to remove installations and subsea infrastructure by a defined time following a cessation in production (Ogeer,

2022[72]). In California, for instance, a lease expires after six months if there is no pre-approved suspension of production. Decommissioning must take place within a year of the lease expiring.

- Put in place policies and rules requiring industry to estimate decommissioning costs and keep these regularly updated. This should include a requirement to provide underlying assumptions (Ogeer, 2022[72]). Governments can assist this process by producing guidance documentation in partnership with industry, outlining how to approach financial securities and calculate decommissioning costs, as well as general guidance to help companies comply with decommissioning legislation and regulations.
- Consider separating regulatory responsibilities for overseeing the environmental and safety aspects of decommissioning from oversight of financial security to avoid potential conflict of interest within regulatory bodies.
- Assess the capacity of the government agency responsible for overseeing decommissioning. Expertise in evaluating decommissioning options and ability to engage with industry is critical to ensuring environmental and safety risks are adequately managed and costs are not transferred to the taxpayer (Ogeer, 2022[72]).

Governments and the fossil fuel industry should consider prioritising the following actions:

- Work together to establish a standardised methodology to calculate costs of decommissioning. This will help to ensure a complete cost assessment, enable governments to compare costs between assets, benchmark costs, assess performance against actual costs and build confidence in cost estimates as the number of assets needing to be decommissioned increases (Ogeer, 2022[72]).
- Consider working together to establish a mechanism to cover the decommissioning costs of orphaned wells based on the polluter pays principle (Ogeer, 2022[72]).
- Establish an international dialogue on decommissioning in the oil and gas sector, bringing together industry and government stakeholders to share lessons learned and best practice, and to agree on a common set of principles and guidelines governing decommissioning in the light of increased risks posed by the low-carbon transition.

2.3.2. Repurposing oil and gas upstream and midstream infrastructure in support of industrial decarbonisation objectives

Integrating industrial decarbonisation planning with repurposing of oil and gas infrastructure can avoid large decommissioning costs, extend the life of assets for low-carbon re-use, create green jobs and foster low-carbon value chains. A cluster-based approach, which leverages effective spatial planning, can be used to integrate oil and gas transport systems with upstream facilities in relatively close proximity to industrial centres, utilising CC(U)S technology for sequestration of CO_2 in depleted offshore oil and gas reservoirs. Upstream oil and gas facilities or renewables installations, meanwhile, can be linked with hydrogen production facilities to produce blue or green hydrogen as feedstock for industry. Re-purposed midstream infrastructure can provide connections with industrial centres.

A recent study examined the potential for repurposing oil and gas pipeline infrastructure for hydrogen and CO_2 transport in EU countries. It concluded that a large proportion of both onshore and offshore pipelines (between 60% and 80%) could be repurposed at lower cost than building brand new infrastructure (Carbon Limits and DNV, 2021[75]).

A cluster-based approach to systems integration, which identifies the optimum combination of available technologies, can leverage economies of scale, contributing significantly to a country's overall decarbonisation objectives, while also reducing CAPEX requirements for new low-carbon infrastructure and maintaining part of the workforce as the oil and gas industry is gradually wound down. Moreover, systems integration can be built out in a modular fashion. This can enable fossil fuel producer developing

and emerging economies, which are largely dependent on fossil fuel revenues and with infrastructure already in place, to approach industrial decarbonisation in a managed way, gradually shifting from blue to green hydrogen in line with their need to monetise proven reserves, generate revenue, ensure an affordable and sustainable energy mix, and implement industrialisation plans.

Integrating oil and gas asset repurposing with industrial decarbonisation planning is technically challenging, and requires advanced integrated planning from a regulatory standpoint given overlapping onshore and offshore jurisdictions, and the diverse roles and skillsets of the entities involved (upstream and midstream operators, mandated gas and electricity transport operators, hydrogen off-takers, industries producing CO_2, and onshore and offshore regulators). Robust partnerships are needed to balance the allocation of costs and risks, and provide fiscal incentives to encourage industry participation. Additionally, clarifying decommissioning liabilities in the event of repurposing can encourage industry participation by reducing risks for oil and gas operators. Decoupling repurposing requirements from decommissioning regulations could also allow for repurposing to be considered at an earlier stage, enabling oil and gas operators to adjust technical specifications and field development plans to ensure that repurposing is feasible at the end of an asset's life.

Box 2.12. **The UK's cluster**-based industrial decarbonisation strategy

UK industrial sectors, including energy-intensive industries such as chemicals, glass, cement, fertiliser, oil refining, paper and pulp, iron and steel, employ more than 2.6 million people, and generate exports worth over GBP 300 billion. They also contribute 16% of CO_2 emissions. The UK's Department for Business, Energy and Industrial Strategy (BEIS) has established an industrial decarbonisation programme to reduce emissions from industry in line with its net zero by 2050 target. The strategy aims to develop four low-carbon clusters by 2030, and one net-zero cluster by 2050. Most of these will be in relatively deprived regions of the UK, including in the North East, the Humber, the North West, and in Scotland and Wales. The strategy is premised on industrial clusters where multiple industries are co-located, and where there are also available offshore oil and gas assets for CC(U)S, and oil and gas transport infrastructure for CO2 and hydrogen transport. BEIS aims to deploy CC(U)S in two industrial clusters by the mid-2020s, increasing to four by 2030, with the objective of capturing up to 10 Mt CO_2 per year.

As part of this strategy, BEIS is co-ordinating closely with industry and providing finance to encourage the development of low-carbon technology. This includes a GBP 1 billion CC(U)S Infrastructure Fund and a GBP 240 million Net Zero Hydrogen Fund which issue grant funding to CC(U)S and hydrogen production developments to cover early project costs and de-risk the early stages of development. The government is also working on a strategy to provide subsidies and revenue support to cluster-based businesses to help them switch to hydrogen fuels, given the associated costs. This is an important factor in building regional demand for hydrogen. The government expects to phase out subsidy support to businesses in the long term. It has also established a task force to streamline the planning process, as well as to work with industry to identify and resolve regulatory barriers to systems integration.

In October 2021, the Hynet North West project, which aims to decarbonise industrial centres in the North West of England and North Wales from 2025, was selected as one of two industrial clusters in Track One of the BEIS industrial decarbonisation programme. The project aims to reduce CO_2 emissions by 10 Mt CO_2 per year by 2030 through the development of facilities to produce, store and distribute hydrogen as feedstock for industry, and capture and store CO_2 produced by industry. The project combines building new infrastructure and upgrading and reusing existing infrastructure. This includes storage of CO_2 in depleted gas reservoirs under Liverpool Bay, for which Eni-UK has a CC(U)S licence, the use of existing gas transport infrastructure to transport CO_2 to storage sites, and the utilisation of salt reservoirs for hydrogen storage. New infrastructure includes the development of a

hydrogen transport network and the development of the UK's first low-carbon hydrogen production facility at Stanlow.

Advantages of the project include its relatively low cost, given the extensive use of existing infrastructure, its flexibility, given hydrogen production and CO2 storage can be expanded in line with demand, and the close proximity of depleted reservoirs for CO2 storage with substantial industrial centres. Hynet North West aims to create 6 000 direct jobs, as well as support a further 350 000 through maintaining industrial competitiveness. It also aims to generate GBP 17 billion for the local region by 2050 and deliver 80% of the UK's clean power target for transport, industry and housing by 2030.

- By 2025, during its initial phase, the project would reduce CO_2 emissions by over 1 million tonnes per year. Key milestones include direct capture of 400 000 tonnes of CO_2 from industrial sites, construction of a low-carbon hydrogen production facility capable of producing 3 TWh per year, the repurposing of existing natural gas pipelines for transport and storage of CO_2 up to 1 million tonnes per year in depleted gas reservoirs, and development of a new hydrogen pipeline network to supply blended gas and hydrogen (20%) to industry.
- Between 2027 and 2028, further CO2 emissions reduction of 3-4 million tonnes per year is envisaged through increasing hydrogen production capacity and supplying additional sites.
- By 2030, the project would reduce emissions by a further 10 million tonnes per annum through capture of an additional 1 million tonnes per year of CO_2 from industry, scaling up hydrogen production to 30 TWh per year, providing at least one major power station with 100% hydrogen, and decarbonising heavy transport including trains, heavy goods vehicles, buses and ships. By 2030, hydrogen storage of 1 TWh across the Cheshire salt basin is envisaged, as well as the development of a 350 km hydrogen pipeline network.

The project involves co-operation and partnership between multiple public and private bodies, each fulfilling a different role and bringing a different skillset to the table. On the private sector side, Eni-UK has the licence for CC(U)S; Cadent, the UK's largest gas network operator is developing the project's hydrogen network and Progressive Energy, a company specialised in CC(U)S and hydrogen production, is responsible for repurposing the CO_2 pipeline and development of the hydrogen production plant.

From a regulatory perspective, the project involves co-ordination between multiple institutions responsible for different aspects of the value chain. The UK's cluster-based industrial decarbonisation programme is managed by BEIS, which is also responsible for engaging with industry on the most efficient approach to hydrogen production and storage, and CO_2 capture. It also manages planning permissions for the project alongside local planning authorities. The Department for Transport is responsible for transport policy and can amend the existing Renewable Transport Fuel Obligation (RTFO) to enable hydrogen to be sold as vehicle fuel at a price comparable with petrol and diesel. The Crown Estate owns the UK seabed and has established a system to lease the seabed for transport and storage of CO_2. The Oil and Gas Authority (OGA) has an existing regime for CO_2 storage licensing. Meanwhile, the Health and Safety Executive (HSE) will regulate and oversee the safety of hydrogen distribution to homes and businesses, along with hydrogen storage and CO_2 transport. For hydrogen blending, this will be undertaken using the existing Gas Safety Management Regulations (GSMR), with the transport and storage of hydrogen and CO_2 governed by the existing Control of Major Accident Hazards (COMAH) regime.

Source: (Hynet, 2020[76]).

Repurposing oil and gas transport infrastructure for hydrogen and CO_2 transport

Governments should consider prioritising the following actions:

- Undertake an initial assessment of national pipeline infrastructure to determine potential for repurposing for hydrogen and CO_2 transport re-use. This should be based on criteria such as material composition, age, location and capacity. Transport infrastructure with re-use potential can be mapped against forecast supply (e.g. hydrogen and carbon), and potential storage sites and consumption centres.
- Based on a preliminary assessment, build a business case to compare the costs of re-purposing infrastructure with those of investing in new infrastructure. Assets with the highest conversion potential can form the object of feasibility studies and environmental impact assessments (EIAs).

Actions requiring international support in contexts where government capacity is low:

- Consider introducing environmental, and health and safety regulations to provide guidance on repurposing oil and gas transport infrastructure for hydrogen and CO_2 transport re-use. Safety standards of pipelines repurposed for hydrogen transport may require adjustments to account for the different physical and chemical properties of hydrogen, while the transportation of CO_2 offshore can be more complex due to the need transport CO_2as a liquid, which may require pipelines to be reinforced.

Repurposing depleted oil and gas reservoirs for CC(U)S

Actions requiring international support in contexts where government capacity is low:

- To guide development of a CC(U)S industry, consider developing a CC(U)S roadmap. This should include an assessment of national CC(U)S potential, development of a CO_2 storage atlas, CC(U)S pilot projects, and elaboration of an actionable strategy for commercial deployment of CC(U)S. The South African CCS Roadmap, which was formally adopted in 2012, provides a good model in this regard. It incorporates five phases to be completed over a period of 20 years: an assessment of CC(U)S potential, completion of CO_2 storage atlas, CO_2 test injection, CC(U)S demonstration and commercial CC(U)S application.
- Consider establishing an expert group to work with industry and lead consultations on potential options to incentivise CC(U)S development. Industry consultation can help to identify reservoirs which would be suitable for CC(U)S, as well as to identify potential regulatory barriers and financial models and incentives to make CC(U)S commercially viable.
- Require industry to undertake a technical assessment of whether an asset has potential for CC(U)S. All project and licence approvals should be contingent on assessment of potential for a reservoir to be repurposed for CC(U)S at the end of the project's life.
- Consider decoupling regulatory requirements for oil and gas infrastructure repurposing from decommissioning regulations. In most jurisdictions, potential repurposing options are only considered during the latter stages of the oil and gas cycle, by which point it may be too late to adjust technical specifications to facilitate re-use. Separating repurposing and decommissioning regulations would enable consideration of repurposing at an earlier stage. Governments should also clarify decommissioning liabilities in the event of repurposing.
- Consider introducing a clean break liability provision for repurposing oil and gas projects. If an asset is repurposed and subsequently operated by a new entity, it will be necessary to clarify who has the decommissioning liability for the facility. If the existing operator retains liability, they may be disincentivised to hand-over an asset for re-purposing.

- Consider introducing regulations to prevent selected oil and gas licences from expiring so they can be used for CC(U)S. Grandfathering licences in this way could streamline administration of CC(U)S licences, as projects would not need to go through a lengthy licence administration process.
- Ensure data relating to oil and gas reservoirs are stored centrally by government, given the risk that data could disappear if a company closes or goes bankrupt.
- Issue guidance on well plugging and abandonment to industry to ensure an option is left open for reservoirs to be used for CC(U)S.
- Consider the role of the shipping industry in the CO_2 sequestration value chain, given that not all countries have available depleted oil and gas reservoirs for CC(U)S, and not all power plants are connected to pipeline infrastructure. Standardisation of facilities will be important to ensure any ship can dock and inject CO_2, and cross border co-operation between regulators will need to be ensured to transport CO_2 across borders.

Integrating oil and gas infrastructure repurposing with industrial decarbonisation

Actions requiring international support in contexts where government capacity is low:

- Adopt a cluster-based approach and use spatial planning to identify the optimum combination of integrating various technologies to maximise cost effectiveness and leverage economies of scale, as opposed to investing in repurposing of individual facilities which are isolated from one another. Governments can map national industrial clusters, assessing their relative proximity to oil and gas facilities which could be converted to hydrogen production and depleted oil and gas reservoirs for CC(U)S, as well as available gas transport infrastructure which can be repurposed for hydrogen or CO_2 transportation. Leveraging geographic proximity of industrial centres with oil and gas assets nearing the end of their commercial lives can generate economies of scale, and form the basis of a framework to establish an integrated decarbonisation strategy.
- Consider options to incentivise the establishment of well-defined and robust partnerships between industry actors with the necessary skillsets to structure an integrated, cluster-based industrial decarbonisation project. Well-structured tender frameworks covering potential industrial clusters provide an effective means to guide and incentivise partnerships between upstream operators, gas and electricity infrastructure operators, and industry who will require hydrogen feedstock or who produce CO_2. Tenders can also be helpful in soliciting workable and innovative solutions from industry, while at the same time delivering cost-effective solutions by requiring consortia to compete with one another on price. No single company is capable of getting such a complex project off the ground, and fostering effective partnerships should be prioritised as a key success factor. The UK's Industrial Decarbonisation Strategy provides a useful blueprint in this regard (BEIS, 2021[77]).
- Assess the regulatory framework to identify ways to reduce complexity, identify overlapping responsibilities between regulators, and facilitate co-ordination, for instance between onshore and offshore regulators on joint permitting, oversight mandates of offshore oil and gas regulators and onshore gas market regulators and electricity transmission regulators, or co-ordinating skillets of regulated entities, such as mandated gas transport companies. Such efforts should seek to simplify the value chain, reduce regulatory complexity as far as is possible, and ensure the roles and responsibilities of all entities involved are clear.
- Ensure the fair distribution of risk and costs between government and industry, including designing and adjusting fiscal terms in legislation or contracts to incentivise investment.
- Incorporate repurposing plans into long-term national decarbonisation strategies, including NDCs.
- In collaboration with industry, systematically identify opportunities for repurposing infrastructure before decommissioning is approved, and even ahead of its retirement (Huang et al., 2021[78]; WEC, 2019[79]).

- Develop a transparent process for consulting local stakeholders on the repurposing of existing infrastructure. Effective communication with local stakeholders is key to the success of repurposing projects, and industry and government alike should effectively communicate benefits including the provision of low-carbon energy, job creation and supply chain benefits, as well as developing plans to mitigate negative impacts.
- Maximise dialogue between governments and industry to define policies aimed at optimising and co-ordinating asset life-cycle planning (WEC, 2019[79]).
- Ensure hydrogen infrastructure is built up in parallel with existing gas assets (Findlay, 2020[80]).
- Systematically and in a timely fashion identify assets at a high risk of stranding due to decarbonisation requirements so that regulators and investors are better aware of risks and can make informed decisions (WEC, 2019[79]).
- Promote cross-sector co-ordination to leverage cross-sector synergies regarding repurposing to ensure the most cost-effective and sustainable management of the infrastructure and reduce stranded assets (WEC, 2019[79]).

2.3.3. Managing early retirement of carbon intensive power generation

Keeping global temperatures within 1.5°C will require widespread early retirement of coal, diesel and unabated gas-fired power plants. Carbon Tracker estimates that in 2018, 42% of the world's coal-fired power plants were uneconomic, with this figure forecast to increase to 72% by 2040. Moreover, 35% of coal capacity cost more to run than renewables in 2018, a figure that is expected to rise to 96% by 2030 (Carbon Tracker Initiative, 2020[81]). The IEA estimates that there is more than USD 1 trillion in unrealised capital in coal-fired power plants globally, mainly in Asia. The relatively young age of many of these power plants means that developing finance options for early closure and repurposing is vital to ensuring a transition that minimises socio-economic disruptions (IEA, 2021[1]).

Retiring power plants early can be challenging. The nature of project finance in the power sector relies on capital being recouped over the full life of a project, which normally covers a 20 to 40-year period. For relatively new facilities, early retirement is likely to entail significant losses for a utility and the investor, as shortening the lifespan of a project means capital invested will not be fully recovered. Additionally, if a government embarks on an early retirement process without sufficient warning or consultation with utilities and investors, it can raise perceptions of risk. This may undermine a country's investment attractiveness which could have implications for the low-carbon transition and energy security, and result in grid absorption issues.

The key to the process is early planning, as well as open and consultative dialogue with utilities and investors. This can help to mitigate negative market perceptions and can open up avenues for financing early retirement, thus avoiding the transfer of costs of early retirement to rate payers and consumers through raising tariffs.

Introducing a well-signalled and gradual early retirement programme for coal, diesel and unabated gas-fired power plants, which establishes clear and predictable criteria, based on factors such as age, efficiency and cost, through which assets will be selected for early retirement well ahead of time, can set the foundations for a well-managed phase-out. This can maximise return on capital expenditure for utilities and investors, limit price increases for consumers and recycle as far as possible capital for investment in renewable energy alternatives.

Scenario modelling of the risks of not retiring carbon intensive power plants early is key to this process, and should look to model the cost to consumers of continuing to run uneconomic projects. It should also model the cost of stranded assets to investors, utilities and consumers (as well as fiscal implications) if no action on early retirement is taken. This process is key to generating buy-in for early retirement programmes and communicating the necessity of closing plants early.

When early retirement costs are borne by consumers, clear communication explaining the rationale for rates increases and mechanisms to alleviate costs on poorer households will be necessary. In the United States, for example, ratepayer-backed securitised bonds have been used to refinance coal-fired power plants where capital has not been fully realised, by spreading costs across ratepayer bills. This mechanism can also be used to recycle power utility capital for reinvestment in cheaper renewables, but requires a legislative environment that will allow for this. It is also dependent on high rates of collection of energy bills to provide sufficient guarantees for finance to be affordable, which is not always the case in emerging and developing countries.

Governments can consider compensating power plant operators for early retirement. Germany, as part of its programme to close hard coal-fired power plants, has taken this approach. The country is holding a series of auctions whereby coal operators state the price at which they would be willing to shut their plants in return for state-paid funding to cover some of their financial losses. Winners are also selected based on anticipated emissions reductions (Reuters, 2021[82]).

Governments should clearly establish criteria to prioritise which facilities should be retired early, and when. Such criteria need to include cost comparisons of renewables and abated gas alternatives, against carbon intensive technologies (coal and diesel), identifying inflection points for when these become uncompetitive against cleaner technologies (e.g. new coal is less expensive than new renewables or gas, or, new renewables or gas are more competitive than existing coal), taking into consideration environmental externalities. They also need to incorporate quantitative analysis of targets relating to long-term decarbonisation plans, or stipulate how much carbon-intensive generation capacity needs to be phased out and when to meet NDC commitments, including any net-zero targets. Power plant age should also be considered, given that plants become increasingly inefficient as equipment and machinery deteriorate with time.

Governments should take an integrated approach to power sector planning. This should consider the potential to transform some plants to low-carbon generation, for example, through retrofitting coal plants to accommodate abated gas, as well as the potential for CC(U)S to reduce CO_2 emissions. Replacing baseload coal-fired power generation with variable renewables capacity can also impact grid stability, and should also be factored into plans. Based on this, governments can send clear signals to the market based on price and GHG emissions reduction targets, and identify relevant plants for early closure based on these criteria.

Emerging and developing countries with shallow capital markets and more limited public funding will need to pursue financing options based on blended or concessional finance from developed countries or development finance institutions. South Africa's power utility Eskom, for example, is looking to raise a USD 10 billion finance package, mainly in concessional financing, over the next ten years to help it repurpose its ageing coal-fired power plant fleet to cater for renewable energy generation under South Africa's energy transition programme. Plans could include the closure of the Medupi and Kusile coal-fired power plants, which have a combined capacity of almost 9.6 GW, 20 years ahead of schedule, in the 2040s (African Energy, 2021[83]; Sguazzin, 2021[84]).

Governments should consider prioritising the following actions:

- Link carbon-intensive power generation (early) retirement plans to long-term, low-carbon development strategies, for example, NDCs and net-zero decarbonisation targets, incorporating avoided emissions over time.
- Undertake scenario-based modelling, incorporating the costs of CO_2-emitting technologies versus those of non-emitting sources of electricity, reflecting environmental and health impacts. Based on inflection points, publish long-term investment signals. Power generation facilities can be ranked based on economic, contractual and market factors to identify potential plants which are most suitable for early retirement or repurposing. Such a dataset can be used to identify facilities for early closure once inflection points are met. This approach should also identify opportunities to

repurpose or retrofit facilities, for example, for abated gas-fired power or renewables with battery storage. For example, if investments in new renewables or abated gas capacity cost less than investments in new coal-fired generation capacity, investments in new coal-fired power projects could be banned. If investments in new renewables cost less than running coal, introduce plans for early phase-out. Scenario-based analysis should also incorporate risk of stranded assets, and the implications on consumer rates versus raising consumer rates over time to pay for early retirement (Carbon Tracker Initiative, 2020[81]).

- Consider the social implications of early retirement or repurposing of assets.

Actions requiring international support in contexts where government capacity is low:

- Develop financing plans for carbon-intensive power plant retirement or repurposing, including the use of concessional finance from development finance institutions.
- Consult with industry operators early and openly on the necessity of carbon-intensive power plant phase-out and on options to maximise return on capital, while offering consumers sustainable solutions based on available alternative options.
- Consider the feasibility of refinancing for early retirement to maximise return on capital, for example, through ratepayer-backed securitisation, including an analysis of the security of bill payment collection and the impact on consumer bills, as well as necessary changes in legal framework and strength of capital markets.
- Explore, where appropriate, least-cost mechanisms for compensating power plant operators, for example, through a similar mechanism to Germany's coal-fired power plant phase-out compensation auction.

Development finance institutions should:

- Provide technical assistance to emerging and developing economies to understand the potential costs and benefits of carbon-intensive power plant retirement and repurposing, alongside the scale up of renewable energy. Technical assistance can be used to develop a roadmap for early retirement or repurposing of assets and mechanisms to access concessional finance.
- Increase concessional finance to unlock private sector investment in repurposing carbon-intensive power generation facilities for renewable power generation.

2.3.4. Capturing value from ageing coal-fired power plants through repurposing

Repurposing coal-fired power plants for renewables generation can facilitate the retirement of old, unprofitable and polluting assets, while offering a cost-effective re-use option for distressed or stranded facilities. Repurposing can address constraints facing greenfield developments, including land availability, with low opportunity costs given limited options for land re-use. Other benefits include the utilisation of existing infrastructure, including substations, transmission and evacuation lines, which can significantly reduce CAPEX requirements for renewable projects and ultimately lower the overall cost of electricity. Repurposing can also help manage social opposition to power plant closure by sustaining the labour force, while also maintaining a revenue stream for government which would be lost if a plant were instead decommissioned.

Combined with battery storage or a synchronous condenser, repurposing can also provide ancillary services to stabilise the grid, which were previously provided by the coal plant. This can increase grid absorption capacity of variable renewables technologies, and could accelerate the low-carbon transition while boosting access to affordable energy. Moreover, as battery storage costs come down, and governments introduce increasingly stringent remediation and environmental requirements, which place greater decommissioning costs on companies and utilities, the economic case for repurposing will strengthen.

Given the different local conditions, types, sizes and ages of coal-fired power plants, and the varying roles they play in the local economy (i.e. meeting national electricity demand and stabilising the grid), repurposing should be considered on a case–by-case basis. Analysis of individual cases should assess different technology combinations and consider different scenarios, including the impact on a system's capacity to meet national electricity demand and risks to grid stability. Cost-benefit analysis can help to shortlist potential technology options, and governments should also assess the socio-economic implications and environmental risks of repurposing.

Governments should consider prioritising the following actions:

- Integrate coal-fired repurposing plans into long-term decarbonisation planning, NDCs and electricity master plans, quantifying the planned contribution of repurposing to overall GHG emissions reduction objectives. An integrated plan which provides clarity on government policy direction can help to reduce risk for the private sector and encourage investment in repurposing projects.
- Consider the socio-economic dimensions of repurposing and develop clear plans to engage and consult with local communities and workers. Develop a transparent mechanism to address grievances and concerns.

Actions requiring international support in contexts where government capacity is low:

- Consider the upstream impacts of repurposing, particularly the implications for mines which provide coal to power plants. In some contexts, where utilities have long-term supply contracts involving multiple power plants, supply can be redirected to other plants and impacts on communities and workers dependent on mines can be mitigated. Where this is not possible, governments should assess the socio- economic impacts of reduced demand for coal in line with just transition recommendations in Section Pillar 2, Section 2.
- Undertake a detailed power system assessment to understand the implications of changing coal capacity to renewables capacity, alongside the retirement and repurposing schedules of other plants and the addition of greenfield renewables projects to the grid, in terms of system stability and energy security. Consider potential solutions to intermittency through the addition of ancillary services and use scenario-based analysis to gauge the impact of different repurposing (and retirement) scenarios on energy systems.
- Undertake a technical analysis on a plant-by-plant basis to determine potential technology combinations and options for each plant, including solar PV, concentrated solar, wind, natural gas, biogas, biomass, battery storage, thermal storage and synchronous condenser technology. This should incorporate a cost-benefit analysis which would run scenarios in which the power plant continues to operate as a coal-fired plant, and in which it is decommissioned. Cost-benefit analysis options can be used to build a shortlist of potential technology options to be taken forward to the feasibility stage.
- Ensure preliminary environmental impact assessments take place for each shortlisted option. These should detail the required assessments or studies that need to take place at the feasibility study phase.
- Consider the financial and economic dimensions of the preferred repurposing option, including opportunities to encourage private sector investment through PPPs. Outline potential financing structures and business models, and seek inputs from private sector through consultation.

2.3.5. Managing decommissioning, land remediation and restoration, and redevelopment of thermal power plant sites and coal mines

Properly planned and implemented land remediation and restoration, and redevelopment of thermal power plant sites and coal mines can create opportunities to revitalise an area, increase the well-being of citizens and create local employment. Conversely, failure to properly formulate and implement mine and power

plant closure, remediation, restoration and redevelopment plans in concert with communities often results in persistent negative health and environmental impacts and in many cases land being unfit or unsafe to be re-used for alternative purposes. Given the importance of land as a key asset for communities, full consultation in the design of land remediation, restoration and redevelopment plans, aligning with the local vision for redevelopment is essential to deliver environmental and restorative justice as part of the low-carbon transition (EBRD, 2020[32]; Krawchenko and Gordon, 2021[85]).

Land remediation is also important to attract investment, as contaminated land or unaddressed environmental damage can deter investors if there are associated health and safety risks for staff (EBRD, 2020[32]). Beautification and site redevelopment can also play a role in limiting outward migration, which is an important factor in local economic regeneration through the longer term.

Governments must ensure industry fulfils its obligations in paying for land remediation, rather than transferring costs to the public sector (Atteridge and Strambo, 2020[36]). For both coal mine closure and thermal power plant decommissioning, long-term planning is important, and understanding the range of site re-use options and associated costs can inform clean-up decisions and facilitate consultations on redevelopment with local leadership and community groups.

Preparing a site for re-use is a complex, three step process, involving removal or demolition, then disposal of industrial structures as part of the decommissioning or closure stage, followed by clean-up of contaminated land and any hazardous materials, based on testing of soil and water samples, to ensure the safety of the site, in line with local environmental regulations. Community representatives should be consulted on the design of land remediation and restoration plans and updated on progress of their implementation.

There are a range of site redevelopment options for both coal mines and thermal power plants. Selection of the preferred option should be based on local redevelopment goals, assessment of economic opportunities, and availability of amenities and infrastructure, and should be made in accordance with permit requirements. In Germany's Ruhr Valley, decommissioned mines have been turned into museums and monuments to attract tourism (Robins and Rydge, 2019[44]). Alternative options include the restoration of natural habitats and other wildlife, and community use. Greening of ash dumps is also a feasible option, either through production of green concrete, or for other products, such as bio-degradable geo-textile, which is used to reinforce and stabilise steep slopes.

Governments should consider prioritising the following actions:

- Require companies to plan for and implement environmental clean-up plans through regulation and contracts, ensuring these plans will be paid for through financial mechanisms such as insurance, rehabilitation bonds and bank guarantees.
- Ensure the cost of environmental remediation and restoration does not get passed to the taxpayer.
- Ensure funding to pay for environmental remediation and closure is ring fenced, for example, through financial guarantees, surety bonds, insurance, cash payment or irrevocable standby letters of credit. Financial guarantees should be updated if the mine closure plan is updated.

Actions requiring international support in contexts where government capacity is low:

- Invest in environmental agency capacity to evaluate EIAs and follow up on implementation.
- Look for opportunities for environmental restoration projects to provide employment for unemployed fossil fuel workers.

The fossil fuel industry should:

- Develop rigorous plans for environmental remediation and restoration.
- Ensure a range of redevelopment options are explored and costed as early as possible in advance of mine or power plant closure. Community viewpoints should be incorporated into redevelopment

design to ensure the proposed redevelopment plan aligns with local redevelopment goals. Local stakeholders should also be consulted and informed as to the scale and progress of remediation and clean-up of hazardous materials.

- Update mine and power plant closure/decommissioning, remediation and redevelopment plans based on potential early closure schedules, as well as progressive restoration throughout a mine's life. This will reduce overall costs.
- Ensure a full EIA is conducted covering all aspects of closure.

2.4. Closing the financing gap

Fossil fuel producer countries face access to capital constraints beyond those common to most emerging and developing countries. Across the oil and gas sector, the low-carbon transition could result in asset devaluation and write downs of varying severity, depending on the pace and scale of decarbonisation.

Fossil fuel-based developing countries are also heavily indebted as a result of the pandemic, facing high cost of capital owing to deteriorating foreign exchange rates. On top of this, asset devaluation for fossil fuel producer countries could further inhibit access to capital and make it significantly more expensive. A key weakness for fossil fuel producer developing economies, relative to other developing countries, stems from the fact that while multilaterals and donors are curtailing support for fossil fuel projects, they experience declining investment from IOCs, whose credit rating normally enables NOCs through joint ventures to access finance. Overall, this harms the creditworthiness of government and NOC alike, both of which as a consequence will find it harder and more expensive to finance low-carbon investments necessary for the transition.

Cost of capital for oil investments, and to some extent gas, is forecast to increase through to 2050, given price volatility and shifts in investor appetite away from fossil fuels, while cost of capital for renewables is expected to come down. As such, maintaining access to affordable capital will be contingent on fossil fuel producer governments undertaking an orderly reorganisation of their assets from being predominantly fossil fuel based, to a diversified portfolio based on low-carbon energy sources. At the same time, current inflationary pressures are increasing capital costs globally, including for renewable energy and climate investments, with important implications for global climate objectives, particularly in developing countries, where perceptions of investment risk tend to be elevated. The transformation is delicate: earnings from fossil fuel assets need to be maintained to support new low-carbon investments to diversify the overall portfolio, but should avoid the possibility of stranded assets which would drive up the cost of capital (OECD, 2019[86]).

However, the regulatory framework and investment environment in many fossil fuel-producer countries currently acts as a deterrent to low-carbon investment, which means that conditions for governments and NOCs to rebalance their portfolios at the necessary rate, in order to avoid spiralling cost of capital and constrained access, are not present.

Because their economic models are premised on ready access to cheap fossil fuels, many producer countries lack the enabling environment to rebalance asset portfolios towards low-carbon alternatives to oil and gas, such as renewable energy and hydrogen fuels.

For instance, in many producer countries, fully integrated state power utilities are responsible for the overwhelming majority of investment in the power sector. These are often highly inefficient, act as obstacles to reforms which would encourage private sector participation, and owing to financial difficulties, fail to make the investments in network and transmission infrastructure needed to accommodate new renewables generation capacity.

Electricity tariffs and transportation fuels in fossil fuel producer countries also tend to be kept artificially low, with consumers protected by fossil fuel consumption subsidies. This distorts market incentives and

makes renewables investments less attractive. It also contributes to financial difficulties facing utilities, which would otherwise generate electricity from renewables more cheaply, making them unreliable partners for the private sector who view them as not credit worthy. Additionally, problems with the regulatory framework can increase uncertainty and risk for investors, and in some cases even prohibit private participation.

Governments can take steps to address these challenges by creating an enabling legal and regulatory framework. This should include a gradual phase-out of inefficient fossil fuel subsidies and a plan to make electricity tariffs cost-reflective. Regulatory changes, such as strengthening the independence and authority of the regulator, and clarifying land acquisition processes and conditions for connecting to the grid, can encourage private investment, while a well-structured and predictable renewable energy auction can encourage competition and inspire confidence in investors.

Governments can also take steps to strengthen local capital markets, and address barriers to investment from global institutional investors. In many fossil fuel producer emerging and developing countries, shallow capital markets limit national financing potential due to competition among investments from a number of different sectors for a limited pool of capital. Foreign sources of capital, financing from development finance institutions and concessional funding, therefore, play an outsized role in financing renewable energy projects, which is not sustainable, nor sufficient to fulfil global low-carbon transition objectives. The nature, composition and distribution of development finance needs to shift rapidly and at scale towards private capital mobilisation in order to close the global clean energy, and wider sustainable development financing gaps (OECD, 2022[87]).

In the context of a shrinking fiscal space and an investment gap of USD 2.5 trillion to USD 3 trillion globally, institutional investors, such as pension funds, insurance funds and sovereign wealth funds (SWFs), can offer an important source of finance for low-carbon infrastructure projects, which can offer long-term, stable returns which align with their investment requirements. Yet, green investment currently accounts for about 8% of total funds investment in OECD and G20 countries, ranging between 1% and 58% depending on the size of the fund, a country's fossil fuel dependence and national transition progress, alongside other factors. Of USD 1.04 trillion of institutional investor infrastructure assets in these countries, USD 314 billion or 30% is invested in green infrastructure. Energy accounts for the greatest share of investments at USD 488 billion, with asset managers accounting for USD 263 billion, pension funds for USD 159 billion, insurance companies for USD 48 billion and SWFs for USD 18 billion, with renewable energy the largest investment subsector (OECD, 2020[88]).

Key actions to raise institutional investment in green infrastructure include improved national and project planning to build up an investible green project pipeline, availability of risk mitigation tools, removal of inefficient fossil fuel subsidies and the introduction of some form of carbon pricing. In addition, fiduciary duties limit the amount which can be invested via unlisted funds, securitised vehicles, or direct investing through project equity and debt.

Box 2.13. OECD guidance on developing green project pipelines

OECD policy guidance highlights the need to build robust pipelines of identifiable, investment-ready and bankable low-carbon projects to which investors can readily commit their time, effort and funding in closing the financing gap for low-carbon infrastructure. Clear infrastructure investment plans need to be translated into clear policy outlining which projects will be needed and when, as well as how to finance them. This approach will eventually enable developers to select projects that match their needs from a range of options, and invest time, and resources in pursuing multiple opportunities.

OECD highlights six success factors in developing robust low carbon project pipelines:

- Leadership. Ensuring governments as a whole and relevant government agencies champion the development of a robust project pipeline.
- Transparency. Having transparent approaches in place to develop sectoral investment plans, source projects, and use data effectively.
- Prioritising. Expediting strategically valuable projects – and shepherding them through development processes.
- Project support. Securing various elements of the investment-enabling environment that affect the risk-return profiles of projects such as policy incentives, the supply of public funds and institutional support.
- Eligibility criteria. Ensuring the pipeline of projects is properly aligned to or supports of long-term climate objectives with strong systems to assess which projects should be promoted and which should not.
- Dynamic adaptability. Ensuring governments have capacity to keep project pipelines aligned with policy objectives over time, so that they remain pertinent and relevant in the long term, and tailored to changing external conditions.

Source: (OECD, 2018[89]).

Meanwhile, securitised products and specialised vehicles formed to operate infrastructure, such as infrastructure investment funds or YieldCos, can support the freeing up of risky capital for new investments. Given institutional investors have long-term investment horizons, the use of securitised vehicles can free up scarce risky capital for new investments, as project sponsors or short-term financiers monetise operating assets by offloading them to the balance sheets of institutional investors (OECD, 2020[88]).

Governments can also establish dedicated public finance mechanisms to support renewable energy and other low-carbon investments, including carbon pricing mechanisms and carbon taxes. For instance, national development banks could provide debt or equity financing for projects, or governments could establish dedicated funds to de-risk projects or provide guarantees. Project preparation financing can also help with development of a pipeline of bankable green projects. Ultimately, such funds, even if relatively limited, where leveraged strategically, can help to crowd in private investment and de-risk projects which otherwise the private sector would consider too risky. This requires thorough assessments of the underlying barriers to commercial investment, and the targeted deployment of public finance, including blended finance, to help overcome them. Public finance should be deployed in such a way that it does just enough to crowd-in commercial investment, but without distorting markets. Preservation of scarce public finance will also be important for wider economic, development and climate objectives, including spending on adaptation and resilience to climate impacts, where market solutions are more constrained.

Lastly, by addressing corporate governance issues, reforming incentive structures and addressing inefficiencies, such as cost-reflectiveness of tariffs and payment collection, governments should work to put SOEs on a sound financial footing. Though politically challenging, in the long term, this will serve to boost investment in infrastructure, reduce the cost of borrowing and decrease the burden on the state budget.

Box 2.14. Enhancing the role of National Development Banks in shaping national low-carbon transition pathways and building green project pipelines

National Development Banks in developing countries could play a more central role in shaping national decarbonisation pathways and facilitating financing for low-carbon technologies and infrastructure. National Development Banks tend to have a strong understanding of local actors, the national development context, sector-specific knowledge and constraints on investment, making them well-placed to shape national planning, as well as having the capacity to lend in the local currency.

Typical National Development Bank functions often include providing public financing for infrastructure projects, but in contexts where they are undercapitalised or capacity in infrastructure deal making is limited, fulfilling this role can be problematic. National Development Banks in these contexts may be better off focusing on building an investible project pipeline, in some cases, providing grants which are convertible to loans if a project succeeds in reaching financial close, as well as contributing to shaping policy through undertaking research and analysis.

In South Africa, the Development Bank of South Africa (DBSA)'s Project Preparation Fund finances prefeasibility and bankable feasibility studies, with the ability to convert this financing to loans if the project is successful. DBSA is also the implementing agency for the Infrastructure Investment Programme, a project preparation facility for South Africa and neighbouring countries, with funding from the European Investment Bank (EIB), Kreditanstalt für Wiederaufbau (KFW), and Agence Française de Développement (AFD) among others. Meanwhile, Brazil's National Bank for Economic and Social Development (BNDES) has an infrastructure project fund which provides technical studies for infrastructure project preparation, as well as financing research on economic and social development.

Source: (Griffith-Jones, Attridge and Gouett, 2020[90]).

Governments should consider prioritising the following actions:

- Create an enabling environment for low-carbon investment, taking steps to reduce risks for the private sector. This might include establishing or strengthening the role of an independent regulator, clarifying land acquisition processes and introducing well-designed contracts to establish a basis on which to raise project finance.
- Discuss all regulatory changes in consultation with the private sector.
- Review rules on private participation, for example, capital controls, and consider revising them.
- Prioritise spending on basic infrastructure required to encourage investment, such as robustness of the grid, expansion of networks and collection of bills in the electricity sector.

Actions requiring international support in contexts where government capacity is low:

- Identify mechanisms to reduce risk to facilitate private sector participation in priority sectors, for instance, through effective tariff collection systems.
- Consider introducing well-structured and predictable auctions to encourage private sector participation and competition, send market signals and develop a plan to meet emissions reduction targets.
- Consider developing dedicated blended finance and state funding instruments to support commercial investment in renewable energy projects, including guarantees, concessional or subordinated debt instruments, grants for project preparation, risk insurance or other risk mitigation instruments, tailored to country, sector, and project-specific risks.

- Support the development of stronger co-ordination and governance mechanisms among beneficiary countries, donors and the private sector, including through the establishment of dedicated country platforms to support the design and implementation of robust decarbonisation pathways and financing strategies to fund them.
- Consider outreach initiatives and the design of a capacity-building programme to raise the ability of local commercial banks to offer financial products and lending to priority low-carbon sectors, such as the renewable energy sector.
- Address inefficient fossil fuel subsidies to eliminate perverse market incentives, reduce wasteful consumption, and level the playing field between carbon intensive and low-carbon investments, as outlined in Pillar 3, Section 3.3. Reduction in subsidies should be undertaken in parallel with a programme to mitigate negative impacts on poorer households (OECD, 2022[91]).

Governments and NOCs should:

- Assess portfolio distribution, with a view to rebalance assets in favour of low-carbon investments, lower the cost of capital and reduce risk of stranded assets. Balance this process with the need to maintain revenue through investment in fossil fuel sectors.

2.4.1. Enhancing and improving access and delivery of climate finance to fossil fuel-based emerging and developing economies

Achieving global climate objectives in fossil fuel-based emerging and developing countries will require a rapid scale up in climate finance. According to the IEA, by 2030, annual investment in clean energy in emerging and developing economies needs to reach USD 1 trillion annually, seven times what it is today, to put the world on track to meet net zero emissions by 2050 (IEA, 2021[92]). Mobilising such a huge amount of capital will require both private and public finance. Public finance should be a catalyst to reduce risk for private investors and boost the required breakthroughs for technologies that are not yet close enough to the market. However, multilateral public finance has a relatively poor track record in mobilising private finance in emerging and developing economies. For example, development finance institutions provide a significant amount of climate finance to the energy sector, which accounts for most of the commercial finance mobilised by development finance, but overall mobilisation figures are still relatively low: only USD 1.9 billion, or 1.2% of Official Development Assistance (ODA) is directed towards development-oriented private sector instrument (PSI) vehicles or blended finance instruments; just under USD 6 billion of commercial capital is mobilised towards renewable energy, and a total of USD 14 billion was mobilised by all climate finance in 2019 (OECD, 2022[87]). The low proportion of grants provided relative to loans (USD 12.3 billion versus USD 46.3 billion in 2018, respectively) also means that the poorest countries struggle to de-risk key projects to mobilise private capital (Bhattacharya et al., 2020[93]). The OECD estimates that private finance mobilised through bilateral and multilateral development finance in emerging and developing economies included in the DAC List of ODA Recipients reached USD 35.1 billion in 2016, USD 40.1 billion in 2017, USD 49.0 billion in 2018, USD 46.4 billion in 2019 and USD 43.8 billion in 2020 (OECD, 2019[86]).

Private finance is necessary to mobilise the resources to scale up low-carbon and climate-resilient infrastructure and low-carbon energy systems. However, the overwhelming majority of private finance currently flows to advanced economies. In sub-Saharan Africa, for example, finance from public and multilateral institutions accounts for about 90% of investments in the power sector.

In developing countries, the uptake of green finance has also been significantly slower than in advanced economies. Less than 20% of USD 1 trillion of green bonds issued globally are from developing countries. Between them, Latin America and Africa combined make up less than 3% of global green bond issuance. For the world to achieve the objectives of the Paris Agreement, affirmative action is needed to enable access to finance for countries with energy-intensive and hard-to-abate sectors, including their NOCs to

facilitate emissions abatement and decarbonise asset portfolios. However, high emitters frequently do not qualify for green finance, as they do not meet the required benchmarks for GHG emissions.

A wide range of climate finance instruments are available to emerging and developing economies, with development finance institutions offering grants, concessional and semi-concessional loans, guarantees, debt and equity finance. The five climate-dedicated funds – the Green Climate Fund (GCF), the Global Environment Facility (GEF), the Adaptation Fund (AF), the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF) – are relatively small, but can be used effectively to mobilise and unlock other sources of finance from development finance institutions and the private sector. Private finance is by far the biggest untapped source of climate finance.

Yet, accessing climate finance can be challenging for emerging and developing economies, with strict fiduciary and eligibility requirements sometimes impeding access. Moreover, it can take a long time for developing countries to access climate finance, with project design and passage through various approvals processes taking between 24 and 36 months. This can deter participation of many private entities who are used to shorter lead times, and can also present issues because staff changes in both development finance and government institutions result in a lack of continuity in project counterparts.

Alternatively, as yet underutilised climate finance mechanisms are available to emerging and developing economies to complement more traditional climate finance offerings through multilateral and bilateral partners.

Carbon markets, though relatively limited currently as a source of finance, offer countries the opportunity to get paid for emissions reduction credits, and debt for climate swaps present the chance to simultaneously tackle the growing debt crisis in emerging and developing economies, free up fiscal space for investment in development and services, and allocate finance to climate projects. Carbon taxes also offer an opportunity to raise revenue, though care needs to be taken to avoid the burden falling on the poorest. Lastly, many countries have taken steps to facilitate the issuance of green bonds to raise revenue and fund investments in priority green sectors.

Box 2.15. Transforming North-South co-operation on mobilising finance for the transition and establishing national climate finance frameworks

Transforming North-South partnerships to aggregate finance for the low-carbon transition in emerging and developing economies will require new approaches to international collaboration capable of unlocking climate finance flows at scale from advanced economies, which are home to the majority of the world's financial resources, to developing and emerging economies, where the climate finance gap is greatest. South Africa's Just Energy Transition Partnership (JETP), signed at COP26 between EU, France, Germany, the UK and the US could provide a model for achieving this goal. The deal commits to mobilising USD 8.5 billion in climate finance though a variety of mechanisms, including grants, concessional loans and investments and risk sharing instruments, to support the country's transition away from coal, and the adoption of renewables, while safeguarding and investing in mining workers and communities.

Though in its infancy, the South Africa JETP could be a game changer in how North-South collaboration works for the transition, leveraging the potential of G7 collective guarantee and financing mechanisms to mobilise and crowd-in private capital. At its June 2022 meeting in Elmau, Germany, the G7 agreed with India, Indonesia, Senegal and Viet Nam, to work towards further JETPs based on the South Africa model. Yet, success will require advanced economies to make good on their financial commitments. If they do not, these deals could do more harm than good, further eroding trust between North and South economies in regard to climate change.

Kenya's National Policy on Climate Finance

Kenya's National Policy on Climate Finance (2018) aims to improve the country's ability to effectively identify, track and mobilise climate finance flows. It serves as a guiding framework to enhance national financial systems and institutional capacity to improve the ability to access, disburse, absorb, manage, monitor and report on climate finance in a transparent and accountable manner.

A key components of the National Policy Climate on Finance is the establishment of a national climate finance platform, which can support the mobilisation, co-ordination and tracking of climate finance to improve transparency and accountability across government, building capacity to develop bankable projects and to effectively manage and implement them. This is accompanied by recommendations to improve fiduciary standards and management. The policy also highlights the need to establish a clear and flexible legal and regulatory framework, which enables the country to capitalise on climate finance opportunities, as well as the development of a national Monitoring, Reporting and Verification (MRV) framework to provide a clear overview of domestic and international climate financial flows, trends, sources and purposes.

The policy also references the need to clearly define roles and responsibilities between government institutions to improve centralised tracking of climate finance opportunities and develop a co-ordinated approach to their mobilisation, as well as capacity building at county government level to manage climate finance funds in an efficient, transparent and accountable way. Lastly, the policy references the potential of carbon market mechanisms to rapidly scale up the amount of carbon finance for developing countries such as Kenya, and the need for the country to position itself to tap into carbon crediting mechanisms following international agreement on Article-6 of the Paris Agreement (finalised at COP26).

Source: (Government of Kenya, 2016[94]); (Robinson, 2022[95]); (Dasgupta and Hourcade, 2022[96]); (G7, 2022[97]).

Governments should consider prioritising the following actions:

- Establish frameworks that ensure verifiable progress towards commitments under NDCs.
- Assess national policy and institutional arrangements for maximising access to climate finance. This should include capacity development needs, and the roles and responsibilities of different government actors, including subnational governments. Kenya's 2018 National Policy on Climate Finance provides a good blueprint for reference (Government of Kenya, 2016[94]).
- Consider establishing a national mechanism to co-ordinate relevant government actors, identify climate finance opportunities, support mobilisation, and improve tracking, monitoring and reporting. This mechanism should connect climate finance opportunities with sectoral and subnational government actors and projects, as well as mobilising resources and working across government to facilitate access to climate finance.
- Review the legal and institutional framework to access and maximise climate finance opportunities, ensuring responsiveness to evolving international climate finance developments, for example, scaling up of international carbon markets.
- Consider designating a government agency to obtain accredited status from climate-dedicated funds such as GCF and GEF. This will improve access to and management of climate finance, as well as access to capacity-building support such as readiness programmes.

Actions where international support would be required where government capacity is low:

- Enhance national MRV of emissions frameworks to facilitate access to climate finance.
- Review adequacy of fiduciary standards and environmental and social safeguards to access climate finance through multilateral climate dedicated funds such as the GCF and GEF. These tend to have strict fiduciary management, transparency and environmental standards, as well as regular

reporting requirements. Failure to adapt to these conditions can result in delays to project approval or implementation, or a project not qualifying for funding.

- Review and improve processes to establish a bankable pipeline of climate change mitigation and adaptation projects in key sectors in line with NDCs, as well as other relevant country strategies and plans.
- Enhance domestic expenditure and project prioritisation processes, ensuring equitable allocation of resources in line with NDCs and value for money.
- Strengthen subnational finance systems to track climate finance opportunities and monitor and report on project implementation.
- Introduce reforms to strengthen domestic capital markets, for example, reviewing and streamlining the regulatory framework, clarifying roles and responsibilities of public agencies, and working with the banking sector to increase access to finance for firms.
- Assess alternative climate finance mechanisms, such as green, sustainability linked or just transition bonds, debt for climate swaps and carbon crediting, to assess suitability given contextual factors, government capacity, and legal and regulatory frameworks.

Advanced economies should:

- Commit to new forms of transformative North-South partnerships capable of aggregating finance for the transition in emerging and developing countries, particularly through the Just Energy Transition Partnerships (JETPs) being developed between G7 countries and India, Indonesia, Senegal, South Africa and Viet Nam. These partnerships could be catalytic in accelerating the transition to sustainable growth, but require G7 economies to make good on their commitments, or risk further undermining trust between North and South economies on climate change.
- Consider how long-term factors, such as environmental improvements and emissions reductions can be factored into ratings assessments to reduce interest rates on loans and improve access to affordable finance for developing countries. For instance, measures to preserve biodiversity, or reduce emissions from fossil fuels and thermal power generation, currently do not figure in ratings agencies' credit rating assessments, despite longer-term implications for economic stability, the environment and citizen well-being (Inter-agency Task Force on Financing for Development, 2022[98]).
- Fulfil commitments outlined in the Delivery Plan for the USD 100 billion per year prepared by Canada and Germany, with support from the OECD, including meeting the USD 100 billion target by 2023, and mobilising more than USD 100 billion through 2025 (UKCOP26, 2022[99]).

Development finance institutions should:

- Collaborate with emerging and developing economies to consider how access to climate finance can be streamlined for more efficient mobilisation. Current obstacles include the slow process to gain accreditation for multilateral concessional finance (e.g. GCF and GEF), complex and demanding eligibility criteria, fiduciary and reporting requirements, and lack of information on climate finance opportunities.
- Collaborate with emerging and developing economies to ensure climate finance flows closely complement national development planning and NDC commitments.
- Review how multilateral and bilateral provision of climate finance works to unlock and capitalise private sector investment in emerging and developing economies. In particular, consider how to increase the provision of guarantees, which represent 5% of commitments but are responsible for 45% of private finance mobilised through MDBs (Bhattacharya et al., 2020[93]).
- Work to raise the proportion of grants relative to loans in the overall share of climate finance provided by developed countries to emerging and developing economies.

- Provide technical assistance and mentor financial institutions and finance ministries in emerging and developing economies to raise their capacity to identify, access, mobilise, disburse, track, monitor and report on climate finance. This includes identifying targeted finance consistent with national development plans, adaptation needs and mitigation actions in keeping with Article-2-(1)(c) of the Paris Agreement.

2.4.2. Mitigating risk to encourage private investment in low-carbon infrastructure

Amplified perceptions of political and macro-economic risk, a lack of bankable project pipelines and financial risks, for instance currency or non-payment risks, can make arranging project finance in developing countries challenging. Private climate finance flows to low-carbon infrastructure projects in developing countries, therefore, tend to be far lower than elsewhere in the world. For example, in 2019/20, just USD 2 billion and USD 11 billion was mobilised in climate finance from private sources in sub-Saharan Africa and South Asia respectively, compared with USD 17 billion and USD 19 billion from public sources. In contrast, USD 79 billion and USD 62 billion was mobilised from private sources in the US and Canada, and Western Europe, respectively and USD 4 billion and USD 43 billion from public sources during the same timeframe (CPI, 2021[100]).

Weaker legislative and regulatory frameworks, shallower capital markets and financially weak public utilities mean the risk adjusted rate of return for infrastructure projects in developing countries can be uncompetitive compared with more advanced economies. Moreover, a lack of government project preparation and deal implementation capacity, combined with burdensome bureaucratic processes, particularly for public private partnership (PPP) projects requiring engagement with multiple government and municipal agencies, can lead to deal making taking far longer than is necessary. In some cases, this contributes to prohibitive transaction costs. Anecdotal evidence suggests that average deal implementation timeframes are between 30 and 72 months in sub-Saharan Africa, versus 12 months in Asia and Latin America (MacLean and Olderman, 2015[101]).

In some cases, blended finance and Development Finance Institutions' financial tools, such as loan guarantees, political risk insurance and subordinate financing, can help to de-risk projects and mobilise private investment. However, they can be complex and take time to mobilise, and given Development Finance Institutions' capital adequacy requirements, are limited in availability. Governments can similarly provide sovereign guarantees to facilitate project financing, for example, backing electricity off-take payments by a financially weak power utility. However, these are treated as contingent liabilities on the government balance sheet, and as such governments running large deficits cannot afford to apply guarantees for all projects.

Resolving these challenges requires an integrated approach to improving the investment environment and improving perceptions of risk. Raising institutional capacity to undertake project preparation and deal implementation, as well as strengthening the regulatory frameworks and guidance for PPP investments, are critical steps. Governments should also establish long-term decarbonisation and economic diversification strategies, clearly defining decarbonisation, diversification and emissions reduction objectives, as well as credible verification and reporting mechanisms to enhance access to climate finance.

Given limited availability, blended finance, risk-mitigation instruments and sovereign guarantees should be deployed strategically. This should aim to de-risk sectors where the private sector is generally more comfortable investing, taking investments over the risk curve to the point where they are self-sustaining. Concessional finance should then be reallocated to de-risk and incentivise private capital in riskier sectors, aiming to crowd in the private investment and improve the cost competitiveness of new technology. This approach will set the foundations for the rest of the transition, build momentum, and optimise allocation of scarce public or multilateral sourced financing.

Box 2.16. Strengthening collaboration between sovereign funds and Strategic Investment Funds to increase access to climate finance and mitigate risk

The complementarities between Sovereign Wealth Funds (SWF) and Strategic Investment Funds (SIFs) present opportunities for creating productive synergies between these two types of investment funds. Sovereign funds hold very large amounts of capital, invested in different types of securities, while having limited capabilities for infrastructure investment and for direct investment. SIFs, on the other hand, are small compared to sovereign funds, and are set up for direct investment, most commonly in infrastructure and small and medium-sized enterprises (SMEs). Many SIFs have the capabilities needed for investing in the development and construction of new infrastructure. This is a capacity that nearly all sovereign funds lack, with the exception of Abu Dhabi's Mubadala Investment Company, through its subsidiary Masdar.

To take advantage of these complementarities for investment in low-carbon infrastructure, sovereign funds could channel part of their capital through SIFs, or set up joint investment platforms with SIFs. There are several benefits to this kind of collaboration. First, sovereign funds can take advantage of SIFs' knowledge of their home markets, and their ability to identify and monitor projects on the ground. Second, collaboration with SIFs can strengthen sovereign funds' deal flow, since the SIF as a local partner can identify, source and validate investment projects that sovereign funds may otherwise find difficult to access. Third, collaboration with SIFs provides sovereign funds with opportunities for diversification. Fourth, collaboration allows sovereign funds and SIFs to share the costs of due diligence, research and monitoring. Fifth, collaboration through a joint platform enables the bypassing of conventional intermediaries, thereby retaining governance rights and more direct control of investments. Sixth, as local partners, SIFs can minimise headline risk and mitigate political risk.

In an interesting example of collaboration between a SIF and sovereign funds, India's National Investment and Infrastructure Fund (NIIF) signed investment agreements with the Abu Dhabi Investment Authority (2017) and Singapore's sovereign fund, Temasek (2018), for USD 400 million and USD 1 billion, respectively. The NIIF also mobilised capital from foreign pension funds. The Canadian Pension Plan Investment Board, and the Ontario Teachers' Pension Plan, as well as AustralianSuper, an Australian pension fund, in 2019 invested a total of USD 650 million in the NIIF, thereby bringing the Master Fund to its targeted size of USD 2.1 billion. Additionally, the three pension funds will have co-investment rights with the NIIF of a total of USD 1.95 billion.

Source: (OECD, 2020[102]); (Bachher, Dixon and Monk, 2016[103]).

Governments should consider prioritising the following actions:

- Strengthen the regulatory framework and guidance around PPPs. In some countries, a dedicated PPP unit exists to guide private investors through the challenging process of structuring a PPP project, and engaging with relevant government and municipal departments. The World Bank provides guidance through the Public Private Infrastructure Advisory Facility (PPIAF). For specific guidance relating to PPPs in the power sector, see Pillar 3, Section 3.4.
- Think strategically about how to deploy sovereign guarantees. Given that sovereign guarantees are treated as contingent liabilities on the balance sheet, governments will only be able to deploy them for a select number of projects. Government strategy should look to de-risk sectors where the private sector is generally more comfortable investing, for example, energy efficiency or solar, taking investments over the risk curve to the point where they are self-sustaining. Cost competitiveness and reduced risks means that the private sector will invest without incentives, though it should be noted that continued innovation will be needed to continue driving costs down.

Concessional finance should then be reallocated to de-risk and incentivise private capital in riskier investments, such as early-stage technology, which can encourage localisation of value added activities, for instance through battery storage facilities.

- Developing countries can enhance access to climate finance by taking a holistic approach to improving the enabling environment for investment and reducing perceptions of risk. This should include establishing long-term decarbonisation and economic diversification strategies, given the importance of clearly defined decarbonisation, diversification and emissions reductions objectives, as well as credible verification and reporting mechanisms to access climate finance.
- In countries with well-established and mature domestic capital markets, project financing (debt and equity) typically takes place in the local currency, meaning both CAPEX and project revenues are in the local currency. Where domestic finance sectors are not strong enough to provide the volume of capital required, international financiers step in with dollar or euro financing, which in many instances can make an infrastructure project, such as an independent power project (IPP) viable. This, however, can create a currency mismatch between CAPEX in dollars or euros and project revenue generated in the local currency. In some cases, this is absorbed by the power off-taker, or electricity utility, or passed on to the consumer, removing the advantage of stable electricity prices which renewable energy normally provides. Currency hedging strategies can help to mitigate this volatility, but can also be expensive, raising the cost of finance. As a longer-term strategy to avoid foreign exchange risk, governments should support initiatives to strengthen local capital markets to mobilise flow of capital in local currency, which will be cheaper and not subject to foreign exchange risk (Mikolajczyk, 2018[104]).

Table 2.1. Risk mitigation tools to mobilise private capital for green infrastructure

Tool/instrument	Description
Co-investment	Public actor(s) invest alongside private investor(s) with either debt or equity with an equal or lower stake than a private investor (any larger investment would be classified as a cornerstone stake
Cornerstone stake	Investment by a public actor in a fund, issue or project amounting to a majority equity stake so as to achieve a demonstration effect to attract other investors
Loan	Debt issuance by a public actor
Loan guarantee	Guarantee by a public actor to pay any amount (either in full or part) due on a loan in the event of non-payment by the borrower
Public seed capital or grants	Concessions fund allocation using public money
Revenue guarantee	Guarantee by a public actor to pay for the core product to ensure revenue cash flow for a project
Back-stop guarantee	Guarantee by a public actor to purchase any unsubscribed portion of an issue (debt or equity)
Liquidity facility	A facility by a public actor allowing the borrower to draw thereupon in case of a cash flow shortfall
Political risk insurance	Guarantee by a public actor to indemnify in case of political risks like currency inconvertibility, expropriation, etc.

Source: Adapted from (OECD, 2020[105]).

Development finance institutions should:

- Collaborate with government counterparts to develop a strategic plan for deployment of risk mitigation tools, given they are limited in availability. This approach should look to crowd in private sector investment in less risky sectors initially before moving to frontier sectors to de-risk investments for the private sector.
- Assess whether it is feasible to issue more risk mitigation tools, concessional financing and subordinate financing by revisiting scope to take on risk, reviewing capital adequacy requirements and required return on investment.
- Invest in early-stage project de-risking, project preparation and planning to contribute to the development of a bankable pipeline of investment projects to attract private capital.

- To strengthen local capital markets, use climate finance to capitalise local financial institutions through local currency denominated credit lines in order to enable local currency lending to low-carbon projects. This approach should look to complement existing local capacity of the domestic finance sector to deliver local currency lending for renewable energy projects. This is a useful tactic in developing countries where a lack of savings limits the lending capacity of domestic commercial banks (Mikolajczyk, 2018[104]).
- Leverage climate finance to enable domestic banks to issue loans with longer-term maturities to match the long payback requirements of low-carbon energy projects in the renewable energy sector (Mikolajczyk, 2018[104]).

2.4.3. Mobilising sustainable finance through green bonds

Green bond issuances, and in some cases Sustainability-linked Bonds (SLBs) (see Box 2.17 and Box 2.18), represent an important mechanism through which governments, multilateral institutions and the private sector have sought to raise finance in a range of low-carbon investments, including mitigation and adaptation projects. The first green bond was issued by the European Investment Bank (EIB) in 2008. Since then, the green bond market has grown quickly, and accelerated rapidly following the signing of the Paris Agreement in 2015. The Climate Bond Initiative (CBI) estimates green bond issuances could reach USD 1 trillion per year by the end of 2022 (CBI, 2022[106]).

China, France, Sweden and Switzerland are government leaders in the sovereign bond market. However, increasingly, emerging markets have also turned to green bonds to take advantage of growing interest in ESG compliant investments. South Africa issued the first emerging market green bond in 2012, and subsequently, a range of other emerging market governments have also issued green bonds, including Chile, Egypt, Indonesia and Morocco.

Green bonds are fixed-income debt securities which offer investors relatively low-risk returns over a given period of time. Crucially, proceeds from green bonds should be spent on a pre-identified and pre-determined set of green investments, which need to be independently verified by third parties for compliance. International initiatives such as the Climate Bonds Standard and Certification Scheme and the European Green Bond Standard offer a set of standards and guiding principles covering issuance.

Box 2.17. Green bond issuances in developing and emerging countries

Green bond issuances in developing and emerging countries has increased significantly in recent years, with 25 countries having issued green bonds since 2012. In 2019, total issuances in emerging markets amounted to USD 52 billion, a 21% increase from 2018. China is by far the largest driver behind this growth, having issued more than USD 34 billion alone, with a share of other emerging economies amounting to USD 18 billion.

Having issued USD 3.9 billion in green bonds between 2012 and 2019, Chile is one of the largest issuers among emerging market economies. As the first country in the Americas, the Chilean government created a Green Bond Framework to channel investments towards green assets, and recently updated it to extend issuances to social and sustainable bonds. In Africa, between 2012 and 2019, South Africa stood out with cumulative bond issuances amounting to more than USD 2.1 billion from 2012 to 2019, followed by Morocco with USD 355 million. In 2020, Egypt joined the green bond market with a USD 750 million issue in 2020 and intentions to increase the number of issuances in the coming years.

An increasing number of developing countries are issuing green bonds as well. Notably, Fiji was the first developing country to offer a sovereign green bond in 2017, with cumulative issuances of USD 48 million by 2019.

Source: (Amundi & IFC, 2019[107]); (Government of Chile, 2019[108]); (Reuters, 2021[109]).

A number of related bonds focus on similar kinds of ESG investments. Social bonds require proceeds to be spent on projects with positive social outcomes, while sustainability bonds require proceeds to be invested in a combination of social and green projects (Amundi & IFC, 2019[107]). Recently, there has been growing interest in the potential of Just Transition Bonds, which would require investment in projects that tackle the negative impacts of the energy transition (see Pillar 2, Section 2) (Responsible Investor, 2020[110]).

Box 2.18. Sustainability-linked Bonds can support organisational decarbonisation objectives

In recent years, there has been a growing market in Sustainability-linked Bonds (SLBs). These differ from other sustainable bonds, such as green bonds or social bonds, in that proceeds are not used exclusively to fund specific green or social projects. Instead, SLBs are linked to general organisational objectives on decarbonisation, for example, a reduction in GHG emissions over a given period. If these targets are missed, then the issuer agrees to pay a higher coupon to the investor.

Italian energy company Enel, for instance, issued the world's largest SLB in July 2019, raising EUR 3.25 billion. The SLB is linked to a reduction in GHG emissions measured by grams of CO_2 per kWh. If the company fails to reduce its emissions in line with these targets, then 25 basis points are added to the investor coupon.

SLBs can offer organisations the flexibility to use funds in whichever way they need to reduce emissions, and represent good ways to support transition strategies because they include clear and measurable key performance indicators (KPIs) and targets which apply to the company as a whole, instead of specific transactions. As such, their use is very suited to companies that are gradually transitioning away from fossil fuels towards low-carbon investments, for example in renewable energy or low-carbon fuels, or in hard-to-abate sectors.

However, as with other types of sustainable bonds, effective MRV mechanisms are key to monitoring progress against targets. It is also important that sustainability targets are sufficiently ambitious to qualify such instruments as truly green, and that penalties (basic point increases on investor coupons), are sufficiently serious to incentivise companies to meet their sustainability targets. In June 2020, the International Capital Markets Association (ICMA) issued the Sustainability-linked Bond Principles, providing guidance to issuers.

Source: (ICMA, 2020[111]).

Green and related bonds can offer useful tools to fund the low-carbon transition. However, the rapid growth in issuances across emerging markets has raised concerns about their integrity as an instrument for investing in genuinely green projects. Currently, there is a lack of global agreement on what constitutes a green investment, and green taxonomies, though under development, are by no means consistent, let alone integrated into green bond issues everywhere. Monitoring, verification and reporting can be patchy across bond issuances, and in some cases, investors do not receive complete and reliable information as to how proceeds have been invested (Otek Ntsama et al., 2021[112]). The verification process can be expensive and requires access to adequate data and information relating to investments, as well as the

existence of a constellation of capacitated, expert firms domestically to undertake this work, which is not the case in all jurisdictions. These weaknesses have led to concerns over lack of regulation, opacity of reporting and the risk of green washing.

Emerging and developing economies can face additional challenges in taking advantage of green bond markets to finance their low-carbon development pathways. Green bonds require considerable expertise and knowledge both in terms of bond issuance and investment in green projects, neither of which are consistently available in emerging and developing country contexts. Green bond issuance is also contingent on a sufficient pipeline of eligible green projects for investment. Underdeveloped capital markets can also result in high transaction costs, and because bonds are debt instruments, sound economic fundamentals and growth are important to convincing investors that the return is worth the risk (Otek Ntsama et al., 2021[112]).

Box 2.19. Building sustainable finance literacy and enabling frameworks: Roadmap lessons from Indonesia and Morocco

Indonesia and Morocco are among the first emerging markets to embrace sustainable finance. Both started from a basis of fairly mature financial markets and through a planned, methodological process, adopted national green finance roadmaps to embed sustainable finance principles into all institutions within their respective finance markets.

Indonesia's financial services authority, Otoritas Jasa Keuangan (OKJ), alongside the Ministry of Environmental Affairs and Forestry, launched its Sustainable Finance Roadmap (2015-2024) in December 2014. The roadmap aims to embed sustainable finance principles across the country's finance sector to contribute to Indonesia's National Long-term Development Plan (2005-2025) and to support the country's 2015 NDC objective of reducing its GHG emissions by 29% by 2030. In 2017, the Umbrella Policy was introduced to complement the Sustainable Finance Roadmap defining sustainable finance in Indonesia and requiring all finance institutions to adopt Sustainable Finance Action Plans.

Morocco's central bank, Bank Al-Maghrib launched the Roadmap for Aligning the Moroccan Financial Sector with Sustainable Development in 2016. This sought to support Morocco's 2015 NDC commitment to reduce the country's GHG emissions by 2030 by 32% through strong involvement of the financial sector. The Moroccan government's estimates suggested an overall investment of USD 45 billion would be necessary to achieve its NDC target. Development of the roadmap involved collaboration with a broad number of financial market actors.

Both countries roadmaps established a strong basis to align their respective finance systems with their climate goals. Morocco's roadmap led to increased collaboration between the Casablanca Stock Exchange and the Moroccan Capital Markets Authority (AMMC) on the development of an ESG Benchmark Index, as well as AMMC's publication of a legal framework and guidelines for green and sustainable bonds. This has led to four green bond issuances totalling USD 356 million. These include an issue by the Moroccan Agency for Sustainable Development (MASEN) covering a new solar plant, two banks issuing green bonds for financing energy efficiency projects, and Casablanca Finance City (CFC) issuing a bond investing proceeds in green buildings.

Meanwhile Indonesia's Sustainable Finance Roadmap led to seven national banks issuing green bonds, and in 2018, Indonesia became the first country in the world to issue a sovereign Sukuk green bond, a Sharia compliant equivalent to green bonds. Subscriptions to the Sukuk issue totalled USD 1.25 billion, with proceeds invested in projects including renewable energy, green tourism, energy efficiency and waste management. The country's Sukuk was significantly oversubscribed and in consequence Indonesia has issued yearly green Sukuks with a combined value of USD 3.24 billion.

The development of Morocco and Indonesia's green finance markets has been successful in part because they started from a position of relative strength in terms of the depth and maturity of their financial markets. However, the approach of publishing clearly defined sustainable finance roadmaps also facilitated the process of pitching progress at the appropriate level, and ensuring all finance sector actors were carried along with planned market developments. In both countries, extensive consultation and engagement has been key to the process. In Morocco, for example, the process for developing the roadmap involved broad-based consultations with a range of market actors. This included the AMMC, the Supervisory Authority of Insurance and Social Welfare, the Moroccan Ministry of Economy and Finances, the CFC, the Casablanca Stock Exchange, the Moroccan Banking Association and the Moroccan Federation of Insurance and Reinsurance Companies. Several of these actors played an important subsequent role in developing core green finance policies such as Morocco's green bonds framework.

In Indonesia, OKJ led a consultation process with 118 banks, identifying pilot institutions to commit to implementing key measures at the launch of the roadmap. Consultations with stakeholders also led OKJ to establish a two-phased approach to develop the market for green finance, based on the capacities of financial institutions in the Indonesian finance sector. In the medium term (2015-2019), the roadmap focused on strengthening the basic regulatory system and on reporting, aiming to raise sustainable finance literacy across all institutions in the sector. Through the long term (2020 to 2024), objectives of the roadmap become more ambitious, aiming to embed climate risk management, improve corporate governance and develop an integrated sustainable finance information system. OKJ has also launched a Sustainable Finance Forum to stimulate discussion among participants in the financial sector, as well as a Sustainable Finance Award to encourage proactive engagement with the process.

Source: (Amundi & IFC, 2019[107]); (Marbuah, 2020[113]; Government of Indonesia, 2021[114]); (SBN, 2019[115]).

Actions where international support would be required where government capacity is low:

- Issue domestic currency transition and green bonds to build a liquid sovereign transition and green bond market for domestic investors, in line with the International Capital Market Association's Green Bond Principles, that recommend transparency and disclosure, and promote integrity in the development of the Green Bond market.
- Define the separate criteria for issuing green bonds, transition bonds and sustainability-linked bonds, including 1) allocation of responsibility for verification and reporting of transition bond proceeds, 2) establishing criteria for verification and reporting on bonds, and 3) ring fencing of sovereign transition bond proceeds from the general budget.
- Review available data collection, monitoring, verification and reporting systems for investments in green projects, considering improvements to ensure investors are provided with credible and complete information as to how proceeds have been invested. Establish a robust reporting framework to ensure this happens in practice. Useful frameworks are available through the Climate Bonds Initiative and the European Green Bond Standard.
- Adopt regulatory requirements for corporate disclosure on environmental risks in line with the Taskforce on Climate-Related Financial Disclosures (TCFD).
- Establish a local corporate transition and green bond index.
- Consider contributing to international efforts to develop and observe a green investment principles guidance framework or green taxonomy to clearly define what constitutes a green investment. This will provide ESG concerned investors with the confidence that proceeds will indeed be invested in green projects.

- Develop a pipeline of eligible green projects that can be financed through transition and green bond proceeds.
- Consider developing a sustainable finance roadmap outlining necessary steps to arrive at a point where issuance of a transition or green bond is feasible. Indonesia and Morocco offer useful blueprints of how this can be done.
- Provide green bond training to staff of relevant institutions, for instance financial regulatory authorities, central banks and capital markets authorities. This can be extended to third-party verifier entities.
- Consider the potential to issue a Just Transition Bond. The design would need to follow similar design principles to green bonds, including the prioritisation of rigorous monitoring, verification and reporting on investments, and the development of a pipeline of eligible just transition projects (Responsible Investor, 2020[110]).

Development finance institutions should:

- Under the leadership of G20 countries, accelerate international collaboration towards building international consensus on green taxonomies which can be applicable to green bond issues worldwide.
- Match prospective green bond issuers with global leading institutions and networks in the green bond market. This can include the Climate Bonds Standard and Certification Scheme, the European Green Bond Standard, the Network for Greening the Financial System and the London Stock Exchange.
- Pay for training in green bond fundamentals, issuance third-party verification in government institutions relevant to issuers in emerging markets.
- Provide technical assistance to prospective green bond issuers to structure green bond issues.
- Popularise the concept of Just Transition Bonds to finance just transition policies in emerging and developing economies.
- Support emerging and developing economies to develop a pipeline of eligible green projects which can be financed from green bond proceeds.
- Invest in improving MVR systems in emerging and developing economy issuers to improve reporting on the investment of green bond proceeds.

2.4.4. Leveraging debt for climate swaps to free up fiscal space in fossil fuel emerging and developing economies

COVID-19 has significantly increased levels of unsustainable debt across fossil fuel emerging and developing economies, inhibiting government capacity to invest in the low-carbon transition and fund public service delivery. According to the IMF, about half of low-income countries and a number of emerging market countries are in or at high risk of falling into a debt crisis (Georgieva, Pazarbasioglu and Weeks-Brown, 2020[116]). For many developing countries, the burden of servicing external debt is crowding out investments in education, healthcare and building resilience to climate change, given government revenue cannot keep pace with payments. For instance, debt service payments on external debt amounts to 20% or more of revenues in 18 developing countries between 2019 and 2025 (Jensen, 2021[117]). Small island developing states, for instance, which are highly exposed to extreme weather events, have limited resources to invest in adaptation infrastructure, as well as to provide disaster relief to citizens. Meanwhile, debt service burdens detract from developing countries' ability to invest in expanding social protection to all citizens, a key factor in safeguarding the most vulnerable from the worst effects of climate change, both physical and economic, as well as those of the pandemic.

The IMF and World Bank alongside G20 countries established the Debt Service Suspension Initiative (DSSI), offering a moratorium on debt repayments to 73 of the world's poorest countries to their bilateral creditors. Private creditors were also asked to participate in the initiative. The scheme ended at the end of 2021 and delivered more than USD 5 billion in debt relief to 40 countries. However, a long-term solution is needed. Unsustainable debt levels have prompted organisations such as the IMF to call for reform of international debt architecture to avoid defaults and economic distress across a number of countries (Georgieva, Pazarbasioglu and Weeks-Brown, 2020[116]).

Though untested, debt for climate swaps have been suggested as a potential mechanism through which to reduce global debt, while at the same time freeing up fiscal space and funding to invest in the low-carbon transition. Debt for climate swaps would build on the concept of debt for nature swaps, which since the late 1980s have successfully freed up more than USD 1 billion in finance for environmental safeguarding projects (Picolotti et al., 2020[118]).

In a debt for climate-swap, bilateral and ideally private creditors would need to forgive host country debt. In return, the debtor government would need to agree to invest in national climate mitigation and adaptation projects, rather than continuing to make external payments to continue servicing its debt. Advocates of debt for climate swaps have highlighted the potential role they can play in contributing to the commitment made by developed countries at COP26 to transfer USD 100 billion in climate finance to developing countries. They also highlight the potential to free up fiscal space for investment in public services in emerging and developing economies during a global health crisis, especially given the impacts of climate change are disproportionately affecting the world's poorest and most vulnerable. It is estimated that restructuring 10% of total global debt (USD 280 trillion in September 2021) through debt for climate swaps would mobilise USD 20 billion to invest in climate mitigation and adaptation projects in emerging and developing economies (Picolotti et al., 2020[118]).

Structuring debt for climate swaps, however, is likely to be challenging and will require deployment of significant effort and resources even to establish proof of concept alone. The capacity of some of the world's poorest countries to manage large-scale climate mitigation and adaptation projects, and the wisdom of insisting these governments spend resources on climate projects rather than provision of basic services, has also been questioned. These countries may be better off going down more traditional debt forgiveness or restructuring routes (Widge, 2021[119]).

Instead, it has been suggested that for debt for climate swaps to achieve scale and have real impact in terms of climate mitigation and adaptation outcomes, they are better off focusing on countries which are currently able to service their debt. In this way, the mechanism could target emerging market economies which are already investing in ambitious climate change and economic diversification objectives but need additional support (Widge, 2021[119]).

Additional requirements include the involvement of China, given its role as predominant creditor to emerging and developing economies. Private sector creditors would also need to be incentivised to participate in debt forgiveness.

Governments should consider prioritising the following actions:

- Build a pipeline of climate mitigation and adaptation projects, which can be financed through proceeds generated from debt for climate swaps.

Actions where international support would be required where government capacity is low:

- Consider opportunities to structure debt for climate swaps with an SOE as the national counterpart. In some countries, there is strong potential for debt for climate swaps to play a role in raising finance for NOCs or indebted utilities to invest in diversification.
- Consider the establishment of a ring-fenced trust or agency to manage proceeds from debt for climate swaps. This will ensure transparency and reduce the risk of corruption (Westphal and Liu, 2020[120]).

Development finance institutions should:

- Under the leadership of G20 countries, establish an international task force to raise awareness and political visibility around debt for climate-swaps (Picolotti et al., 2020[118]).
- Involve Chinese creditors in potential engagement on debt for climate swaps, as they are the predominant source of credit for emerging and developing economies.
- Engage with credit rating agencies, such as Moody's, Fitch Ratings and Standard & Poor's, to explore how requests for debt for climate swaps can avoid resulting in downgrading to a debtor country's credit rating, and whether there are mechanisms for a debt for climate swap to work in favour of a debtor country. Currently, any request for debt relief to the Paris Club is considered equivalent to a default (Picolotti et al., 2020[118]).
- In considering debt for climate swaps, prioritise countries that are currently servicing their debt and have ambitious low-carbon transition programmes which need additional funding. For heavily indebted poor countries, alternative options to debt relief should be sought, for example, through expansion of the Debt Service Suspension Initiative (DSSI) (Widge, 2021[119]).
- Explore incentives for private sector creditors to participate in debt for climate swaps. This might include credits which could be held against firm commitments to reduce emissions, or restructuring old debt into green recovery bonds (Volz et al., 2020[121]).
- Identify means to reduce transaction costs.
- Provide technical assistance to emerging and developing economies to negotiate debt relief and terms of investment of proceeds with creditors.
- Provide technical assistance to emerging and developing economy governments to develop an appropriate pipeline of projects to finance through debt for climate swap proceeds.

International organisations, creditor and debtor countries together should:

- Collaborate to establish high-level champions from creditor and debtor countries to advocate for debt for climate swaps. This could also potentially include representatives from potential agency or SOE counterparts (Picolotti et al., 2020[118]).
- Work to facilitate at least one debt for climate swap to establish proof of concept and provide a model and lessons learned for future debt for climate swaps (Picolotti et al., 2020[118]).
- Appoint third-party advisers to oversee transactions (Volz et al., 2020[121]).

Notes

[1] Other studies suggest the low-carbon transition will result in net gains in job creation. For example, the New Climate Economy estimates taking ambitious climate action could generate 65 million jobs by 2030, resulting in a net gain of 37 million after offsetting employment reduction in some declining industries (The New Climate Economy, 2018[122]). The International Renewable Energy Agency (IRENA) points to the creation of 111 million additional jobs on current global climate policy trajectories, and 137 million new jobs under a more ambitious 1.5°C scenario by 2030. This is equivalent to a net increase of 51 million under the 1.5°C scenario (IRENA, 2021[29]).

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Pillar 3 Systemic change and economy-wide decarbonisation

This Pillar articulates a vision for long-term systemic change and economy-wide decarbonisation, shaping a least cost pathway to net-zero to enable the achievement of sustainable development outcomes, whilst also addressing biodiversity loss and environmental degradation. Pillar 3 provides guidance on "how" fossil fuel developing economies can seize the transformational opportunities associated with the low-carbon transition, by pursuing green industrialisation, valuing natural capital and building low-carbon value chains with more value-added produced locally. Pillar 3 outlines strategies to accelerate decarbonisation of the power, transport, building sectors, leading to no-regrets and delivering benefits for citizens' well-being. The Pillar also offers guidance on pricing negative externalities of carbon intensive technologies and modes of production through carbon pricing and inefficient fossil fuel subsidy reform as key steps to deliver least cost decarbonisation plans, as well as reforming fiscal systems to maximise revenue generation, while ensuring equitable distributive outcomes.

3.1. Laying down the global foundations for systemic change: Resetting the relationship between importer and producer fossil fuel-based and mineral-rich developing economies

The uneven global response to the COVID-19 pandemic and ongoing climate, environment and biodiversity crises have highlighted the enormous inequality in access to finance, resources and opportunities which separates advanced economies from the rest of the world. Meanwhile, Russia's invasion of Ukraine is having a profound impact on energy prices and food security, especially in developing countries. Despite having contributed least to climate change and suffering the worst effects from its physical impacts, developing countries have largely been excluded from accessing the climate finance they need to set their economies on a path to sustainable prosperity, while the overwhelming concentration of coronavirus vaccine deployment in high-income countries is indicative of widening inequalities between North and South when it comes to access to healthcare and basic social protection.

These facts have highlighted the limitations of the 20th century social contract, a trade-off between economic growth and productivity on the one hand, and environmental and social protection and labour rights on the other, which has defined the post-Second World War period in the Global North. While citizens in high-income countries have undoubtedly gained from improved workers' rights and social protection, vast swathes of the rest of the world have been excluded from these safeguards. The interconnected nature of the pandemic and climate and environmental crises have highlighted the 20th century social contract's inability to respect planetary boundaries, biodiversity and the sustainable use of natural resources (Frey et al., 2021[1]).

In parallel, the divide between the rich and the poor, both nationally and internationally, has grown rapidly, with direct implications for the climate crisis. Today, the emissions of the world's richest 1% are 30 times higher than per capita levels consistent with a 1.5°C increase in global temperatures (Frey et al., 2021[1]), and per capita emissions in advanced economies dwarf those in developing countries. Emissions from high-income countries therefore exacerbate the worst physical impacts of climate change including pollution, rising temperatures, land degradation and extreme weather events in countries which are most vulnerable, in turn raising the cost of adaptation measures and contributing to poverty.

International finance and global debt architecture compound challenges for developing countries who face greater obstacles than their advanced economy peers in accessing affordable debt and capital. The cost of borrowing for a country in sub-Saharan Africa with a lower than investment grade rating, for instance, will be seven times higher than for an advanced economy, while perceptions of political, regulatory and payment risk mean developing countries have a far worse track record in attracting private capital in low-carbon investments than high-income countries. Meanwhile, the pandemic has led to burgeoning debt levels for many developing countries, with debt service repayments accounting for huge proportions of government revenue. Between 2019 and 2025, debt service payments on external debt will amount to 20% or more of revenues in 18 developing countries (Jensen, 2021[2]).

Box 3.1. The Great Financing Divide

The Inter-agency Task Force on Financing for Development's Financing for Sustainable Development Report identifies the Great Financing Divide as a defining feature of the difference between advanced and developing economies in responding to the COVID-19 pandemic. Advanced economies during the pandemic were able to borrow huge amounts of money at low interest rates with long maturities, enabling them to invest in recovery and safeguarding the livelihoods of citizens and businesses. In contrast, the capacity of developing countries to respond to the pandemic was severely curtailed by a

lack of access to long-term affordable debt, in spite of the fact that economic slowdowns and debt proportions as a percentage of fiscal revenue were far more pronounced in advanced economies.

Key issues for developing countries include the role credit ratings agencies play in assessing debtor risk of default. Almost all of the 61 sovereign ratings downgrades during the COVID-19 pandemic were developing countries, despite advanced economies performing worse in terms of economic slowdowns. Yet, developing countries found it harder to access long-term debt, and have had to borrow at higher rates and with shorter maturities than advanced economies, resulting in more burdensome service payment schedules, which account for a far higher proportion of fiscal revenue than in advanced economies. This has resulted in almost 60% of LDCs and LICs being at risk of debt distress or in debt distress in 2022, up from 30% in 2015. A key issue is the lack of transparency in credit rating agency methodologies, which penalise developing countries based on perceived risks.

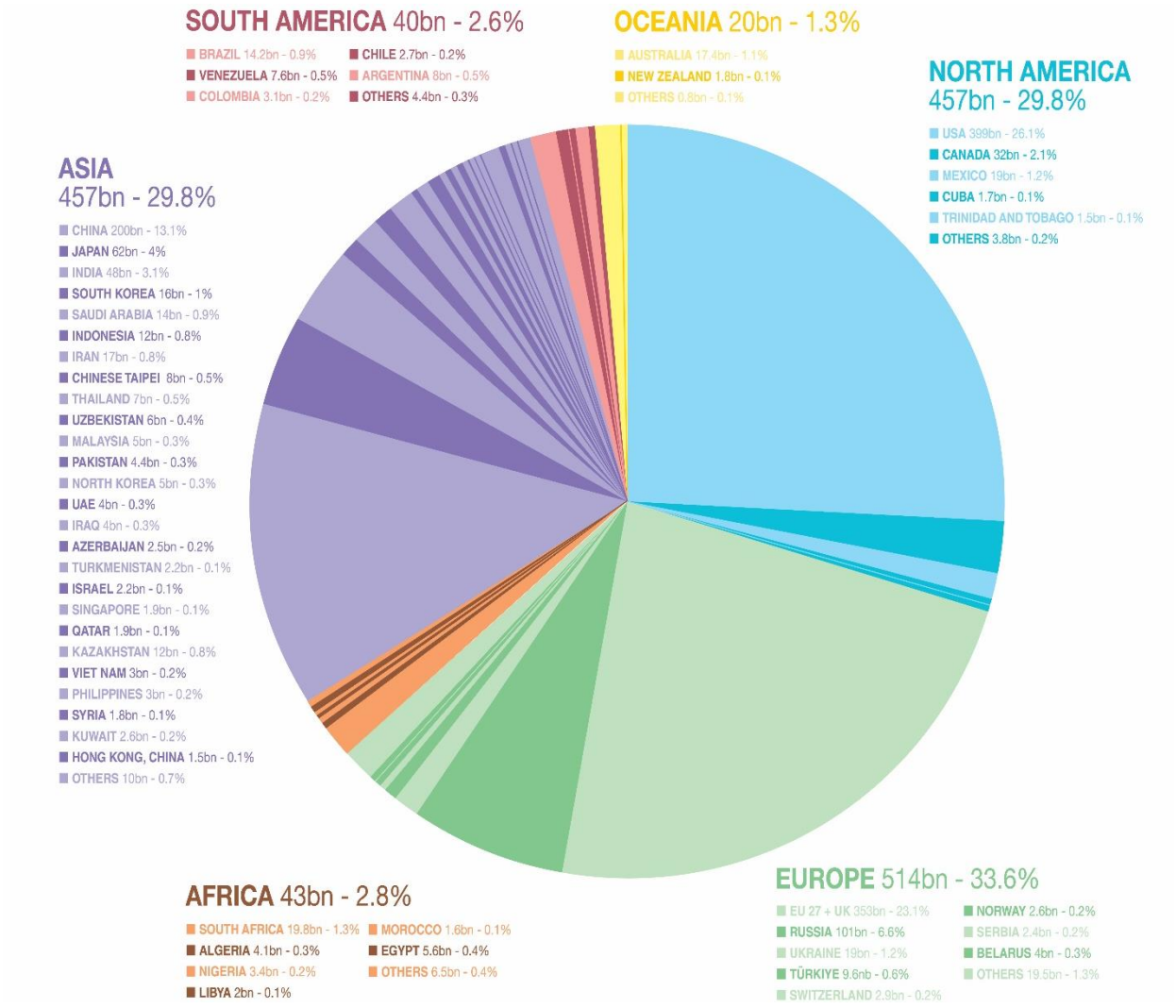
Source: (United Nations, Inter-agency Task Force on Financing for Development, 2022[3]).

Not only does this mean that many developing countries struggle to mobilise the necessary financial resources to invest in low-carbon transition plans, but also that over decades, public investment in essential public services and infrastructure, as well as institutional and capacity strengthening, has gradually been eroded undermining the relationship between the citizens and the state. Even before the COVID-19 pandemic, many developing countries were experiencing low productivity challenges, high vulnerability and inadequate social protection coverage. In many developing countries, an economic model premised on ready access to cheap fossil fuels affords few benefits for most of the population. Today, 785 million people around the world lack access to electricity, while 2.6 billion lack access to clean cooking solutions (IEA, 2021[4]). Meanwhile, several amplifying factors make developing countries particularly vulnerable, including pre-existing limited fiscal space, a growing burden of unsustainable debt, high levels of poverty and inequality, and more fragile health and sanitation systems, as well as widespread economic informality. At the same time, the pandemic has pushed a further 100 million people into energy poverty, while rampant inflation threatens to exclude investments in developing countries on the margins of risk acceptability from accessing finance (SE4All, 2020[5]).

Any discussion on the low-carbon transition in developing countries must recognise these realities, as well as the unequal global system that has contributed to them. A systemic rethink of the economic model is required to break the assumed link between economic growth and societal progress which has led to a resource-intensive development model characterised by inefficiency, waste and overconsumption in advanced economies and unsustainable production in developing countries.

For developing countries who have contributed least to historic emissions and whose per capita emissions are meagre compared to those of their advanced economy peers, the low-carbon transition is a development issue, entailing the simultaneous achievement of environmental, social and economic objectives as reflected in the SDGs, as well as decarbonisation. For governments to articulate compelling arguments encouraging citizens to accept the short-term costs of the transition, meaningful progress on economic, social and environmental development indicators needs to be prioritised, while balancing decarbonisation targets against their historic contributions to climate change and the realities of persistent widespread exclusion from access to affordable energy at a domestic level, as well as debt and finance at an international level.

Figure 3.1. Regional contributions to cumulative global CO_2 emissions (1751-2017)



Source: Adapted from Energy for Growth Hub and the Africa Center, 2021.

Enabling a just low-carbon transition in developing countries will require shifting away from a system that perpetuates existing power dynamics and consumption patterns and the reshaping of the resource-driven global governance system. Moving away from GDP and investor credit metrics as the dominant indicators of societal progress will be key to this process. A more holistic set of indicators, incorporating human well-being and natural capital measurement, can facilitate more equitable and affordable access to international finance and debt for developing countries (SYSTEMIQ, The Club of Rome, and the Open Society European Policy Institute, 2022[6]). Global governance systems should shift from a resource-driven system of competition for and cheap access to natural resources to a system based on collaboration, mutual trust and shared benefits to preserve and regenerate natural resources and work for the well-being of people. This will require advanced economies to drastically reduce materials consumption, which at current levels is unsustainable, investing instead in circular and regenerative business models that incentivise land regeneration, as well as re-use and recycling of materials. Circular economy principles can reduce demand for scarce natural resources, while also avoiding the risk that the energy transition's thirst for critical minerals and scarce resources, often under stress, exacerbates environmental and social injustice,

resulting in an unequal sharing of the costs and benefits of mining between advanced and developing economies (Kalt and Tunn, 2022[7]).

In parallel, profound systems change in international relationships are needed to build transformative win-win partnerships (SYSTEMIQ, The Club of Rome, and the Open Society European Policy Institute, 2022[6]). Such partnerships should account for a fair share of the resources to be used to support local and regional development. This means, for example, building green mineral value chains in the countries and regions where those resources are located. Transformative partnerships between producing and importing countries should also address the major stresses to deliver human needs (i.e. water and land use), when considering the potential for generating revenue from new exports, such as green hydrogen.

Global efforts to diversify and increase resilience of critical minerals, hydrogen and renewable power supply chains offers extensive opportunities for long-lasting and mutually beneficial collaboration between developing producers and advanced economies, including through technical assistance on governance, legal and regulatory frameworks, and mitigating social and environmental risks, as well as financial support for geological mapping and technology transfer to facilitate the development of green value chains in new countries.

A global just transition should also consider the impact of climate policy making in advanced economies across borders. For instance, the EU's Carbon Border Adjustment Mechanism (CBAM) could impose a carbon price on certain imported goods such as iron and steel, cement, fertilisers, electricity and aluminium. Meanwhile, the EU's Green Deal and European Industrial Strategy emphasise partnerships with mineral rich economies to improve the supply of critical minerals for the transition. To avoid any unintended consequences on developing countries, importer governments will have to step up and accept the responsibility of supporting exporter governments to keep pace with change and decarbonise sectors, subject to CBAM. Without accompanying transition support, mechanisms such as CBAM could render entire industries and sectors in developing countries uncompetitive for export, with dire consequences for jobs, economic growth and poverty.

Just energy transition partnerships can help importing countries meet energy security, while providing long-term revenue certainty to underpin a transition to renewable energy generation and the growth of low-carbon industries in producing countries. This will allow them to avoid high-carbon lock-in, and enable the progressive phase-down/out of fossil sources as renewables are phased in, while also offering off-takers certainty to facilitate renewables development and provide incentives for importer countries to invest in risk mitigation and subordinate finance instruments to de-risk renewables development.

Advanced economies should:

- Fulfil and exceed the annual commitment to provide developing economies with USD 100 billion in climate finance under the Paris Agreement, raising the proportion of blended finance through highly concessional loans, grants, subordinate finance, risk mitigation tools and guarantees to unlock private capital in clean investments. These efforts must recognise that USD 100 billion alone will be insufficient to meet global climate objectives and facilitate a transition which progresses at the required pace across the world. The primary goal should be to stimulate increased flows of private climate finance to developing economies.
- Move first and fastest to phase-down/out domestic production of fossil fuels and prioritise energy imports from developing country producers, guided by long-term, mutually beneficial partnerships to support the low-carbon transition, through the achievement of all SDGs, including energy access and security, and consistent with an equitable global phase-down/out of fossil fuel production and Paris-aligned emissions reduction pathways (Calverley and Anderson, 2022[8]).

Importer and producer developing economies together should:

- Promote the concept of a new global deal for development to underpin the low-carbon transition, based on recognition of the interplay between environmental and social justice, achievement of all SDGs, and the need to ensure developing countries possess the means to invest in effective public services, social protection, sustainable infrastructure, energy access, healthcare and education, particularly in fossil fuel producer regions and communities. Equalising access to affordable finance and debt will be critical to achieving this goal and is a necessary condition for building public acceptance for low-carbon transition policies across the world.
- Establish transformative low-carbon win-win partnerships, as well as public-private partnerships for the deployment of low-carbon technology, progressive fossil fuel phase-down/out and renewables phase-in and capacity building.
- Explore opportunities for partnerships between IOCs and NOCs, as outlined throughout Pillar 1, which could be based on recognition of the shared responsibility for curbing flaring and venting in producing countries (see Pillar 1, Section 1.2.3). Partnerships could be established to build capacity on measurement, verification and reporting of CO_2 and methane emissions, to facilitate the flow of technical and financial support for the deployment of the best available technologies for emissions abatement, and to jointly investigate the potential for a domestic natural gas market in order to monetise any associated gas, if gas is (also) used domestically.

3.1.1. Reshaping the relationship between the state and its citizens: A necessary condition to build broad societal support for the low-carbon transition

The climate crisis and the pandemic highlight the necessity of reshaping the social and environmental contract between the state and its citizens, recognising the intrinsic links between human welfare and ecosystems. This is true everywhere, but especially in developing countries, as the welfare of the poor depends on their access to, and the quantity and quality of terrestrial and marine ecosystems, as well as of other forms of biodiversity. Developing countries are also most vulnerable to the physical impacts of climate change and biodiversity loss, such as the degradation of critical ecosystem services, sea level rise, drought, wildfires, floods and loss of life. Focusing just on economic growth, and greening later, would be much more costly than following a path now to transform to a greener, more resilient and inclusive economy, as this would entail sharper subsequent corrective measures, higher risk of irreversible environmental damage, high-carbon lock-in and stranded assets, exacerbated by adverse distributional impacts. Deploying nature-based solutions, delivering benefits to the environment and communities, as well as setting the right incentives for the preservation and sustainable use of natural resources, will be key to shaping more sustainable patterns of production and consumption. This includes building a shared understanding within society of the goals to be achieved, the steps to be undertaken, and the resources to be deployed to realise such a large-scale and profound transformation, and to obtain broad societal support to navigate through the transition.

France's Gilets Jaune (Yellow Jacket) movement demonstrates the risks of public opposition to low-carbon policies and its potential to derail progress of the transition if burdens and costs are perceived to fall primarily on poorer citizens. For all countries, distributing the costs and benefits of the low-carbon transition equitably, and ensuring that those most exposed (including women, migrants, informal workers, ethnic, racial and religious minorities, and Indigenous communities) are not disproportionately affected by negative impacts is a necessary condition for building public acceptance of systemic decarbonisation, and overcoming political economy obstacles to correcting misaligned incentives and internalising negative externalities of fossil fuels production and use.

Structuring effective mechanisms for procedural (affected groups included in decision making), distributional (equitable sharing of costs and benefits) and restorative (compensation for environmental

and health impacts) justice is key to this process and can play an important role in ensuring citizens shape a low-carbon trajectory that enjoys wide stakeholder buy-in.

Developing countries may face additional challenges in building support for low-carbon transition strategies and policies because of persistent under-investment in public services, infrastructure, healthcare and education, and the associated need for institutional and individual capacity strengthening. This, in many cases, has undermined trust in governments, with citizens less willing to bear short-term transition costs against long-term benefits for household bills and livelihoods. Where natural resource rents are owned and distributed by the state, fossil fuel producer governments are likely to face greater resistance if a record of state capture, corruption and impunity has further deteriorated the relationship between the state and its citizens.

Articulating a compelling vision that places equitable income distribution, promotion of human capital, poverty alleviation, strong public integrity policies, and environmental and social justice through inclusive decision making at the heart of the relationship between the state and its citizens, can help governments build support for low-carbon transition strategies and policies, alongside decarbonisation plans. Open and inclusive policy making, in which governments broaden the sphere of action in which citizens can influence policy choices, will help to build consensus and strengthen government understanding of citizen needs and concerns, while facilitating public acceptance and support for policy reform. Governments can also leverage digital solutions to facilitate open and inclusive dialogue with citizens, as well as multiple platforms to effectively communicate the benefits of low-carbon transition policies and what they are doing to mitigate impact on citizens who will be negatively affected.

Governments should consider prioritising the following actions:

- Incorporate equity and justice issues into national development and decarbonisation frameworks, recognising the interlinkages between environmental and social justice, as well as the importance of valuing biodiversity, nature and ecosystems as core components of a sustainable, inclusive and prosperous society. Governments need to integrate this vision into development and decarbonisation frameworks, clearly articulating how the costs of transition policies on poorer households will be mitigated, and building a compelling vision as to what the benefits will be, when they can be realised and what the necessary steps are to achieve them. Moving away from an economy based on cheap access to fossil fuels should lead to a more equitable distribution of income, better access to services and sustainable infrastructure, as well as health and environmental benefits.
- Prioritise strong and engaged intermediary structures, including political parties, unions, associations, community and civil society groups, providing avenues and mechanisms for them to meaningfully participate in the vision and policy design process, in line with recommendations relating to planning for a just transition included in Pillar 2.
- Invest in educational and information-sharing tools and campaigns which build awareness of the risks of climate change and a continued reliance on fossil fuels, as well as outlining a vision for transformation, including how citizens can be involved.

3.1.2. Using scenario analysis to assess and manage transition risks

Traditional forecasting methods, which rely primarily on identifying trends from historic data, offer little when it comes to identifying and planning for transition risks. Instead, governments should aim to raise their capacity to integrate new techniques, such as scenario analysis, stress testing and horizon scanning, to identify risks and develop strategies to successfully manage them.

Ultimately, navigating the complexity of risks and uncertainties presented by the low-carbon transition, and taking advantage of opportunities, will entail more sophisticated, holistic and flexible policy making. This

must enable governments to anticipate and adapt to changing circumstances, and should reflect national socio-economic conditions and development plans.

Scenarios may need to be revisited following unexpected geopolitical developments. For example, Russia's invasion of Ukraine has spurred volatility in global commodity markets, causing prices for fossil fuels to rise rapidly. Future scenarios for fossil fuel production and demand will need to account for this volatility, while also addressing the weaponisation of energy exports, renewed energy security concerns and rising domestic energy nationalism which undermines international energy and trade cooperation.

Governments should consider prioritising the following actions:

- Use global fossil fuel supply and demand scenarios as a common basis for the discussion of national development plans and the role of fossil fuels within them.
- Consider the interaction between fossil fuel production, revenues and demand under different climate/energy transition scenarios, factoring in the costs of domestic consumption and debt servicing, and the effects of lower prices on export revenues and tax income. This will support better understanding of carbon linkages (i.e. how carbon risks would flow from the fossil fuel sector to the wider economy).
- Consider the implications for the profitability and fiscal stability of the government (where significant sums of public and private finance are invested in the sector), the companies (including NOCs), as well as the sectors and economies that are most exposed to market risks (e.g. devalued or stranded assets).
- Develop plans that are robust enough to address the lowest case scenario for fossil fuel investments, market prices and demand.
- Consider that established fossil fuel revenues could be used to support the implementation of a green transformation strategy at home while production is exported – instead of following the traditional "fossil fuel-led" development pathways, with emphasis on the linkages between the fossil fuel sector and fossil fuel-based value chains, which would increase risks. In any case, this option is unlikely to be available to new producers, given the timeframe to market and anticipated speed of decline in oil and gas demand and prices under a 1.5°C pathway.

Actions requiring international support in contexts where government capacity is low:

- When assessing the opportunity to explore for and develop hydrocarbon reserves, consider the type of oil or gas and its likely export markets, the scale of the resource, and the cost of development and production against best estimates of commercially viable production under the 1.5°C scenario, with due regard given to assumptions related to the choice and deployment of carbon abatement technologies.
- Assess the resilience of current plans in the sector to gradual or more disruptive change in international and domestic energy and industrial markets, in particular in the "lowest case" scenario, where revenues are lower than expected and projects are delayed or do not reach a final investment decision.
- Build capacity to undertake non-traditional forecasting techniques (which go beyond identification of trends from historic data), risk management such as stress testing and scenario analysis, as well as effective institutional co-ordination processes to facilitate government-wide collaboration on risk management. This will help governments begin to plan for unanticipated events, identify them earlier and minimise negative impacts. Important techniques include scenario development and deep dive analyses, assessing how transition risks will play out in different sectors and communities (Collins, Florin and Sachs, 2021[9]).
- Consider incorporating horizon-scanning techniques into planning apparatus. Horizon planning can be used to identify weak signals of coming changes, based on which governments can plan and develop mitigation strategies (Collins, Florin and Sachs, 2021[9]).

Using scenario analysis to assess and manage risks of continuous reliance on fossil fuels

Multi-decade scenario analysis can help simulate risks of continuous reliance on fossil fuels and their impacts on national plans for revenue management and spending, energy and industrial policy. This analysis can also plot the interaction of production, exports and/or domestic consumption, infrastructure development, revenues, associated emissions and well-being indicators under different transition pathways.

This will help inform decision making regarding the fossil fuel sector, in the light of economic and social trade-offs associated with different development pathways as well as alternative options for revenue-generation, access to energy, sustainable infrastructure and sustainable economic growth.

The impact of risks associated with continued reliance on fossil fuels will vary depending on a country's stage of fossil fuel production, the type and scale of resources, their production cost and low-carbon nature, as well as the planned allocation of production to export and/or domestic markets. These factors should be considered in macroeconomic scenario analyses conducted by central banks, regulators and ministries of finance, in line with the Network for Greening the Financial System.

Box 3.2. Scenarios for fossil fuel production and demand

Future scenarios for fossil fuel production and demand are highly dependent on assumptions about technology development and deployment, and future global climate policy. They also depend heavily on assumptions about the deployment of CC(U)S, carbon removal strategies, and on the competitiveness of "green" hydrogen produced by the electrolysis of water, versus "blue" hydrogen, produced by steam methane reforming of natural gas. Patterns of demand will also be affected by the impacts of climate change itself, which will be more severe and disruptive the less successful efforts are at meeting the Paris Agreement objectives.

Scenarios can be based on climate models or on energy systems models. The first type of model is used to study the climate effects of GHG emissions, whereas the second type considers the energy sector reforms necessary to reach climate targets. Scenarios can also incorporate climate effects and energy supply and demand across different economic sectors.

According to the IPCC's Sixth Assessment Report, limiting global warming to 1.5°C will require global CO_2 emissions to decline by about 48% by 2030 and 80% by 2040, compared to 2019 levels. To limit global warming to below 2°C, CO_2 emissions need to decline by about 27% by 2030 and 52% by 2040, compared to 2019 levels. In modelled pathways that limit warming to 1.5°C, the global use of coal, oil and gas in 2050 is projected to decline with median values of about 95%, 60% and 45%, respectively, compared to 2019.

According to UNEP's 2020 Production Gap Report, global coal, oil and gas production would need to decline annually by 11%, 4% and 3%, respectively, between 2020 and 2030, to be consistent with a 1.5°C pathway. The same report finds that countries are instead planning and projecting an average annual increase of 2%, that would by 2030 generate more than double the emissions consistent with the 1.5°C limit.

The Energy Transitions Commission finds that reaching net zero by 2050 will require electrification of 65-70% of final energy demand, versus 19% today. It will also require an expansion of the role of clean hydrogen to 15-20% of final energy demand, hydrogen-based fuels (ammonia, synthetic fuels), biomass as bioenergy or bio-feedstock for the chemical industry, and natural gas combined with CCS.

The IRENA Transforming Energy Scenario would cut fossil fuel-use by about 75% by 2050. This scenario sees emissions fall at a compound rate of 3.8% per year, to 70% less than today's level by 2050. The largest consumption declines would take place in coal, reducing by 41% by 2030 and 87%

by 2050, and oil by 31% by 2030 and 70% by 2050. Natural gas demand would increase by 3% by 2030, but would decline 41% by 2050. Under this scenario, the share of renewable energy in electricity generation would increase to 65% by 2030 and the share of renewable energy in the global energy mix would increase from 19% in 2019 to 79% by 2050.

The IEA's Net Zero Roadmap finds that the share of fossil fuels in the global energy supply would need to be reduced from around four-fifths currently to one-fifth by 2050. Coal demand would need to be reduced by 90%, gas demand by half and oil demand by 75% by 2050. By then, electricity will account for around half of total energy consumption, with solar providing 20% of global energy demand. Due to energy efficiency improvements, global energy demand will under this projection be around 8% smaller in 2050 than it is today, although the size of the world economy will double. Clean energy investment will need to triple by 2030, to around USD 5 trillion per year up from around USD 1.4 trillion today.

The rapid drop in oil and natural gas demand in the net-zero scenario means that no fossil fuel exploration and no new oil and natural gas fields are required beyond those that have already been approved for development in 2021. Fossil fuels would still be used for non-energy purposes in sectors where the complete elimination of emissions is particularly challenging (mostly oil to fuel aviation in particular), and in the electricity and industrial sectors requiring USD 650 billion investment in CC(U)S. A small amount of unabated coal and natural gas are used in industry and in the production of energy, resulting in around 1.7 Gt CO_2 emissions in 2050, which would be offset by Bio-Energy with Carbon Capture and Storage (BECCS) and Direct Air Carbon Capture and Storage (DACCS). Investment in fossil fuel-based CC(U)S could be avoided if additional investment were mobilised for extra wind, solar and electrolyser capacity, for electricity-based routes in heavy industry, and for expanded electricity networks and storage to support this higher level of deployment, with an additional cumulative investment to reach net-zero emissions in 2050, which would be USD 15 trillion higher than in the Net Zero Emissions by 2050 Scenario.

The IEA's (2021) report on financing the clean energy transition in emerging and developing economies finds that annual clean energy investment in these economies must increase from less than USD 150 billion in 2020 to over USD 1 trillion annually by 2030 to reach net-zero emissions by 2050. These countries, which are home to two-thirds of the world population, will represent 90% of future emissions growth. However, they only receive 20% of the funding for low-carbon technologies and other green investment.

Meanwhile, the IEA's Africa Energy Outlook 2022 notes that Africa's industrialisation will rely in part on expanding its use of natural gas. The report states that 5 000 billion cubic metres of natural gas have been discovered in Africa, but have not yet been approved for development. This resource could provide 90 billion cubic metres of gas per year by 2030, sufficient to drive development of the continent's fertiliser, steel and cement industries, as well as water desalination. Cumulative CO_2 emissions from utilisation of this gas over a 30-year period would amount to 10 Gt, raising the continent's share of global emissions to just 3.5%. However, the report also notes the importance of Africa leveraging its gas to primarily meet domestic needs, rather than for export, while in parallel preparing for a gradual decline in revenues from fossil fuels.

Source: (IPCC, 2022[10]); (SEI, IISD, ODI, E3G, and UNEP, 2020[11]); (Energy Transitions Commisson, 2020[12]); (IRENA, 2020[13]); (IRENA, 2022[14]); (IEA, 2021[4]); (IEA, 2022[15]) (IEA, 2021[16]); (IEA, 2022[17]).

What can governments do to build capacity to develop scenarios on future fossil fuel production and demand?

- Set up a team or identify a technical agency dedicated to modelling and scenario building.
- Support the continuity and growth of internal capabilities by regularly updating scenarios and engaging with external stakeholders to ensure quality assurance
- Build partnerships with external institutions to enhance capacity and co-develop energy models and scenarios
- Disclose assumptions and data used and engage with a broad range of stakeholders, including civil society, to foster well-informed national policy dialogue.
- When outsourcing scenario development, ensure that absorptive capacity exists within government to aid understanding and use of scenario results.

What can the fossil fuel industry do to support governments in developing scenarios on future fossil fuels production and demand?

- Share fossil fuel production and demand scenarios at project level wherever possible
- Fully disclose scenario data and modelling methodologies and help governments understand the underlying data and assumptions as well as the implications for fossil fuel production.
- Explain how long-term strategies are tested against different carbon-constrained scenarios.
- Explain that in order to remain sustainable and competitive, a leaner and more efficient oil and gas industry is required. This will include shortening investment cycles, developing low-carbon and low-cost resources, minimising product losses including methane leakage, and increasing recycling and re-use of inputs such as water, as well as infrastructure repurposing, wherever technically and economically feasible.
- Help governments improve understanding around the deployment of significant higher levels of artificial intelligence and automation, and remote operation and management.
- Publicly disclose how company decarbonisation and sustainability plans will impact specific projects in producer countries. Fossil fuel companies – both private and state-owned – should disclose production, energy transition and responsible exit plans for their projects. They should also engage with stakeholders on the social and economic impacts that project continuation, wind down or transfer would have on host governments and communities (e.g. impacts on payments to government and local employment, timelines and decommissioning plans).

What can development finance institutions do to support governments in developing scenarios on future fossil fuel production and demand?

- Provide training and capacity-building support to government technical agencies to develop scenario analysis and the capacity of ministries to understand and use scenario results.
- Build partnerships to co-develop energy models and scenarios.
- Provide funding to access proprietary tools for scenario development.

3.1.3. Integrating national development and decarbonisation plans

Low-carbon development integrating climate change with development objectives is a process of structural transformation that requires the elaboration of a long-term vision developed through a multi-stakeholder governance process and a coherent strategy, underpinned by a combination of consistent policy direction and careful sequencing of complementary and mutually reinforcing measures to enable an efficient and cost-effective shift to a low-emission and climate resilient economy. Long-term integrated development planning, incorporating interconnected energy, climate, environmental, macro-economic fiscal, labour, skills, industrial, infrastructure and transport policies, will be key for fossil fuel producer developing and emerging economies

to align short and mid-term policy choices with long-term objectives, increase policy coherence and support implementation. Setting a long-term direction underpinned by wide stakeholder buy-in will also require articulating the benefits of low-carbon development models, which can outlast election cycles and changes in government administrations. Mainstreaming low-carbon and climate resilience development strategies into national development planning should also integrate effective Measurement, Reporting and Verification (MRV) mechanisms to regularly take stock of progress, and be sufficiently flexible to adapt to changing circumstances and the emergence of new technologies and evolving climate conditions.

This will entail taking co-ordinated and harmonised actions horizontally across multiple departments and vertically across levels of government (national, regional and local, with meaningful stakeholder engagement), all pulling in the same direction, as opposed to an array of isolated policy measures often implemented in an inconsistent manner and leading to suboptimal or even contradictory outcomes.

Just transition plans, Nationally Determined Contributions (NDCs), and national development and economy-wide decarbonisation plans should be integrated into a coherent national development and decarbonisation programme that clearly articulates how social, environmental and economic objectives will be achieved, alongside delivery of the least-cost pathway to decarbonisation. Moreover, the process of building a national development framework, coherent with the NDCs, provides an important way to build public acceptability for the low-carbon transition, if steps are taken to integrate citizens' voices into the policy making process and the framework is delivered from the bottom up. Developing countries can also integrate conditional components into their NDCs. These are emissions reduction and avoidance initiatives and investments that are achievable contingent on the receipt of international finance, technology and capacity transfer. This is an important mechanism to hold advanced economies to account regarding shared responsibility for decarbonisation, and to clearly delineate the limits of what can be accomplished based on domestic resources alone and what will require international support. Fossil fuel producer developing countries should capitalise on efforts to diversify oil and gas supply to insist on technology and skills transfer and finance to deploy emissions abatement technologies on oil and gas production, processing and transport. This represents a key factor in maintaining market access, as well as longer-term partnerships to support deployment of renewables generation and investment in infrastructure for transmission, distribution and transport, which will be key to sustaining a longer-term move away from a dependence on fossil fuel revenue.

Achieving overall policy coherence between decarbonisation strategies and overarching development plans requires close collaboration and alignment between institutions mandated to lead on each process. In many countries, the environment ministry leads on the NDC, while the finance, economy or planning ministry is normally responsible for overall economic planning and prioritisation of development programmes through the national budgeting process, as well as being the designated recipient of international development assistance and climate finance. Imbalances in administrative capacity, established lines of communication with other government departments and levels of influence between these institutions can make it challenging to integrate NDC initiatives into the national development planning process, particularly where projects are funded through national budget allocations and compete with other spending imperatives.

Shared leadership roles on NDC development, for example, between environment and finance ministries, and clear legal mandates over which entities are responsible for which components of NDC development can help to: 1) better integrate NDC development with the broader economic planning process; 2) ensure initiatives in the NDC are adequately resourced, while aligning NDC and economic planning cycles, and 3) ensure similar stakeholders are consulted across both processes to improve policy coherence.

Clearly defined sectoral goals, based on SMART (Specific, Measurable, Agreed-upon, Realistic and Timebound) design principles bracketing targets and initiatives by sector and GHG type can support implementation, clarifying requirements for agencies responsible for oversight (Bird, Monkhouse and Booth, 2017[18]).

Table 3.1. Suggested interim measurement indicators to track decarbonisation progress by sector

Sector	Milestones	Potential indicators
Energy	Transition to low-carbon (abated gas) and renewables generation sources, and replacement of fossil fuels with low-carbon or zero-carbon synthetic fuels; progressive roll out of energy access.	• Renewables penetration • Coal share in energy mix • Unabated/abated gas share in energy mix • Share hydrogen and synthetic fuels in energy mix • Power system performance (losses, outages, voltage drops) • Population energy access and access to clean cooking • Reduction in mortality and disease rates linked to household pollution • Phased declines in fossil fuel production, in line with global climate targets
Manufacturing and industry	Energy and material intensity of manufacturing to decrease, with production processes, especially in hard-to-abate sectors.	• Electrification rates • Energy efficiency improvement • Circular economy indicators, for example, share of recycled waste • Penetration of new technologies (e.g. green hydrogen and abated gas with CCS)
Transportation	Domestic vehicles use should be more efficient and progressively substituted by non-carbon transport modes. Aeroplanes, trucks and ships to become less carbon intensive.	• Size, age and performance (e.g. CO_2 per km of fleet) • Electric and alternative vehicles penetration • Use of alternative clean fuels • Availability of shared mobility options • Long-distance freight/shipping performance
Residential use and buildings	Efficient (new or retrofitted) buildings are necessary to keep energy demand low	• Performance of buildings (age, heat insulation, energy performance) • Low-carbon heating and cooling (heat pumps, solar water, heating) • Automation and control systems • Efficient lighting and appliances
Agriculture, forestry and land use	Agriculture should become sustainable while satisfying increasing food demand	• Incidence of sustainable crop selection and animal farm practices • Fertilisers and nitrate incidence • Afforestation/reforestation and land use • Food loss and diet patterns

Source: Adapted from (D'Arcangelo et al., 2022[19]).

Governments should consider prioritising the following actions:

- Consider how to align NDC and national development planning processes, integrating planning cycles with NDC actions, and interim and long-term targets into budget allocation cycles. This process is key to aligning decarbonisation, social, economic and environmental development objectives, and balancing climate change goals.
- Consider how to optimise sequencing of reforms, based on national circumstances and political economy considerations. For example, policies which lead to increased costs for certain segments of the population can be spread over time to avoid creating obstacles, while they can also risk derailing simpler, less contentious reforms which may be more straightforward to introduce.

- Establish interim and long-range decarbonisation measurement indicators based on extensive industry and cross-government consultation to ensure they are ambitious yet achievable, as well as consistent with a just and least-cost decarbonisation pathway and complementary to overall development objectives. Basing these targets on SMART design principles will facilitate oversight from implementing agencies (Bird, Monkhouse and Booth, 2017[18]).
- Consider how to align and harmonise authorship and ownership of NDC and national development planning, particularly in contexts where the former is led by the environment ministry and the latter is led by the finance or economy ministry, which may carry more weight in cross-governmental administration and engagement processes. Joint ownership between the environment and finance or economy ministry can ensure both institutions pull in the same direction in integrating decarbonisation and development goals. An inter-governmental co-operation agency or commission with a strong mandate can help to facilitate this process, ensuring policy making adheres to high-level climate and development goals.
- Clearly delineate which NDC targets are achievable with domestic resources only, and which are conditional and can be achieved upon receipt of technology and skills transfer and financing from international partners. Clearly defined and costed activities, which are accompanied by a clear rationale as to how they will contribute to further emissions reduction beyond what is considered unconditional in the NDC, will facilitate access to international support, and can support discussions with importer governments and development finance institutions to make this support a reality.

Actions requiring international support in contexts where government capacity is low:

- Invest in robust MRV systems and build cross-sectorial capacity to monitor, follow-up and report on progress against emissions reduction targets as an important requirement for attracting climate finance and guarding against greenwashing, and to enable timely changes to policy direction when measures are not working or prove to be counterproductive to overall achievement of least-cost transition outcomes.

3.1.4. Mobilising transition finance

The IEA Net Zero report states that “for many developing countries, the pathway to net zero without international assistance is not clear. Technical and financial support is needed to ensure deployment of key technologies and infrastructure. Without greater international co-operation, global CO_2 emissions will not fall to net zero by 2050” (IEA, 2021[20]).

In developing countries, uptake of green finance has been significantly slower than in advanced economies. Less than 20% of USD 1 trillion of green bonds issued globally are from developing countries. Between them, Latin America and Africa combined make up less than 3% of global green bond issuance. For the world to achieve the objectives of the Paris Agreement, international support is needed to enable access to finance for countries with high emissions, including their NOCs and heavy industries. However, high emitters frequently do not qualify for green finance, as they do not meet the required benchmarks or criteria for GHG. The slow uptake of green finance in emerging economies raises the question of whether it is fair to impose the same benchmarks and criteria used in advanced economies on developing economies that are already struggling to provide basic services to their populations. Furthermore, under current criteria, countries that score low on environmental, social and governance (ESG) performance standards, but make genuine efforts to improve would not be able to access green finance.

Box 3.3. What is transition finance?

Transition finance has recently been gaining traction as a complementary approach to existing green finance instruments that, in the area of climate change mitigation, tend to focus on providing and mobilising finance for economic activities and projects that are already low- or zero-carbon. To date, transition finance is a nascent and evolving space and as such does not currently have a commonly agreed definition. However, a 2021 OECD review of related approaches and instruments found that existing approaches tend to view transition finance as being intended to decarbonise economic activities or entities that are currently 1) emissions-intensive, 2) may not yet have a zero-emission alternative economically available or credible in all contexts, 3) but are important for socio-economic development.

In this context, transition finance is considered a promising avenue for mainstreaming climate transition considerations in finance and across corporates, especially when supporting energy-intensive and hard-to-abate sectors to decarbonise. Transition finance-related instruments and approaches have, however, been criticised by financial market participants and civil society for creating greenwashing risks and showing a lack of environmental integrity. This is further compounded by the heterogeneity of existing transition finance approaches, which can be difficult to compare across jurisdictions and markets. One of the key risks is creating carbon-intensive lock-in through investments into emissions-intensive assets or infrastructures with a long lifetime. Even if those investments are aimed at efficiency improvements and emission reductions, absolute emissions of the targeted assets and infrastructures may remain too high to be consistent with the temperature goal of the Paris Agreement. A key challenge in transition finance is to balance these risks when ensuring environmental integrity and preventing emission lock-in, while remaining inclusive of sectors and geographies in need of finance for their climate transition.

The OECD Guidance on Transition Finance applies to corporates and posits that to prevent greenwashing and support cross-border co-ordination in the transition finance space, transition finance transactions should be based on credible corporate climate transition plans. This can ensure that there is an entity-wide strategy behind the related financial instrument, including mechanisms to prevent carbon-intensive lock-in for assets and infrastructures at risk. The guidance therefore proposes that transition finance should be understood as “finance deployed or raised by corporates to implement their net-zero transition, in line with the temperature goal of the Paris Agreement and based on credible corporate climate transition plans”. It sets out ten key elements of credible corporate climate transition plans, such as target-setting and reporting on progress, and proposes modifications for small- and medium-sized enterprises as well as certain corporates operating in emerging markets and developing economies, in order to allow for inclusiveness. While the guidance focuses on non-financial corporates, many of its elements can also apply to other entities, including, for example, national and municipal administrations.

Source: Authors based on (OECD, 2022[21]); (Tandon, 2021[22]).

Transition finance complements green finance

Compared to green finance, transition finance often refers to finance that targets progress on climate and environmental parameters, rather than only satisfying certain climate and environmental thresholds or criteria (see Box 3.3 for further background on transition finance). Whereas green budgeting and reporting, green financial instruments and green taxonomies, as well as other green finance-related tools, can be used in a static manner by stakeholders to inform their investment decisions, transition finance aims to be more forward looking and dynamic (Box 3.4 clarifies the difference between green, sustainability-linked and transition financial instruments such as bonds). Transition finance does not necessarily require

countries or companies to have achieved certain performance standards today to be eligible for financing, but instead provides finance for countries and companies that set themselves on an ambitious and verifiable path of transition, including performance milestones and targets to be met over a certain period, measured by pre-defined and verifiable KPIs and metrics. For example, under some existing transition finance approaches, equity investments in existing natural gas projects could be linked to progress towards eliminating emissions from natural gas production for hydrogen or from existing natural gas-fired power plants by applying CC(U)S to the flue gases from natural gas-powered plants or to the design of transition ready and future-proof infrastructure (see also Pillar 2, Section 2.3). Without transition finance, emerging and developing economies with energy-intensive and hard-to-abate sectors could be excluded from the financing that they need to transform their energy systems and, more broadly, their economies, while advanced economies continue to decarbonise.

An important challenge for transition finance in emerging and developing economies is to balance environmental credibility with inclusiveness, by creating credible criteria and mechanisms whereby this financing is allocated, including mechanisms for monitoring, verification and reporting of progress on climate and environmental parameters, and to prevent carbon-intensive lock-in.

Box 3.4. Bond instruments to support the climate transition: Green, sustainability-linked and transition bonds

Interest in green and transition finance continues to grow, as an increasing number of companies, financial institutions, and jurisdictions across the world adopt net-zero targets. In this context, fixed-income instruments are gaining traction in green finance more generally, but especially in the transition finance space. To date, most transition finance-related instruments are sustainability-linked bonds and loans, although a new denomination of transition bonds is also starting to emerge. Green bonds are also often included in the transition finance discussion, despite their narrower focus on low- and zero-emission projects, as they are a key building block in an issuer's overall climate transition. For example, ICMA's Climate Transition Finance Handbook takes the view that a "transition" denomination should communicate an issuer's strategy to align with the Paris Agreement goals. This means that a "transition bond" could be either a green, sustainability, sustainability-linked or a transition bond, if it contributes to the issuer's climate transition strategy.

Green bonds

Green bonds are generally use-of-proceeds instruments whereby the funds raised are used to finance or refinance projects or assets that are deemed eligible through a project categorisation or taxonomy. Funds raised through green bonds are committed to projects that contribute to climate or environmental objectives, such as investment in renewable energy or zero-emission transport. The most prominent standard for green bond issuances, both by private and sovereign issuers, is the International Capital Market Association (ICMA) Green Bond Principles, which are voluntary process guidelines to "promote integrity in the development of the green bond market" by providing clarity on the approach to issuance, transparency and disclosure.

Sustainability-linked bonds

Sustainability-linked bonds are performance-based instruments that allow companies to raise finance for general purposes, while setting out sustainability performance targets that need to be achieved by the issuer. The bond's finance terms, such as the coupon, are linked to these targets and vary depending on whether the issuer achieved the predetermined target. Targets can generally cover several sustainability-related dimensions, including climate, environmental and social elements, though nearly 60% of issuances in Q1 2022 specifically targeted GHG or carbon emission reductions. For this

reason and because sustainability-linked bonds are accessible to issuers from all sectors and geographies, they are considered as a promising financial instrument for transition finance.

Transition bonds

Transition bonds are a very recent market segment, with to date less than 20 issuances explicitly labelled as such and mostly issued by non-financial corporates in Asia, using the ICMA Climate Transition Finance Handbook. The Climate Bonds Initiative (CBI) is currently undertaking work on a dedicated transition label, which would define transition bonds as use-of-proceeds instruments, used to finance specific economic activities and projects that are compliant with CBI's criteria, in a manner similar to green bonds.

Source: Authors based on (OECD, 2022[21]); (Tandon, 2021[22]); (ICMA, 2020[23]); (ICMA, 2021[24]); (CBI, 2022[25]); (CBI, 2022[25]).

Governments should consider prioritising the following actions:

- Establish frameworks that ensure verifiable progress towards commitments under NDCs.
- Adopt regulatory requirements for corporate disclosure on environmental risks in line with the Taskforce on Climate-Related Financial Disclosures (TCFD). Monitor progress of the International Sustainability Standards Board (ISSB)'s work on sustainability disclosures, which builds on recommendations of the TCFD, to enhance provision of information on sustainability-related risks and opportunities necessary for investors to assess enterprise value (IFRS, 2022[26]).

Actions requiring international support in contexts where government capacity is low:

- Foster standardisation of transition finance guidelines, standards and definitions, on how to measure sustainability performance, including relevant KPIs, as well as mechanisms to guard against risk of greenwashing, to provide investors with the necessary information to assess the credibility of transition plans and monitor implementation.
- Consider issuance of domestic currency transition bonds to build a liquid sovereign transition bond market for domestic investors. This will be contingent on development of guidance and standards for sovereign transition bonds, which enable investors to assess the credibility of transition plans, progress against them and guard against greenwashing.
- Criteria for issuing sovereign transition bonds could include 1) the allocation of responsibility for verification and reporting of transition bond proceeds, 2) establishing criteria for verification and reporting on bonds; and 3) ring fencing of sovereign transition bonds proceeds from the general budget.
- Establish a local corporate transition bond index.

What can financiers do?

- Local commercial and investment banks can seek out protocols for transition bond issuance and develop internal processes to identify eligible projects, including by seeking clients with credible climate transition plans. OECD guidance on transition finance can help identify relevant corporates with credible transition strategies.
- Banks can provide more efficient foreign exchange hedging to mitigate the risk of currency volatility for foreign investors venturing into local markets.
- Local investors (including pension funds) can demonstrate a stronger interest in transition bonds, and in providing new green retail products.
- Index providers can create local corporate transition bond indexes when appropriate.

What can government and financiers do together?

- Bond issuers (sovereign and corporate) can contribute to long-term market creation by 1) incorporating long-term risks to their economies and business models, 2) building system resiliency, and 3) cultivating a new set of investors and building credibility by establishing a history of issuance for transition bonds.
- Provide training on the process and benefits of issuing transition bonds.

What can development finance institutions do?

- Provide guarantees tied to transition bonds. Possibilities include a basket of bonds in which development finance institutions take the first-loss (equity) tranche.

3.2. Economic diversification

With some countries expected to see a 51% drop in government oil and gas revenues, as a result of the shift to a low-carbon world over the next two decades, economic diversification, including through economy-wide decarbonisation, is an imperative for fossil fuel-producer emerging and developing countries, to set their economies on a pathway to sustainable growth. This is particularly the case for countries that are dependent on oil and gas for 60% or more of their fiscal revenue, and in some cases above 90% (Coffin, Dalman and Grant, 2021[27]). Economic diversification, in addition to increasing resilience to external shocks through reducing dependence on few sectors or commodities, can help to decouple government spending from price fluctuations, create quality jobs and broaden the tax base, as well as reduce pollution and environmental degradation by moving away from fossil fuel-intensive industries. This strategy can also contribute to strengthening the contract between the state and its citizens, given the positive correlation between broader taxation, citizens holding government to account, improved public spending, and more inclusive and improved policy making. Fossil fuel revenue can provide an important avenue for governments to fund strategic and targeted investments to set the foundations for economic diversification and to stimulate productivity and competitiveness in the private sector. For example, Ghana's One District, One Factory scheme uses oil revenue to build a factory in each of the country's 260 districts to promote export competitiveness, while Saudi Arabia's Public Investment Fund has allocated USD 1.1 billion to support SME development.

Fossil fuel producer emerging and developing economies should adopt strategies to build diversified, value-added economies, characterised by increased productivity of non-fossil fuel private sector firms and diversified export revenue. Ultimately, no single sector or industry will be able to replace revenue from fossil fuels, and the process of diversifying and transforming the economy will be a lengthy and uncertain endeavour, requiring long-term vision, with few guarantees of success.

Governments can play a role in correcting market failures and misaligned incentives to investment, production and consumption that are environmentally harmful and exacerbate fossil fuel path dependency, while at the same time clearing the way for the uptake of cleaner substitutes (see Pillar 3, Section 3.3). However, this can be challenging given the established and widespread availability of cheap carbon-intensive products and infrastructure which benefit dominant, incumbent industries and in which large volumes of capital have been invested. Addressing this imbalance requires raising the competitiveness of new sectors.

Through improved public-private co-ordination, involving public-private dialogue processes and programmes to create and identify opportunities for private sector investment, governments can set an enabling environment through which they can manage the transition away from fossil fuel dependence and scale up low-carbon technologies. This process requires a long-term but flexible vision, as well as an institutional structure enabling the identification of opportunities that align with national development objectives and circumstances upon which government and industry can build together. Rather than trying to pick winning sectors from the outset, governments can pursue a flexible portfolio of potential options emerging from public-private dialogue and identify the most appropriate enabling measures. Effective

feedback loops and constant, proactive engagement with industry and business is vital to incorporating lessons learned into adaptive and integrated policy making, with government participation in industry networks and associations feeding back into government plans. A core function of government's role is to ensure experimental programmes take place to test what technologies work in the local context and how they should be adapted, and that resulting lessons are fed back into government policy making and support for businesses (Alternburg and Assmann, 2017[28]).

Box 3.5. Key transition management elements for developing countries to overcome fossil fuel dependence and phase-in low-carbon technological substitutes

1. Plan proactively as an initial step, including the development of a long-term vision and a clear roadmap with interim goals and steps.
2. Communicate early and clearly with investors and the private sector about the intended vision and roadmap to achieve policy objectives. Involve stakeholders, including manufacturers, business associations and standardisation bodies, as early as possible in the process to identify innovations and opportunities that are best suited to the national context.
3. Carefully select a portfolio of options to provide with government support, ensuring that the selection is reviewed by independent experts to avoid capture by lobby and interest groups.
4. Pursue a sequential approach to providing support to greener technologies, tightening restrictions, applying charges and removing preferential treatment for fossil fuel-intensive businesses.
5. Explicitly include policy learning in the process of phasing in low-carbon technologies, ensuring that policy making builds on lessons learned, and feedback mechanisms are in place to end public support if it is shown not to be working.
6. Leverage multiple available policy options, including mandates, market pull policies, research and development, skills and capacity development, and standards and certification, based on analysis of local context and engagement with consumers and the private sector.
7. Invest in quality control and assessment mechanisms, including technology testing, to build confidence among consumers in new low-carbon technologies.

Source: (Alternburg and Assmann, 2017[28]).

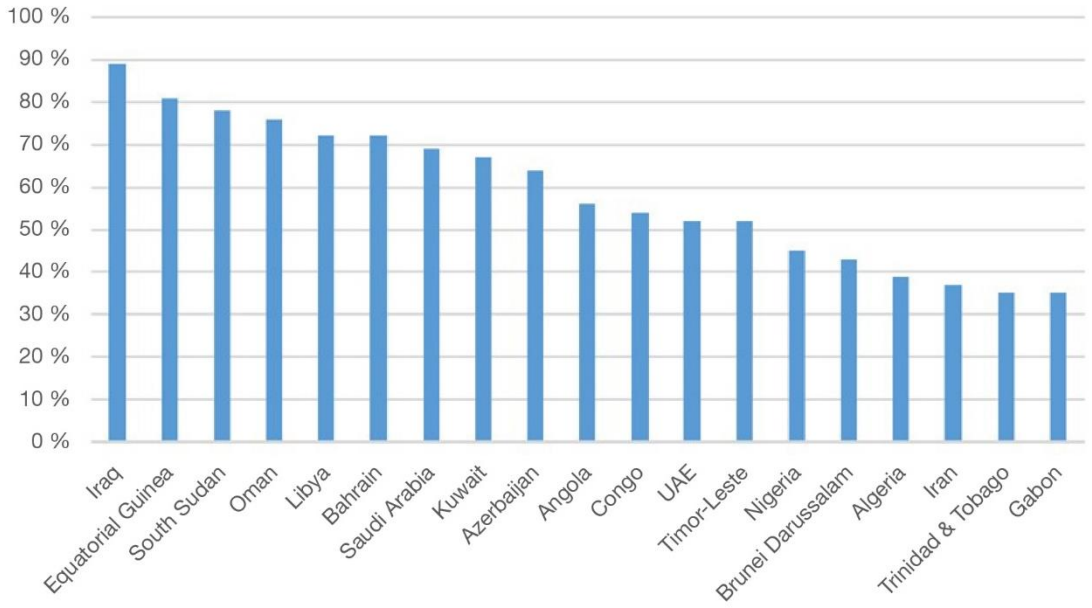
For the most part, countries with limited but high potential domestic technology manufacturing capabilities will be late-comers to the market, and will be catching up with established manufacturers. One way to build domestic manufacturing skills, expertise and know-how would be for governments to support firms to invest in assembly, with future potential for manufacturing in specific low- and medium- tech green products (e.g. solar heaters, solar water pumps, solar driers, drip irrigation systems, rainwater harvesting technologies or LPG, LNG or ethanol cooking stoves), or to promote manufacturing of components for renewables technology or batteries for domestic deployment and exports (e.g. blades for wind turbines, or PV modules, and mirrors). This strategy has notably been employed by China, a late-comer to solar photovoltaic components manufacturing, but now the dominant player, as well as Chinese Taipei in the electronics sector. India's National Mission on Transformative Mobility and Battery Storage, which aims to develop gigascale manufacturing in five years, also employs this strategy, initially focusing on battery module and battery pack assembly, and at a later stage progressing to battery cell manufacturing as the firms' capacity improves (Kumar and Shrimali, 2020[29]).

However, pursuing a bottom up or catch-up strategy still requires good choices as to which products are likely to be successful. Governments need to undertake a baseline assessment and build credible and reliable statistics on existing industry capacity, raw materials, energy availability and financing, size of local

enterprises, level of participation in value chains, supplier landscape and institutional capacity for skills and small and medium-sized enterprise development to inform strategic planning, required skills upgrading and technical training activities, as well as potential government incentive schemes and support measures. Industry demand analysis is also key to building economies of scale necessary to drive costs down and take advantage of potential export opportunities.

Regional co-ordination has strong potential to create market demand at scale, and avoid overlap between countries in terms of manufacturing capability and co-ordinating roadmap development to foster technology transfer and collaboration on financing. Additionally, joint ventures or strategic partnerships with advanced economies can support technology transfer and financing.

Figure 3.2. Fiscal dependence on oil and gas revenues by country (2015-18 average revenues as a percentage of total government revenues)



Source: (Coffin, Dalman and Grant, 2021[27]), *Beyond Petrostates: The burning need to cut oil dependence in the energy transition*, Carbon Tracker Initiative, https://carbontracker.org/reports/petrostates-energy-transition-report/.

Many fossil fuel producers are well placed to respond to growth in demand of green products, fuels and services given established energy and trade infrastructure, such as ports, pipelines and storage facilities, a skilled workforce familiar with producing, converting and handling energy fuels and products, and existing energy trading relationships (IRENA, 2022[30]).

In parallel, fossil fuel producer governments should pursue horizontal or non-sector-specific, broad-based policies which aim to build a thriving SME sector as an engine for quality job creation – especially in contexts with rapidly growing young populations who will need jobs – and to drive innovation and competition, with a view to integrating firms into regional and/or global value chains (GVCs). Participation in such value chains represents a central challenge for developing countries, many of whom are distant from manufacturing hubs, and face high transport costs. This is particularly the case for countries in Latin America and sub-Saharan Africa. Participating in higher value-added segments of the value chain, which create skilled jobs and higher income, rather than, for example product assembly, can be difficult to achieve in the face of international competition. Broad-based measures to improve the business environment, including streamlining business registration processes and revising bankruptcy rules, alongside policies to attract foreign direct investment in promising sectors, such as establishment of special economic zones,

ideally linked to resource corridors offering improved shared infrastructure for multiple sectors, can help to enhance the quality and efficiency of SMEs, ultimately enabling them to compete with international peers.

Facilitating access to finance for SMEs is one of the most transformative changes governments can introduce. If finance is deployed strategically and targeted towards a company's development needs, it can enable a firm to invest in the skills, business intelligence, design capacity, processes and equipment it needs to innovate, upgrade its products and build efficiency, to better compete on price and quality with international peers. Access to finance is a central impediment to upgrading firm productivity in developing countries, where the banking sector is often undercapitalised and few financial products are available for SMEs. In fossil fuel-producer countries, fossil fuel revenue flows directly from NOCs to governments without passing through the banking sector, leading to a situation in which the country is income rich, but banks are cash poor. In these circumstances, governments can try to address this balance by targeting SME financing programmes through the local banking sector, or through other financial intermediaries, such as a Strategic Investment Fund (SIF) to raise firm productivity and competitiveness.

Some fossil fuel producers have adopted vertical diversification strategies focused on industries linked to fossil fuels further down the value chain, such as chemicals and plastics manufacturing. Saudi Arabia's Vision 2030, for instance, aims to expand the country's existing petrochemicals industry. For a few fossil fuel producers, particularly those with low-cost production and competitive existing downstream industries, this can be an effective way to diversify revenue and monetise existing reserves. However, for the overwhelming majority of fossil fuel producer emerging and developing countries, which lack a comparative advantage and trade relationships in these downstream sectors, and without enabling infrastructure in place, the downside risks of vertical diversification will be too high, particularly given the high cost of abatement when cross-border carbon pricing mechanisms, such as the EU's CBAM, kick in in the middle of the current decade. These countries are better off adopting broad-based measures to stimulate the competitiveness of non-fossil fuel sectors.

Box 3.6. **IEA's support for producer economies under the Clean Energy Transitions Programme** (CETP)

Through its Clean Energy Transitions Programme (CETP), the IEA is working with producer economies to leverage their existing capacities and competitive advantages in traditional energy forms towards clean and low-carbon energy technologies. The aim is to help countries chart a low-carbon pathway for their own growing energy demand, while also exploring export opportunities for emerging low-carbon energy sectors, such as hydrogen.

This is a broad-ranging programme that cuts across the work streams of the IEA. It includes supporting renewable and clean energy deployment through policy reform; navigating the pathways available to countries seeking to implement national hydrogen strategies; and bolstering economic resilience through the promotion of local value chains. The programme functions through high-level dialogue; tailored support for national policy development; and thematic workshops and training. The programme has successfully put on the international agenda the unique challenges faced by this unique subset of countries, hosting with Oman a "Ministerial Dialogue on Clean Energy Transitions and Economic Resilience in the MENA region" in September 2021, while the IEA Executive Director published a joint opinion article with the Deputy Prime Minister of Iraq on the importance of climate action in producers.

The energy transitions in the producer economies programme supports the IEA's ongoing work by feeding lessons learned and data collected from producer economies back into IEA analysis and publications, such as the World Energy Outlook, Energy Technology Perspectives and Renewables Market Report.

Source: (IEA, 2022[31]); (IEA, 2021[32]); (Allawi and Birol, 2021[33]); (IEA, 2021[34]); (IEA, 2020[35]); (IEA, 2021[36]).

Governments should consider prioritising the following actions:

- Consider strategies for economic diversification at the earliest possible opportunity, especially for communities in fossil fuel producer regions, recognising that a broad-based approach which incorporates horizontal, or non-sector specific policies, alongside targeted green industrial policy, will maximise chances of success in a highly competitive and constantly evolving global market place. Governments should recognise that economic diversification is a long-term process, requiring constant adjustments to policy making to ensure overall value for money, and to support projects which bear fruit, while abandoning those that are less successful.
- Promote strong SMEs which can innovate, take risks and grow, as this is key to accessing regional and/or GVCs, creating quality jobs and broadening the tax base.
- Facilitate access to finance for SMEs, as this is key to help them make the necessary investments in strategy, human resources, processes, equipment and research and development, to become competitive in the international marketplace, and move into higher-value segments of the value chain. Fossil fuel producer governments can look to channel finance to SMEs through financial intermediaries in contexts where the domestic banking sector is under capitalised. Financing should be targeted to the development needs of SMEs, and based on clear strategies to grow and export.
- Provide missing inputs and services. Education, human capital, and access to quality and affordable services and infrastructure, including transport, trade-related infrastructure, broadband and reliable electricity are key to setting the foundations for non-fossil fuel private sector growth and encouraging foreign direct investment.
- Address non-tariff barriers, such as land permitting, access to electricity and intellectual property rules, as this can incentivise investment, both domestic and international, to boost productivity and participate in regional and/or GVCs.
- Prioritise measures which promote upskilling, technology transfer and development of local SMEs through strong linkages between international and domestic firms.
- Assess how export revenue from fossil fuels can be deployed to support economic diversification policies and incentives through the long term. Deploying emissions abatement technologies, in line with Pillar 1, will be crucial to maintain market access for fossil fuel exports through the medium term, but revenues should be deployed to support investments in sustainable, low-carbon infrastructure, particularly transport, broadband and energy, as well as to reinforce diversification strategies.
- Carefully assess the potential benefits, risks, costs and trade-offs of pursuing a dual-track approach to diversification which incorporates investments in downstream industries related to fossil fuels, for example, abated gas utilisation or chemicals manufacturing. Governments should only consider vertical diversification strategies on the basis of existing competitive advantage and rationale for investment (e.g. existence of proven reserves, enabling infrastructure and a market).
- Governments should also consider regional disparities by identifying and encouraging opportunities for economic diversification in fossil fuel producer regions. This requires the establishment of forums to build dialogue with local governments and business associations in order to develop assessments of opportunities. Based on these, roadmaps for regional economic development can be built and play to the strengths of local industries in terms of jobs and support for SME development (OECD, 2020[37]).
- Assess the product space and national comparative advantage to determine which green tech products, services and components are best suited for local development. This is likely to be products and components where skills, infrastructure and knowledge requirements are not too distant from existing products and services already under production, and for which there is

significant domestic and regional demand to enable firms to build economies of scale in order to drive costs down, which will be key to being competitive in international markets.

- Assess market size, or the extent of potential demand, as this will play an important role in establishing which products will achieve economies of scale, an important factor in driving down costs and building firm competitiveness against international peers.
- Assess existing manufacturing capabilities for assembly and component manufacturing, as well as potential for technology partnerships. This should be paired with a gap analysis to identify gaps or required investments to develop enabling infrastructure, local skills and manufacturing potential, and to meet global quality standards.
- Deepen understanding of low-carbon technology products, value chains and investment flows to base informed decisions on attracting investment.
- Raise awareness and share information with commercial banks on green products market potential, encouraging them to develop new financial instruments and products to support firm development.
- Encourage investment in enabling trade-related infrastructure and special economic zones to promote export clusters.
- Set clear objectives and time-bound metrics for governments to assess the success and failure of incentive schemes and SME financing. These should be regularly reviewed in order to avoid wasteful public spending, while recipients of state support should be under constant evaluation to ensure finance and incentives are directed at firms with the most potential.
- Create a level playing field between fossil fuel-intensive products and services and green equivalents. This requires the removal of inefficient fossil fuel subsidies and internalising externalities through incremental carbon pricing or other regulatory measures, such as mandates or bans on certain carbon-intensive products and services, as outlined in Pillar 3, Section 3.3.
- Regional memorandums of understanding and co-ordination on roadmap development for specific green industrial clusters can help to expand markets for firms to reach economies of scale, encourage technology transfer and pool financing, while avoiding overlaps in terms of which products and services neighbouring governments choose to support.
- For late market entrants, consider a bottom-up or catch-up approach to developing manufacturing know-how, and capacity to compete on quality and price.

Actions requiring international support in contexts where government capacity is low:

- Joint venture partnerships with advanced economies can support technological and skills transfer in target sectors.

3.2.1. Producing hydrogen and derivatives

For many fossil fuel-producer emerging and developing countries who have access to abundant, low-cost renewables and water resources, or large volumes of natural gas which can be produced and abated cheaply, production of hydrogen and hydrogen derivatives may offer an attractive means by which to diversify the export base, and a vital source of foreign exchange as fossil fuel exports gradually decline. Abundant solar and wind resources in many fossil fuel-producer developing and emerging countries can enable the conversion to green hydrogen as renewables generation in their power systems is gradually expanded. In fact, a number of developing and emerging economies have a strong track record in electrolysis, the process of producing hydrogen from water, albeit powered by fossil fuels rather than renewable energy. This is the result of efforts to improve food security through production of hydrogen for domestic fertiliser manufacturing: India installed 106 MW of electrolyser capacity in 1958, Zimbabwe 74.8 MW in 1975, and Egypt 115 MW in 1960, indicating the presence of a track record and know-how when it comes to hydrogen on which many countries can build (De Sisternes Jimenez and Paul, 2020[38]).

Many fossil fuel producer countries are well placed to invest in hydrogen development, given existing energy infrastructure, including gas storage, and transport and ports, which can be repurposed to accommodate hydrogen production; a skilled workforce which is used to handling, converting and processing energy fuels; and existing energy trade links (IRENA, 2022[39]).

The global market for hydrogen is expected to grow rapidly over the next 30 years, accounting for up to 12% of final energy consumption by 2050, two-thirds of which will be green hydrogen produced from renewables, with the remaining one-third produced from abated thermal consumption of natural gas, with emissions capture through CC(U)S. Current hydrogen sales stand at USD 174 billion, roughly equivalent to sales of Liquefied Natural Gas (LNG), but according to some estimates, could reach annual volumes of USD 600 billion, with a total investment value of USD 11.7 trillion by 2050. This would require installed electrolyser capacity and the technology to convert water into hydrogen, in order to rise from approximately 0.3 GW to 5 000 GW by 2050, two-thirds of which will be produced from renewable energy. Green hydrogen is expected to compete with blue hydrogen on a cost basis by 2030, with cross-border trading set to scale up through the 2030s (IRENA, 2022[39]).

As renewable energy ramps up, fossil fuel producers with low-cost low-carbon gas, as well as abundant renewable energy potential, have an opportunity to progressively shift away from hydrogen production from abated thermal consumption of natural gas, with strict methane emissions requirements and CO_2 emissions captured through CC(U)S, towards green hydrogen. This strategy is currently being pursued by Oman, Saudi Arabia and the United Arab Emirates (IRENA, 2022[39]).

Net-zero targets set by advanced economies are largely unachievable without substantial hydrogen imports, a fact which is enshrined in the EU Green Deal and EU Hydrogen Strategy, which outlines plans to co-operate with the African Union on hydrogen and hydrogen derivatives supply. The European Union's REPower Plan, which aims to reduce dependence on Russian fossil fuels and fast forward the green transition, has set a target for 10 million tonnes of domestic hydrogen production by 2030, and a further 10 million tonnes of imports by the same year (European Commission, 2022[40]). Win-win partnerships between advanced and developing economies can encourage technology, finance, skills transfer and investments, as well as improve project bankability by providing predictable revenue streams. They can also help meet both the domestic needs and long-term supply requirements of importer economies. In fact, over 30 countries, including a number of emerging and developing economies, have outlined hydrogen development roadmaps, and there are a range of bi-lateral agreements between advanced and developing economies to promote development of the industry with the view to cementing long-term supply agreements.

Box 3.7. Emerging and developing country hydrogen strategies and bi-lateral hydrogen development agreements

A number of developing and emerging countries have developed national hydrogen development strategies, with a growing number of bi-lateral hydrogen development and supply agreements:

- In February 2022, South Africa's Department of Science and Innovation launched its Hydrogen Society Roadmap, which outlines steps to develop 15 GW of electrolyser capacity by 2040.
- Morocco's National Hydrogen Commission published its hydrogen roadmap in 2021. By 2030, the country plans to produce 4 TWH for the local market and 10 TWH for the export market, requiring development of 6 GW of new renewable energy capacity, which could create 15 000 jobs.
- Egypt installed a 100 MW electrolyser project in December 2021 and has plans for a new 100 MW electrolyser facility for production of green ammonia. The country aims to launch its USD 40 billion hydrogen strategy in 2022, which includes plans for 1.4 GW of electrolyser capacity by 2030.

- Chile launched a green hydrogen strategy in 2020. This aims to establish 5 GW of electrolyser capacity in 2025 and 25 GW by 2030, with plans to produce the world's cheapest hydrogen by 2030, and to become one of the world's top three hydrogen exporters by 2040.
- Colombia's National Hydrogen Strategy and Roadmap (2021) outlines plans to facilitate development of a green hydrogen industry, taking advantage of the country's abundant renewable energy potential, and outlining a plan to deliver cost competitive green hydrogen by 2030. The strategy also considers production of blue hydrogen, using CC(U)S to capture emissions, while Colombia's Energy Transition Law describes fiscal incentives for production of green and blue hydrogen.

In addition, a number of advanced economies have established inter-governmental hydrogen agreements to encourage technology, skills and finance transfers, and to secure potential future supply agreements. Germany, for example, has established supply agreements with Australia, Chile, Morocco, Namibia, Tunisia and Ukraine.

Source: (Department of Science and Innovation, South Africa, 2021[41]); (IRENA, 2022[39]); (Davis and Mohamed, 2022[42]); (Ministry of Energy and Mines, Government of Colombia, 2021[43]).

In addition to diversifying the export base, hydrogen currently offers the only viable way to decarbonise hard-to-abate sectors, such as chemicals, steel, haulage, aviation and shipping. These sectors are key to building the necessary demand at scale to increase the commercial viability of the hydrogen industry, and can create a virtuous cycle between decarbonisation efforts and sustainable industrial development. Developing countries with lots of cheap renewables can position themselves as green industrial hubs for hard-to-abate sectors, such as steel and cement, which will need access to abundant green hydrogen and for which global demand will continue to expand in line with the growing global population, industrialisation and urbanisation. The OECD published a *Green Hydrogen Opportunities for Emerging and Developing Economies* report which focuses on business models, including for integrated green hydrogen/green steel projects, and provides a checklist to help policy makers build an enabling environment for implementation of a green hydrogen strategy, addressing barriers to investment as well as assessing financial solutions to support deployment of green hydrogen (Cordonnier and Saygin, 2022[44]).

Integrating domestic hydrogen production into energy systems can help to reduce dependence on exports while decreasing attendant price volatility, and provide grid stability by enabling energy storage. This can help quicken the addition of renewables generation to the grid for countries suffering intermittency issues. Meanwhile, regional co-operation on hydrogen infrastructural development, cross-border regulation and free trade agreements can support demand creation to increase the commercial viability of regional hydrogen industries.

For remote areas with no energy access, or which are reliant on electricity generation from diesel, hydrogen could help reduce the cost of electricity to communities and remote industrial facilities, such as mines. This is because cheaply produced hydrogen from renewables can be trucked or piped long distances, as well as stored on site for later use, generating electricity at the end location far more cheaply than can be achieved by connecting these zones to the grid.

Furthermore, countries whose power systems rely heavily on turbine-generated thermal power can consider replacing diesel and gas with hydrogen through power plant repurposing, thereby reducing the upfront CAPEX requirement for new power projects, providing baseload power and utilising carbon intensive assets which could otherwise become stranded. Indonesia, South Africa, and Trinidad and Tobago are experimenting with replacing diesel-fired power generation with methanol and ammonia alternatives for use in telecommunications towers. Lastly, hydrogen can support the decarbonisation and depollution of urban areas through the replacement of conventional fuels in public transport with fuel cell transport. China, Costa Rica and Malaysia have introduced fuel cell buses, while India is considering requiring refineries and fertiliser plants to incorporate some green hydrogen into their feedstock (IRENA, 2022[39]).

Box 3.8. Financing and business models to facilitate green hydrogen development

Scaling up green hydrogen production will require a massive investment effort. Global estimates point to a range between USD 500 billion and USD 1 500 billion between now and 2030 to put the hydrogen sector on a path consistent with global net-zero emissions by 2050, including investment in green hydrogen manufacturing equipment, production sites and infrastructures for the transportation and distribution of hydrogen. Investments will also be needed across the hydrogen value chain in renewable power generation capacity and grid infrastructure as well as to produce new hydrogen-based products from new industrial processes.

Mobilising this amount of capital will require investors to act today. However, technology costs are high, and reducing them implies a learning curve to reduce them, with years ahead before cost competitiveness is reached. Governments therefore need to establish an enabling environment to mitigate investment risks. Moreover, governments and development finance institutions alike will need to mobilise substantial public financing to encourage the commercialisation of green hydrogen, supported by a strong regulatory framework. Establishing a strong network of partners all along the value chain to collaborate in developing and implementing a suite of innovative financing and business models will provide benefits. However, without the implementation of de-risking instruments, green hydrogen will not be attractive to the private sector.

Governments should identify early opportunities that do not rely on subsidies and other support to create initial markets, particularly in regions endowed with abundant and cheap renewable power, where the production of green hydrogen will already be cheaper than hydrogen produced from natural gas. These can be linked with small-scale projects or niche markets that have a business case while offering an opportunity to learn by doing.

For first movers and large-scale projects, green hydrogen and its products must rely on a mature value chain and existing markets. Economies of scale to reduce costs, along with long-term contracts with first-mover customers willing to pay a premium for green hydrogen and its products, will help accelerate hydrogen development. Here, vertically integrated partnerships, for instance between a supplier of green electricity, a green hydrogen producer and off-takers of green hydrogen can play an important role in sharing the risks among several actors. Additionally, besides a cheap and continuous supply of renewable power, access to water, land and infrastructure will be essential, as they will be decisive factors for those who invest to export green hydrogen products like steel, ammonia and clean synthetic fuels. Regulatory approaches such as mandates and blending obligations can also help create market demand, together with ambitious policies and commitments like green public procurement. These will alleviate the risks, and therefore contribute to creating an attractive environment for investors.

Governments of emerging and developing economies have limited budgetary resources and are constrained in the financing of large projects. The size of the investment envelope for large-scale projects will require diversification of financing sources and risk among actors. Developing the green hydrogen market will necessitate designing specific financing solutions, notably through public-private partnerships and blended finance. Although grants or concessional loans can enable them to bridge the gap to economic viability of projects, it will be critical to bring in project developers and unlock private capital mobilisation. Structural reforms, such as the phase-out of inefficient fossil fuel subsidies or carbon pricing mechanisms, can strengthen the rationale to invest in clean fuels technologies such as green hydrogen rather than in fossil fuels.

Source: (Cordonnier and Saygin, 2022[44]).

However, commercial green hydrogen development in emerging and developing countries will require electrolyser and fuel cell technology to achieve further cost reductions, as well as international partnerships to foster technology transfer to prospective producers. While many developing countries have some background in hydrogen production, this is primarily confined to large firms, and substantial skills and knowledge development will be required to build a competent and skilled labour base, particularly in regard to the deployment of innovative green hydrogen solutions in remote locations.

The power needs for hydrogen production are also enormous – 21 000 TWh by 2050, according to IRENA, equivalent to total power demand today. The water requirements are also very substantial, amounting to 7-9 billion cubic metres under a 1.5°C scenario, equivalent to 0.25% of total freshwater consumption today (IRENA, 2022[39]). Developing countries facing significant energy poverty, as well as those that are water stressed, will need to consider whether investing in hydrogen production is the best use of scarce resources, given parallel social, economic and environmental development objectives.

Lastly, though hydrogen represents an attractive way to diversify exports, it will not be as lucrative as oil and gas, entailing higher levels of competition and lower profits, given that there are fewer limitations on where hydrogen can be produced. This has benefits in terms of global security of supply and price stability, though this may be impacted by disruptions to the supply of critical minerals required for electrolyser and fuel cell production (e.g. platinum group metals and nickel, but also rare earths), and may also mean that countries are less likely to become as dependent on hydrogen exports through the longer term as some have become on oil and gas. Hence, governments should consider hydrogen industry development only as one part of a broader, holistic strategy to diversify away from fossil fuel revenue dependence, and should consider also whether hydrogen is better off being deployed to support decentralised energy provision to alleviate energy poverty, rather than exported.

Governments should consider prioritising the following actions:

- Assess how the hydrogen industry fits into overall economic, social and environmental strategy, given competing challenges such as energy poverty and water scarcity, as well as the high upfront costs of investing in hydrogen (Beswick, Oliveira and Yushan, 2021[45]).
- Assess existing infrastructure, skills and energy trade relationships in determining the feasibility of hydrogen investments. This should be complemented with a gap analysis to understand the investments and technology transfer that would be required to build a competitive hydrogen industry.
- Recognise that hydrogen produced from natural gas with strict methane emissions requirements and CC(U)S should only be considered if the enabling gas infrastructure is already in place. If it is not, governments risk investing substantial capital in investments which could become stranded, unless also used to supply the domestic market.
- Set clear milestones for a gradual transition to green hydrogen as costs come down below the production of hydrogen from abated natural gas. Assess plans for long-term infrastructure against the risks of stranded assets, ensuring any new infrastructure is hydrogen ready and future-proof, for instance ensuring pipeline conversion to hydrogen and biomethane is feasible – accounting for technology requirements and costs from the outset to ensure conversion is possible when costs come down (see also Pillar 2, Section 2.3).
- Recognise that the energy intensiveness of hydrogen production means it needs to be deployed to decarbonise hard-to-abate sectors, such as aluminium, cement, fertiliser, and iron and steel, or to power rural and remote areas first, where there is no alternative.
- Consider the capital-intensive nature of the hydrogen industry, weighing investments against other competing priorities, such as investing in storage for the grid, utility scale projects, and transmission and distribution infrastructure.
- Establish strong private sector dialogue mechanisms to build the right regulatory framework for the hydrogen industry.

- Consider demonstration projects as an effective means to reduce perceptions of risk for the private sector, build domestic skills and knowledge, and drive down costs.
- Consider how regional integration and sharing resources can support the development of a hydrogen industry (power pools, electricity interconnections, demand creation).

Actions requiring international support in contexts where government capacity is low:

- Develop strategies to build long-term technical competency for conversion, handling, and transport of hydrogen and hydrogen derivatives.
- Develop a roadmap with clear signals for demand creation, such as mandates on the industrial use of hydrogen fuel and hydrogen derivatives, and public procurement and certification schemes to provide revenue predictability for hydrogen projects, pulling investment through with demand-side policies to make projects bankable. This may also include investing in equipment to enable the transition from gas to hydrogen, developing business strategies to take advantage of new opportunities and recruiting staff with the right expertise, as well as reinforcing investor confidence in the existence of a market place for low-carbon hydrogen and supporting co-operation between government and industry.

Producer and importer economies together should:

- Establish long-term international partnerships to create a hydrogen development roadmap based on long-term supply agreements, and to foster knowledge, finance and skills transfer. This will allow hydrogen exporters to benefit from revenue smoothing and will ensure capital can be raised affordably, which is essential given that predictable revenue streams are key to project bankability.

Development finance institutions should:

- Provide fossil fuel producer governments with technical support to assess the economic, social and environmental costs, technology transfer requirements, and feasibility of integrating hydrogen development into overarching sustainable development and decarbonisation strategies.
- Support the development of credible rules and standards governing hydrogen production and trading, which transcend national boundaries, and guard against green-washing.

3.2.2. Developing lithium-ion battery value chains

Lithium-ion batteries are set to play an important role in global decarbonisation, enabling a 30% emission reduction in the transport and power sectors, creating significant economic value and quality jobs, and facilitating the roll out of electricity access to unserved areas through combining renewable energy and electricity storage technologies with mini and decentralised grids. Battery demand is set to grow 25% year-on-year, equivalent to a 19-fold increase to reach 2 600 GW in 2030, according to the World Economic Forum's base case scenario. This will be driven mainly by lithium-ion battery use in electric vehicles, which will account for 60% of demand in 2030, when 34 million electric vehicles are expected to be sold worldwide, 45% of which will be in China, as well as its role in facilitating uptake of renewable energy in the power sector through enhancing grid absorption capacity. Between 2015 and 2018, energy storage demand grew between 60% and 70%, with 220 GWh expected to be installed by 2030 (WEF, 2019[46]).

Meeting this anticipated scale-up in demand for battery storage will entail enormous investments across the battery value chain, including mining, refining and beneficiation, cell manufacturing, battery pack assembly and recycling. Of up to USD 440 billion by 2030, some USD 100 billion will be invested in the mining sector and USD 200 billion in cell manufacturing. Demand for cobalt is expected to grow by 4 times, lithium by 6 times and class one nickel by 24 (WEF, 2019[46]). Substantial investments and actions to ensure good governance in the mining sector, as well as comprehensive measures to mitigate negative social and environmental impacts, and to realise tangible local benefits, are crucial (see Pillar 3, Section 3.2.3).

Meanwhile, significant progress will also be required to decrease the carbon footprint of battery manufacturing, reduce the critical minerals requirements in battery technology, and to increase recycling, re-use and refurbishments of batteries and critical minerals to reduce overall demand for new materials and pressure on mine sites. This will necessitate decarbonisation of battery cell manufacturing through the progressive addition of renewables technologies to the grid. In parallel, investment in recycling facilities and innovation in battery design to enable disassembly, which can facilitate recycling and re-use, will be key to the sustainability of battery value chains and enabling their end of life treatment (WEF, 2019[46]).

Developing and emerging economies can position themselves to participate in battery value chains, where possible, collaborating regionally to leverage economies of scale, optimise resource use, build market demand, and eventually upgrade products and service to participate in GVCs. For many developing country minerals producers this could facilitate their transformation from exporter of raw materials to becoming more productive components of the value chain, through beneficiation and manufacturing. For example, batteries represent between 40% and 50% of the value of electric vehicles, with battery cells accounting for 70% of the battery pack. Raw materials represent 50% of the value of cell production, with manufacturing accounting for the remainder (TIPS, 2021[47]).

Box 3.9. Leveraging regional value chains for sustainable transformative development in Africa and Latin America

Increased collaboration to build and strengthen regional value chains can offer emerging and developing countries an opportunity to pool resources, build market demand for new products and services, and to strengthen regional knowledge and expertise, which can encourage innovation and adaptation of products and technologies to local contexts. Through leveraging economies of scale, regional value chain development can also support firms in developing and emerging markets to build competitive advantage, attract investment, and ultimately participate in GVCs through upgrading products and services.

Regional collaboration which leverages natural resource endowments could offer the opportunity to build demand for green products and technologies, such as lithium-ion batteries or alternative low-carbon fuels, so long as environmental and social aspects are effectively integrated into mineral development planning. In sub-Saharan Africa, for instance, the availability of different minerals resources required for lithium-ion battery manufacturing could provide the foundation for collaboration on the development of regional lithium-ion battery value chains. This may include, for example, working towards the development of battery precursor plants and two, three wheelers regional hubs, supported by centres for excellence for advanced battery research to develop the required competencies and skills. Bauxite, for example, is available in Guinea; copper in the Democratic Republic of Congo (DRC) and Zambia; cobalt in DRC, Madagascar and South Africa; manganese in Gabon and South Africa; nickel in Botswana, South Africa, and Zimbabwe; phosphate in Algeria, Egypt, Morocco and South Africa; and lithium in Zimbabwe. To fully realise these opportunities, African developing countries need to put in place an enabling environment to unlock private investment, enhance mineral exploration, attract technology partners and mobilise private capital. At the same time, abundant renewable energy potential in Africa could offer the opportunity to build regional demand for green hydrogen as an alternative to fossil fuels, with countries leveraging electricity interconnections to optimise resource use in hydrogen production for both domestic needs and export.

Despite this potential, however, many regions across the Global South are yet to capitalise on the transformative potential of regional value chains. Intra-governmental trade, for example, in sub-Saharan Africa stands at just 15% of the continent's total trade. The African Continental Free Trade Area (AfCFTA), which came into force in January 2021, can foster the development of regional value chains, including through addressing non-tariff barriers, creating of improved intra-regional infrastructure and

transport networks, and supporting firms to work across borders and attract investment by providing them with access to greater markets.

Likewise, many countries in Latin America that have substantial reserves of critical minerals will be well-placed to take advantage of growing global demand. There is potential for the creation of lithium battery and electric vehicle hubs in the region, incorporating a life cycle approach to critical minerals, good governance in the mining sector, and the development of sustainable and responsible value chains. Enhanced co-operation between mining and manufacturing companies across the region will be necessary to pull together the technology, qualified human resources and materials (40 different elements) needed to produce lithium batteries and electric vehicles (EVs), which can all be found in the region in the necessary quantities and qualities. Forging alliances with global battery and EV manufacturers will be key to deploying best available technologies and encouraging knowledge transfer.

Source: (AUC/OECD, 2022[48]); (BloombergNEF, 2021[49]) and authors.

Cell manufacturing is currently dominated by a few firms in a few economies, mainly limited to China, Japan, South Korea and the US. Developing and emerging economies are unlikely to be able to compete in terms of research and development and innovation, or on skills and knowledge, yet there are opportunities for them to participate elsewhere in the battery value chain.

South Africa, for example, in 2011 launched its Energy Storage Research, Development and Innovation Programme, consisting of several universities, to identify opportunities for the country to participate in global battery value chains. Initially focusing on research and development and innovation, the programme shifted focus to leveraging South African comparative advantage in minerals processing and beneficiation, as well as battery pack assembly, on the basis that, initially at least, South African firms would struggle to compete with global technology leaders without substantial investments in knowledge and skills (TIPS, 2021[47]).

The consortium has identified regional collaboration on resources, including lithium, cobalt, manganese, nickel, graphite, bauxite, copper, iron, phosphate and titanium, all of which are available on the African continent, as an opportunity to underpin battery value chain development, as well as domestic comparative advantage in minerals beneficiation as key opportunities for scale-up. In South Africa, beneficiation to battery standards currently does exist for manganese and aluminium, but not other metals. The Manganese Metal Company currently refines manganese ore into manganese metal, including for use in lithium-ion batteries, and is the only supplier of electrolytic manganese metal not in China, while Hulamin, an aluminium semi-fabricator, is an existing producer of a number of lithium-ion battery-related products. Additionally, some South African firms are able to undertake battery assembly using imported cells. From August 2021, South Africa will ban hazardous e-waste, including lithium-ion batteries, in landfills, while planned investments in waste management, including a pilot recycling facility, will improve the country's capability to undertake end-of-life treatment (TIPS, 2021[47]).

Governments should consider prioritising the following actions:

- Consider establishing a cross-disciplinary body, including industry, educational institutions and government bodies, to assess assembly and potential future manufacturing capacity in the lithium-ion battery value chain, based on existing industries and resource endowments.
- Review the policy and regulatory framework to encourage growth and innovation in selected segments of the lithium-ion battery value chain (i.e. assembly, manufacturing of pre-battery precursors, repair, refurbishing and recycling). Government policy should aim to cut red tape, lower barriers to market entry, facilitate access to information on market potential and improve access to finance for firms, where necessary. Tax subsidies on research and development can also encourage firm innovation, but should be combined with regular ex-post evaluation of support

provided to ensure effective use of available resources and redirect support when it proves not to be working.

- Consider the potential for regional collaboration, including investment in trade related infrastructure, commitment to free trade, regional integration, removal of non-tariff barriers, pooling of resources and collaboration on skills and knowledge development, to help build a market for lithium-ion battery parts and collaborate on manufacturing and research and development. Public procurement, particularly on a regional basis, given its scale and capacity to provide market signals, could also be used to create regional and national demand.

3.2.3. Developing a responsible mining sector and sustainable critical minerals value chains

Growing demand for critical minerals, metals and rare earth elements can offer mineral-rich developing and emerging economies an opportunity to invest in the mining sector as an engine for sustainable growth, economic diversification and localised development. Twenty-three critical minerals are vital to the deployment of solar panels, wind turbines, electric vehicles, battery storage, hydrogen electrolysers and fuel cells, and demand for them is forecast to grow rapidly through to 2050. For instance, the World Bank estimates that demand for minerals required for solar, including copper, iron, lead, molybdenum, nickel and zinc, could increase by 300% in 2050 under a 2°C aligned scenario (Hund et al., 2020[50]). Furthermore, the production of graphite, lithium, and cobalt will need to increase by more than 450% by 2050 to meet demand from energy storage technologies (Hund et al., 2020[50]), with over USD 1 trillion in global mining investments required by 2035 (Wood Mackenzie, 2020[51]). In fact, if advanced economies in Europe and the United States were to maintain the same levels of consumption, currently known resources or planned mines could supply only about 50% of the lithium and 80% of the copper required for electric mobility and renewable energy generation globally (FT, 2022[52]).

Much of this rapid increase in mining activities will occur in developing countries. For the global low carbon transition to succeed, advanced economies will need to form partnerships with developing countries to support cleaner, better-governed mining extraction activities for the next several decades (The Hill, 2022[53]).

For fossil fuel-based emerging and developing economies with substantial reserves of critical minerals and metals, and whose labour force could relatively easily transfer from fossil fuels jobs to mining jobs with limited reskilling required, mining development represents an attractive opportunity, particularly given US and EU efforts to diversify and build more resilient and sustainable global supply chains to minimise the risk of supply disruption.

Latin America, with Chile, Brazil, Peru, Argentina and Bolivia is well placed to meet the demand for critical minerals for the low-carbon transition, while in Asia, Indonesia, Philippines and Malaysia have significant reserves of bauxite and nickel, and India is a major producer of iron, steel and titanium (Arrobas et al., 2017[54]). Africa is also well placed to meet supply of critical minerals, and holds substantial reserves of bauxite, chromium, cobalt, copper, gold, iron, lithium, manganese, platinum and uranium. The DRC, South Africa, Zambia, and Zimbabwe are home to substantial reserves of copper and cobalt. Platinum can be found in South Africa and Zimbabwe; uranium in Namibia, Niger and South Africa; gold in Ghana, South Africa and Sudan; iron in South Africa; manganese in Gabon, Ghana and South Africa; bauxite in Guinea and lithium in Zimbabwe (EIU, 2022[55]). However, many of the locations in which there are substantial reserves of the 23 most relevant minerals and metals and rare earth elements to the transition are also hotspots for fragility and conflict, with many of these concentrated in Latin America, Southeast Asia and sub-Saharan Africa. For example, human rights abuses, child labour and pollution are well documented in eastern DRC, an area which produces 63% of the world's cobalt, a key material for electric vehicle manufacturing, and where 20% of mining takes place through artisanal and small-scale mining (ASM); while extraction of nickel in Guatemala, an important metal in solar panels and energy storage, has been linked to violence and forced displacement (Church and Crawford, 2018[56]).

Good governance of the mining sector

Ensuring that mining contributes to sustainable development requires robust regulation, laws and policies for the mining sector, as well as equitable revenue generation, distribution and use, underpinned by institutions in charge of effective implementation and enforcement (Church and Crawford, 2018[57]).

Governments in mineral-rich developing countries should develop a holistic and integrated governance framework that covers the entire value chain of the extractive sector, from geological mapping, mineral exploration, mine development, mining, mineral processing and refining, ore transportation, manufacturing of end-use products, to recycling and mine closure (IRP, 2020[58]). The success of a sustainable mining sector should be measured based on the strength of its economic outcomes but equally on the existence of sound environmental management, respect for the rights and interests of affected stakeholders, and observance of the highest governance and transparency standards (IRP, 2020[58]).

Box 3.10. The Sustainable Development License to Operate: Moving toward an integrated and inclusive mining governance framework

The International Resource Panel in its report Mineral Resource Governance in the 21st Century: Gearing Extractive Industries Towards Sustainable Development, calls for moving beyond the established paradigm of the "Social License to Operate", towards a new governance reference point that enables public, private and other relevant actors in the extractive sector to make decisions compatible with the 2030 Agenda's vision of sustainable development.

The new governance framework is referred to as the "Sustainable Development License to Operate", and extends the Social License to Operate in several important ways. It addresses a broader subject matter integrating all pillars – people, planet, prosperity, peace and partnership – of sustainable development, and sets out principles, policy options and good practices for enhancing the extractive sector's contribution to achieving the SDGs.

The Sustainable Development License to Operate is designed to improve the net societal benefits of mining, and is not necessarily meant to function as a licence in the compulsory or regulatory sense. It addresses a broader subject matter covering the nexus of all environmental, social and economic concerns that fall within the remit of the SDGs and related targets. The concept is relevant to all actors in the extractive sector across the public, private and civil society sectors; its implementation is a shared responsibility across nations and different actors along the minerals value chain; and it sets out not only minimum standards of practice, but also a set of internally consistent principles, policy options and good practices for enhancing the extractive sector's contribution to achieving the SDGs.

Source: (IRP, 2020[58]).

While price fluctuations and commodity cycles are standard attributes of the minerals sector, these can be further exacerbated by the specific characteristics of the energy transition, including technological breakthroughs, mineral substitution and improved recycling rates. Governments in mineral-rich developing countries should recognise that natural resource revenues are volatile as restrictive trade policies, sanctions and regional and global conflicts can also create supply shortages and influence pricing. This volatility has implications for revenue management and spending, as it is difficult for governments to anticipate future revenues flows and use those revenues effectively.

To manage the counter-cyclical nature of resource revenue flows and ensure the availability of a consistent level of resources for spending, governments should establish a clear and consistent fiscal policy framework coupled with a commitment to sound macroeconomic management of natural resource

revenues. For example, stabilisation funds can help protect the economy when commodity markets collapse and revenues from natural resources decline by ensuring long-term fiscal sustainability that supports long-term development objectives. Stabilisation funds should be integrated into the budget through clear rules regarding the deposit of natural resource revenues, and the withdrawal of money for use in government spending and investment (OECD, 2019[59]).

The projected expansion of mining for critical minerals could increase the risk of corruption. For mineral-rich countries, corruption poses a major threat to sustainable development. The increasing global competition for access to natural resources, high rents generated by resource exploitation and the "gate-keeping" function performed by governments, combined with discretionary powers, and limited competition among key economic players are among the factors that increase the exposure of the mining sector to corruption. Consequently, governments in mineral-rich developing countries should ensure that corruption risks are mapped at each stage of the value chain, and that their legal and institutional framework is equipped to eliminate or mitigate these risks to the greatest extent possible across a broad spectrum of inter-connected policy areas, including licensing, procurement, tax issues and public financial management (OECD, 2016[60]).

In particular, governments in mineral-rich developing countries should set out a robust regulatory regime for the granting of mining exploration and production rights. It is recognised that a robust legal framework with comprehensive laws and regulations, setting out conditions of general application for extractive operations and limiting the scope for project-specific negotiated terms, provides a stronger foundation upon which a country can manage its extractive industries according to national priorities (OECD, 2020[61]).

Governments should ensure that beneficial ownership information is required and assessed. This can help reduce corruption by identifying whether mining contracts have been awarded to entities that involve politically exposed persons. The public disclosure of signed mining contracts can also add an important dimension of accountability to the licensing process by identifying any deviation from standard terms and conditions, any company receiving undue favourable treatment, or any instances where decision makers have granted contracts to companies where there is a conflict of interest. Contractual transparency is increasing globally, and since January 2021, all countries implementing the EITI Standard are required to publish new and amended contracts, licenses and agreements concluded with extractive companies (EITI, 2019[62]).

Rapid increases in demand for lithium, cobalt, copper and rare earth elements pose the greatest risks from an environmental and social standpoint. Cobalt, aside from human rights abuses, is often associated with air and water pollution, and soil contamination, as well as health impacts for miners and surrounding communities, particularly given much of the mining is non-mechanised and takes place in dangerous conditions. Lithium and nickel can contaminate water, while rare earth processing entails the use of hazardous chemicals and substantial production of waste materials (Dominish, Florin and Teske, 2019[63]).

The scaling up of due diligence and certification schemes will be key to enhancing supply chain transparency, enforcing social and environmental safeguards and putting pressure on upstream and processing companies to implement better practices. Building on existing international standards, legislation and due diligence schemes for responsible sourcing of minerals from conflict-affected and high-risk areas, new forms of international cooperation and upgraded standards need to be developed to cater to the green critical minerals sector, as well as the recycling and waste management industries, while strong and concerted government action on both the supply and demand side is necessary to tackle waste, pollution and environmental damage, and human rights abuses.

Box 3.11. Aligning with the global benchmark: OECD standards on responsible business conduct (RBC)

Businesses, especially those engaged in supporting the low-carbon transition, can make a positive contribution to sustainable development, provided they address the potential adverse impacts linked to their activities or supply chains. The OECD Guidelines for Multinational Enterprises are the only multilaterally agreed and comprehensive code of responsible business conduct that governments have committed to promoting. In order to foster implementation of the Guidelines, the OECD has developed several government-backed standards on supply chain due diligence, including in the extractives sector. Importantly, these standards address potential adverse impacts along the whole value chain, including along transport, trading and processing.

A burgeoning architecture of regulatory and market expectations has taken shape around OECD standards on RBC, particularly in the minerals value chain. Legislation and industry norms incorporating RBC standards and concepts have been adopted in OECD countries like Colombia, France, Germany, the UK and the US as well as by the EU and non-OECD countries that play critical roles in mineral supply chains including China, the DRC, Rwanda and the United Arab Emirates. Premier exchanges and trading hubs including the Dubai Multi-Commodities Centre, the London Bullion Market Exchange, the London Metal Exchange and the New York Mercantile Exchange have incorporated OECD standards into their sourcing requirements.

The OECD carries out Alignment Assessments against OECD due diligence standards of industry schemes and multi-stakeholder initiatives set up partly to help companies comply with such requirements. Anchoring policies to support the development of a responsible mining sector in these global benchmarks will promote coherence and help avoid fragmentation in certification systems.

- **The OECD Guidelines for Multinational Enterprises (MNE Guidelines)** provide principles and standards for responsible business conduct in a global context consistent with applicable laws and internationally recognised standards.
- **The OECD Due Diligence Guidance for Responsible Business Conduct** provides plain-language explanations of the MNE Guidelines' due diligence recommendations to help enterprises avoid and address adverse impacts related to workers, human rights, the environment, bribery, consumers and corporate governance that may be associated with their operations, supply chains and other business relationships.
- **The OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas** provides detailed recommendations to help companies respect human rights, prevent corruption and financial crime and avoid contributing to conflict through their mineral purchasing decisions and practices.
- **The OECD Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractive Sector** provides practical guidance to mining, oil and gas enterprises in addressing the challenges related to stakeholder engagement related to social, economic and environmental impacts.
- The handbook **Frequently Asked Questions: How to address bribery and corruption risks in mineral supply chains** provides practical answers to frequently asked questions on how companies can identify, prevent, mitigate and report on risks of contributing to bribery and corruption through their mineral sourcing.

Source: (OECD, 2011[64]); (OECD, 2018[65]); (OECD, 2013[66]); (OECD, 2017[67]); (OECD, 2021[68]).

As perceptions around the economic value of critical minerals are heightened, this may lead to calls for greater state participation in the mining sector, where the involvement of SOEs could increase risks related to revenue mismanagement, corruption, and environmental and social impacts (EITI, 2022[69]). This may involve SOEs securing larger stakes in mining projects or having more stringent requirements related to domestic processing and local content. Governments may also consider investing in certain critical minerals up to the pre-feasibility level, as this would allow the state to use its share of the minerals as feedstock for vertically integrated operations. For example, the DRC plans to build a 10 000 metric-tonne cathode precursor plant to leverage its abundant cobalt resources and hydroelectric power, and to become a low-cost and low-emissions producer of lithium-ion battery cathode precursor materials (BloombergNEF, 2021[49]).

Without adequate safeguards, state participation can exacerbate many governance challenges. In particular, the sale of publicly owned minerals can have a significant impact on the development trajectory of resource-rich developing and emerging economies due to the large volume of commodities sold and the amount of money involved. Governments of mineral-rich developing countries should ensure that their SOEs are mandated and resourced to carry out transparent and competitive buyer selection procedures that reduce discretion and close opportunities for corruption (OECD, 2020[70]).

Box 3.12. National mining companies: A driver or a barrier to the development of a responsible mining sector?

Although not as prevalent as NOCs, national mining companies (NMCs) play a significant role in many mineral-producing countries, including in Botswana, Chile, Eritrea, Guinea, Kenya, Mongolia, Morocco, Myanmar, Namibia, South Africa, Zambia and Zimbabwe.

Many NMCs were privatised during the 1980s and 1990s due to pressure from international financial institutions in response to low prices, high financing costs, and low productivity due to mismanagement of the NMCs themselves. However, there is now a trend towards greater state control in the mining sector – driven through growth in state-controlled mining and smelting in China and in response to the expected demand for critical minerals.

The success of NMCs has been mixed. In some case, they have been effective vehicles for the development and implementation of government policies. For example, in Chile, Codelco, which emerged from the nationalisation of foreign-owned companies in 1971, now produces 10% of the world's refined copper, has contributed USD 102 billion to the Chilean state, and sells its own production, both cathodes and copper concentrate, to international buyers including BMW, Nexans and Mitsui. Codelco uses transparent pricing formulas and determines the price of copper based on market prices set by the London Metals Exchange (LME). It has implemented standards to regulate various aspects of the company's activities (including commercial relations, conflicts of interest and business with politically exposed persons) based on international best practice. In Morocco, OCP is a world leader in phosphate production and is well placed in the Resource Governance Index (75/100). In Botswana, Debswana and Okavango Diamond Company have been recognised for their governance and positive contributions to development.

In other cases, NMCs have fostered inefficiency, revenue shortfalls and corruption. For example, the 2017 Resource Governance Index found that 72% of NMCs do not disclose sufficient quality, timely information about their activities and finances to enable proper external assessments to be carried out. NMCs are also less transparent on average than NOCs. For example, in the DRC, decades of corruption, underinvestment and lack of maintenance led to a general decay of mining infrastructure, and an investigation into Gécamines found a systematic undervaluation of assets that were sold on average at one-sixth their commercial market value, costing the state at least USD 1.36 billion from

2010 to 2012. Despite these developments, Gécamines retains de facto power to select private partners for the projects in its portfolio, and contracts are awarded without due process, leading to cases of suboptimal selection of partners, corruption, and further losses to the state.

Source: (RCS Global, 2018[71]); (Manley and Wake, 2015[72]); (Bauer, 2018[73]).

Collaboration between governments, the private sector, local communities and civil society organisations is crucial in order to leverage the extractives sector to catalyse long-term, competitive, diversified and, sustainable development. Communities can benefit through equitable revenue distribution and spending. In the past, taxes and royalties from mining operations were collected by the central government and local communities saw little direct benefits from those revenues. However, over the last decade several countries have introduced regulations to share those mining proceeds between central government, regional/local authorities, and communities. For example, in Ghana, the Mineral Development Fund collects all royalties on behalf of the government and then distributes them to local authorities, central governments and communities. Governments should recognise that it may not always be possible to fully maximise financial, economic, social and environmental benefits in the same timeframe, but all benefits should be incorporated into the objectives of the project over its life cycle (OECD, 2020[61]).

Through integrated planning, mining projects can serve as an anchor for power generation, local procurement of goods and services, and shared use of infrastructure. Governments should set out a framework to foster direct and local entrepreneurship through the local provision of goods and services, and enable the development of other sectors or segments of production that can support the creation of a diversified economy. Governments should first seek to understand the mining industry, its production and market structure, and consider how the country can position itself well along regional and global value chains. Subsequently, they should aim to support local firms to comply with international standards and industry requirements, in order to generate in-country shared value opportunities (OECD, 2016[74]).

Another area where local communities can benefit is through skills development and employment. Mining can contribute to building human capital through direct training and education of the workforce by the private sector. Governments should note however, that with increasing technological developments, mines are likely to be more mechanised and require less employees. Governments may consider encouraging the establishment of local employee ownership schemes where local employees and/or communities are given an ownership stake in the mining projects through shares in the mining company or joint venture.

Mining projects are often located in remote or underdeveloped areas and mining companies will need to construct a significant amount of infrastructure to support the mine. This may include roads, airstrips, water, electricity and sanitation systems, as well as health and accommodation facilities. Governments should encourage the shared use of infrastructure so that local communities can also benefit. In addition, infrastructure requirements should be integrated into local and national planning as well as set out in the mining licence/contract.

Governments may require or encourage the use of benefit sharing agreements between mining companies and local communities, including Indigenous Peoples, to establish a clear process for engagement. Benefits may include payments, profit sharing, local hiring, skills development, education, cultural support, and environmental protection and remediation (Raderschall, Krawchenko and Leblanc, 2020[75]).

Governments in mineral-rich developing countries should also consider the role that renewable energy can play in a sustainable mining sector as there are opportunities to integrate off-grid electricity generation solutions into mining operations, which often represent a significant share of resource-rich countries' final energy consumption (IEA, 2017[76]). As an example, in 2014, the mining and quarrying sector accounted for 38% of total electricity consumption in Chile. Due to the increasing competitiveness of renewable energy technology, solar and wind power solutions have become increasingly attractive to the mining industry,

with Latin America, particularly Chile and Mexico, leading the way in the integration of utility-scale renewable energy projects for mines (Alova, 2018[77]).

A sustainable mining governance framework should also consider the end of life of the mine – including environmental remediation, and any future industrial use of the site. For example, solar arrays and wind turbines can be installed at closed mining sites, where mines are located in close proximity to power lines, enabling grid connection. The conversion of mining sites to renewable energy can offer local communities and businesses an opportunity for revenue, employment and continued economic growth, while also contributing to the low carbon transition (Church and Kuehl, 2022[78]).

Mineral-rich developing countries can draw from a number of mining governance initiatives and standards when developing their legal frameworks (see Box 3.13). A mapping of mining governance initiatives and standards by the International Resource Panel in 2020 identified over 80 initiatives – ranging from comprehensive policy frameworks to platforms for dialogue; from legally binding initiatives backed by United Nations sanctions and national laws to voluntary initiatives; and from single stakeholder-led to multi-stakeholder platforms that bring together many types of stakeholders (IRP, 2020[58]).

Box 3.13. Selected key mining governance initiatives

Africa Mining Vision

The Africa Mining Vision (AMV) sets out a comprehensive governance framework that extends beyond the mining sector. The AMV seeks to integrate mining into industrial and trade policy and to extricate Africa from its historical role as an exporter of raw materials to become a manufacturer and supplier of knowledge-based goods and services.

It sets out a developmental approach meant to break mining enclaves by fostering economic and social linkages between the extractive sector and other sectors of the local economy, promoting resource-based industrialisation and economic diversification, developing socio-economic infrastructure for broader use and accelerating regional integration.

EITI Standard

The Extractive Industries Transparency Initiative (EITI) Standard provides a framework and a process for promoting greater transparency and accountability in the oil, gas, and mining sectors. The EITI Standard requires the disclosure of information along the extractive industry value chain, from how extraction rights are awarded, to how revenues are managed and allocated by government.

By so doing, the EITI seeks to foster multi-stakeholder collaboration, promoting a healthier and more accountable sector that can play a positive role in development.

Model Mine Development Agreement

The Model Mine Development Agreement is an output of the Mining Law Committee of the International Bar Association. It sets out a collection of examples from existing mine development agreements and other materials to help negotiators and drafters reflect on some of the difficult issues of legality, fairness and balance presented by large foreign natural resource investment, particularly in developing countries.

The final product is web-based and publicly accessible. It is not “prescriptive” in the sense of setting out one standard form; rather, it seeks to provide an agenda for negotiations based on a sustainable development objective that is common to all parties.

Mining Policy Framework

The Mining Policy Framework is an output of the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), and sets out concrete objectives and processes to achieve good governance in the mining sector, and to effectively advance sustainable economic development and reduce poverty. As a non-binding policy guidance tool, the MPF lays out international best practice across six key pillars of mining law and policy.

Natural Resource Charter

The Natural Resource Charter is an output of the Natural Resource Governance Institute (NRGI), and offers policy options and practical advice for governments, societies and the international community on how best to manage resource wealth.

To help governments make decisions, the charter contains 12 precepts. The first 10 precepts elaborate guidance on how a country and its government might manage natural resources. The last two precepts speak to international actors – extractive companies and those responsible for international governance.

Source: (African Union, 2009[79]); (EITI, 2019[62]); (IBA, 2011[80]); (IGF, 2013[81]); (NRGI, 2014[82]).

Governments should consider prioritising the following actions:

- Develop a holistic and integrated governance framework that covers the entire value chain of the extractive sector. This should encompass accountability and transparency, licensing and permitting, taxation, local impacts, revenue distribution, government spending and environmental safeguarding (NRGI, 2014[82]); (IRP, 2020[58]).
- Ensure that they have the core institutions needed to promote and regulate the minerals and metals industry. This may include a Geological Survey, a Mining Directorate and an Environmental Directorate/Agency. In the case of developing countries, governments should assess the possibility of sharing some key resources/expertise at the regional level with the support of regional institutions (IRP, 2020[58]).
- Undertake geological mapping and/or invest in the acquisition of geological data to understand the extent of endowments of critical minerals and rare earth elements and present geoscience data in an accessible way to attract private sector investment.
- Assess the potential role of mining as part of a broader development strategy. National mineral policies and strategies should be aligned with the SDGs, and should consider the risk of environmental degradation and human rights abuses, and the cost of investing in enabling infrastructure (IRP, 2020[58]).
- Consider the full life cycle of natural resource developments and their value chains when identifying in-country shared value opportunities (OECD, 2016[74]).
- Set up mechanisms to ensure the benefits of the mining industry are shared in a way that is equitable, fair and visible at the local level (Church and Crawford, 2018[57]). The OECD's Toolkit for Mining Regions Well-being provides a tool to help identify the main strengths and challenges on well-being in mining regions, assessing economic, social and environmental dimensions (OECD, 2021[83]).
- Ensure that non-revenue generation benefits (taxes and royalties) are fully considered and explored. Mining projects can serve as an anchor for renewable energy and power generation, local procurement of goods and services and shared use of infrastructure.

- Set out a framework for the mining sector to foster direct employment and local entrepreneurship through the provision of goods and services, to encourage the shared use of infrastructure and innovation, and enable the development of other sectors or segments of production that can support the creation of a diversified economy (OECD, 2016[74]).
- Support local firms to comply with international standards and industry global requirements for quality and price, including through the adoption of, and compliance with certification standards (OECD, 2016[74]).
- Explore opportunities for the mining sector to provide electricity off-take in remote areas not covered by the grid, where feasible, supporting roll out of energy access to surrounding communities as a core component of the national development strategy.
- Integrate supply chain due diligence requirements into mining sector regulation and legislation for transition critical minerals, in line with the recommendations set forth in the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (OECD, 2013[66]).
- Clarify specific avenues and/or further institutionalise regulatory approaches that promote LSM-ASM co-operation on industrial concessions in order to ensure consistency for production sharing or supply agreements, reduce uncertainty around the business environment and make it more attractive to LSM operators to work with artisanal miners on a commercial basis (OECD, 2019[84]).
- Create economically viable artisanal exploitation zones. This may include the demarcation of land plots suitable for ASM activities. Viable artisanal exploitation zones also require regulatory approaches that attract investors, partners and customers to help carry out overburden removal and mine planning (OECD, 2019[84]).
- Set out a clear and consistent fiscal policy framework coupled with a commitment to sound macroeconomic management of natural resource revenues with properly sized stabilisation funds. This can help to insulate the economy from price, production or other external shocks and ensure medium- and long-term fiscal sustainability that supports long-term development objectives (OECD, 2019[59]).
- Set out a robust regulatory regime for the awarding of mining exploration and production rights, and use bid rounds where relevant (OECD, 2020[61]); (IRP, 2020[58]).
- Undertake a mapping of corruption risks at each stage of the value chain and ensure that the legal and institutional framework is equipped to eliminate or mitigate these risks to the greatest extent possible across a broad spectrum of inter-connected policy areas, including licensing, procurement, tax issues and public financial management (OECD, 2016[60]).
- Ensure that SOEs are mandated and resourced to carry out the buyer selection process without suffering public revenue losses through sub-optimal allocation and corruption (OECD, 2020[70]).

Actions requiring international support in contexts where government capacity is low:

- Develop scenario and sensitivity analysis capacity to understand future demand and prices, and what this means for the economics of a proposed mine. This effort requires both commodity-specific expertise and modelling expertise, which may not always be available in-house. The resulting analysis should include related economic spillovers: local employment, local inputs of goods and services, shared use of infrastructure, social development benefits of a project, etc. (Toledano et al., 2020[85]).
- Establish stabilisation funds to provide a financial buffer when commodity markets collapse and revenues from natural resources decline. These funds should be integrated into the budget through clear rules regarding the deposit of natural resource revenues, and the withdrawal of money for use in government spending and investment (OECD, 2019[59]).

- Identify changing trends in global consumption and production patterns (progressive ore grades decline and increasing labour, transport, energy, processing, capital/ equipment costs), changes to end uses for minerals (innovation in final products), and carbon emissions trading (OECD, 2016[74]).

Development finance institutions should:

- Form partnerships with developing countries to ensure cleaner, better-governed mining extraction activities to support the global low carbon transition during the next several decades.
- Provide technical support to governments to improve mining sector governance throughout the mining life cycle.

Government and the mining industry together should:

- Expand existing supply chain regulations to apply to green transition minerals. Priority should be given to cobalt, lithium and rare earths, due to projected rapid increases in their demand and their importance to the low-carbon transition (Church and Crawford, 2018[57]).
- Engage proactively and constructively with ASM to address risks of conflict and improve access rights and security conditions. Potential options include assigning land in LSM concessions to ASM; developing and implementing training programmes and technical assistance to improve safety, extraction and processing techniques; promoting health and safety; and providing mining equipment to improve health and safety and extraction and processing techniques to improve efficiency and limit waste (OECD, 2019[84]).
- Engage with local multi-stakeholder groups to reach a consensus on how to integrate ASM into the formal mining sector, including addressing informal fees, generating payments for regulatory services and formalising the role of ASM cooperatives (OECD, 2019[84]).
- Collaborate to leverage the extractives sector to catalyse long-term, competitive, diversified and, sustainable development, including by ensuring that local communities impacted by mining are also beneficiaries, determining which types of infrastructure and power projects need to be built to support mining operations, ensuring the sustainable use of water and creating opportunities to roll out power access based on mining (OECD, 2016[74]).

The mining industry should:

- Identify areas for pre-competitive collaboration with industry peers and stakeholders, including major contractors and suppliers to catalyse the mining sector for sustainable development (e.g. collective identification of skills requirements and solutions to common environmental challenges) (OECD, 2016[74]).
- Evaluate the potential to unbundle contracts for services and supplies, to support the creation of enhanced opportunities for local businesses, in particular SMEs (OECD, 2016[74]).
- Evaluate the potential to make advance purchase orders and forward purchase agreements or implement other mechanisms that could help facilitate the integration of local suppliers in extractives sector value chains (OECD, 2016[74]).
- Publicly report on environmental and social risks in the value chain and how these are being addressed (OECD, 2013[66]).
- Renewable energy technology manufacturers and electricity vehicle manufacturers should engage with upstream mining and processing companies to improve social and environmental practices through improvements to transparency, reporting on supply chain risks and response plans.
- Engage communities in a meaningful way across the mineral life cycle. Incorporate the views of stakeholders and local communities using best practice tools, for example, IFC Performance Standards on Assessment and Management of Environmental and Social Risks and Impacts.

- Adopt international best practice on tailings management through adherence to the Global Industry Standard on Tailings Management (Global Industry Standard on Tailings Management, 2020[86]).
- Undertake risk-based due diligence in line with the OECD Due Diligence for Responsible Supply Chains of Minerals to identify, prevent and mitigate risks of corruption deeper in the supply chain, potentially outside the scope of criminal liability, but nonetheless directly linked to company operations. Industry should then publicly report on those risks, regardless of the requirements of home country legislation (OECD, 2021[68])
- Consider the future industrial use of the site at the post-mining stage. The conversion of mining sites to renewable energy can offer local communities and businesses with an opportunity for revenue, employment and continued economic growth, while also contributing to the low carbon transition (Church and Kuehl, 2022[78]).

Circular economy approach

A transition to a circular economy can play a key role in reducing demand for minerals and metals, which, in turn, can mitigate and reduce the harmful environmental and social impacts often associated with resource extraction. A circular economy approach is grounded in energy efficiency, re-use and recycling of material inputs to reduce pressure on mineral extraction, with a view to building a more resilient global economy and reducing vulnerabilities (FT, 2022[52]). Alongside, advanced economies, several developing countries have adopted initiatives incorporating circular economy principles. For example, in 2017 Nigeria, Rwanda and South Africa launched the African Circular Economy Alliance, to share best practices for the design and implementation of regulatory frameworks that promote the circular economy (UNEP and IRP, 2020[87]).

However, mineral-rich developing countries should consider carefully the implications of the implementation of circular economy principles in advanced economies – especially in terms of reduced demand for minerals and metals and the corresponding loss of export earnings. In its Circular Economy Action Plan, the EU has set a goal to double the use rate of circular material by 2030. Many new mines are scheduled to come into production during this timeframe, and their economic viability could be significantly impacted if the EU reaches its target and reduces its demand for primarily extracted materials from the developing world (Toledano et al., 2020[85])For example, a study assessing the impact of an EU-wide transition to a circular economy on the region's raw material trading partners found that 24 developing countries rely on raw material exports to the EU for between 1% and 8% of their GDP (UNEP and IRP, 2020[87]). In order to mitigate the risk of lost export earnings, mineral-rich developing countries should adopt policies to capture a greater share of value by adding value to the extractive products before they are exported, as well as diversifying their economies including into emerging sectors such as recycling and renewables (UNEP and IRP, 2020[87]).

The scaling up of recycling and re-use can offer a viable job creating industry in its own right. A key part of the circular economy is the recycling and re-use of electronic waste (e-waste).

Global e-waste is projected to reach 120 million metric tonnes per year by 2050, and with less than a 20% formal recycle rate, the annual value of global e-waste is over USD 62.5 billion. Consequently, the circular economy can provide potential opportunities for developing countries to reuse their own mineral consumption through the re-use and recycling of e-waste. For example, the Nigerian government, along with the Global Environment Facility and the UNEP have initiated a project to build a formal e-waste recycling industry in Nigeria (Toledano et al., 2020[85]).

However, the processing of e-waste carries significant health and environmental risks for developing countries, as e-waste may contain several hazardous materials, such as lead, mercury, cadmium and arsenic. Many developing countries lack effective policies and robust infrastructure for the processing and management of e-waste, which can cause hazardous materials to leach into the land or atmosphere if proper processing techniques are not followed (Bazilian, 2020[88]); (Parajuly et al., 2019[89]).

Furthermore, developing countries are often used as a dumping sites for unwanted e-waste from advanced economies. In recent years, some advanced economies have taken steps to reduce this trade. The European Union adopted a directive on e-waste in 2012 (Directive 2012/19/EU on waste electrical and electronic equipment, WEEE), that forbids exports of hazardous e-waste to countries that are not members of the EU or the OECD. Furthermore, since 2019, the export of e-waste from advanced economies to developing countries is also prohibited by international law (Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Annex VII.) (European Court of Auditors, 2021[90]).

However, despite the existence of EU and international regulations, this trade continues. Illegal e-waste shipments are often misclassified as "used equipment" rather than waste in order to escape legal requirements, as there are economic incentives for the trade and a low risk of getting caught (IISD, 2021[91]). A 2017 experiment by the NGO Basel Action Network tracked 314 items of e-waste in ten EU Member States. Eleven items ended up in seven different non-OECD countries and territories including Ghana; Hong-Kong, China; Nigeria; Pakistan; Tanzania; Thailand and Ukraine. In another example in 2020, Spanish police dismantled an organised criminal group responsible for illegally shipping over 750 tonnes of hazardous e-waste from the Canary Islands to Africa (European Court of Auditors, 2021[90]).

Governments should consider prioritising the following actions:

- Adopt policies to capture a greater share of value by adding value to the extractive products before they are exported to account for the reduced demand for minerals and metals and the corresponding loss of export earnings (UNEP and IRP, 2020[87]).
- Invest in the critical minerals recycling and re-use industry as a component of an economic diversification strategy. The circular economy can provide potential opportunities for developing countries to re-use their own mineral consumption through the reuse and recycling of e-waste (Toledano et al., 2020[85]).

Actions requiring international support in contexts where government capacity is low:

- Develop a robust regulatory framework for the protection of the environment and human health, through the sustainable management of e-waste (Perry et al., 2019[92]).
- Ensure that e-waste legislation is aligned with internationally recognised conventions, such as the Basel Convention, and internationally recognised recycling standards (Perry et al., 2019[92]).

Development finance institutions should:

- Integrate support for circularity initiatives into development assistance, such as Aid for Trade. This could be harnessed to help countries transition to resource-efficient, more circular economies as well as adjust to the risks and opportunities posed by circular economy policies in the economies of major trading partners (UNEP and IRP, 2020[87]).
- Consult and share information with developing country governments about new circularity measures. Ensure that reasonable time is given to enable stakeholders to adjust, and that adequate assistance is provided to developing countries to support their adaptation (UNEP and IRP, 2020[87]).
- Enhance international dialogue and co-operation in an effort to better understand and respond to the distributional impacts of circular economy policies (UNEP and IRP, 2020[87]).

Advanced economies should:

- Develop regulations to stop the export of e-waste to developing countries and strengthen compliance monitoring mechanisms for companies.

3.2.4. Developing sustainable agricultural supply chains

With the world's population expected to grow to almost 10 million people by 2050, meeting global food security needs while avoiding catastrophic climate change and limiting biodiversity loss will be an acute challenge. Agriculture, forestry and other land use globally currently accounts for about 23% of GHG emissions and about 50% of the world's vegetated land (IPCC, 2020[93]). Food insecurity, caused by rapid population growth and the physical impacts of climate change, has been exacerbated by the Russia's war in Ukraine, given these two countries account for about 29% of global wheat exports and 19% of maize exports. Meanwhile, spiralling gas prices have led to rising fertiliser costs which could potentially result in global agricultural output to fall by millions of tonnes (Hanson et al., 2022[94]). Already since the start of the COVID-19 pandemic, the number of food insecure people around the world has doubled, from 135 million to 276 million, while 750 000 people are facing famine, including acute starvation and malnutrition in Afghanistan, Ethiopia, Somalia, South Sudan and Yemen (United Nations, 2022[95]) (OECD/FAO, 2021[96]).

Rising global food demand risks exacerbating deforestation and conversion of grassland to cropland, destroying ecosystems and biodiversity. If oil and gas prices are high, governments could be incentivised to pursue policies which encourage unsustainable biofuels production to offset high fuel prices, which in turn could lead to the destruction of natural ecosystems that provide substantial carbon storage (Hanson et al., 2022[94]). A large proportion of the expansion of agricultural land is expected to take place in developing countries. Sub-Saharan Africa, for example, has seen 53 million hectares converted to crops in the last 20 years, equivalent to a 34% increase, 79% of which replaced natural ecosystems. Latin America has seen 34 million hectares converted to crops, 39% of which was previously natural ecosystems (Hanson et al., 2022[97]).

Abiding by Paris Agreement objectives and feeding future populations will require the agriculture sector to become more efficient, increasing crop and livestock yields per unit of land used. For developing countries, improving agricultural performance, particularly through investment in processing and value addition to upgrade participation in regional and global value chains, offers an opportunity to boost economic growth and create jobs. Poorly developed logistics and transport infrastructure in rural areas, low levels of sustainable fertiliser use, and a lack of energy availability necessary for agrifood processing limits opportunities for value addition and increases costs. Sub-Saharan African countries, for example, mainly export raw agricultural commodities for production and processing overseas. Facilitating the development of regional agrifood value chains in downstream segments, such as processing, marketing, transport and retail, could create additional skilled jobs, which is especially relevant in Africa where half of the labour force is employed in agriculture, which functions as a dominant source of employment in rural areas (AfDB, 2022[98]).

The physical impacts of climate change are already damaging agricultural yields in developing countries, with more regular extreme weather events such as droughts, floods and wildfires destroying livelihoods or making traditional farming practices unviable. The need for investment in adaptation, including land irrigation and adoption of climate-resilient farming techniques, seeds and crops, is therefore critical to address food insecurity and build the resilience of rural communities. Small-scale farmers in developing countries are the most vulnerable, given a lack of access to affordable finance, technology and mechanisation, information, training and education to enable them to adapt to changing conditions.

In parallel to raising yields, global GHG emissions from agriculture will need to reduce to remain consistent with the Paris Agreement. In terms of origin, livestock accounts for 45% of global agricultural emissions, energy use for 22%, rice methane for 16% and soil fertilisation for 13%. However, land use change, or conversion of natural ecosystems, primarily forests and grasslands into cropland, also has a very significant impact on emissions, as these practices remove carbon storage which will require years or even decades of regrowth to replace (Locke, 2021[99]).

Decarbonisation of the agriculture sector, particularly large-scale farms, can be especially challenging because emissions are hard to measure and are influenced considerably by environmental and local

conditions, as well as farming techniques. However, a range of approaches are available to decarbonise farming methods, including reducing the carbon content of fertiliser and making its use more targeted, diet modification to reduce methane emissions from livestock, raising yields and reducing flooding times of rice paddies, and switching to localised renewable energy generation solutions rather than using fossil fuels (Locke, 2021[99]).

Government support to agriculture, particularly in developed countries, distorts markets, stifles innovation and harms the environment, while also disincentivising increased agricultural output in developing countries. Between 2017 and 2019, 54 OECD and EU countries, plus 12 emerging economies, spent on average USD 536 billion per year on direct support to farmers, half of which came from policies to maintain domestic prices above international levels. At the same time, these countries spent comparatively little on measures to underpin long-term sector performance, including research and development, infrastructure, biosecurity and other enabling measures, amounting to USD 106 billion on average per year. Reforming public support to agriculture would improve agricultural output and efficiency in both developed and developing economies, reduce waste and increase competitiveness of the food industry (OECD, 2022[100]).

In addition, public support to farming can offer governments an effective and powerful tool to improve environmental practices and incentivise farms to adopt low-carbon practices and clean technologies (OECD, 2020[101]). For example, Brazil, under the country's National Plan for Low Carbon Emissions in Agriculture, has offered lines of credit to farmers who adopt less emissions-intensive practices, while making finance available to encourage research and development on climate resilient crops (Russell and Parsons, 2014[102]). Yet, public support for farming can be hard to reform, given entrenched interests from influential groups, while smaller-scale farmers who are most in need of access to affordable finance receive little support.

Improving access to agricultural services, especially training and information services relating to productivity and adaptation to changing climate conditions, such as adopting climate resilient seeds and crops, or diversification of products, for example blending crops, livestock and forestry, can build resilience by diversifying revenue streams. Technology can also play an important role in adaptation, providing information on changing weather patterns to support adaptation of planting timing and harvesting, as well as improving communication to ensure farmers are aware of subsidies and support for which they are eligible. In Malawi, for example, information on weather patterns and accompanying agriculture advice is provided to small-scale farmers by the inter-ministerial National Agriculture Content Committee via radio programmes and mobile messaging, enabling farmers to make informed decisions based on climatic conditions (Ferdinand, Rumbaitis del Rio and Fara, 2021[103]).

Eliminating food waste, which currently accounts for one-third of all food produced before it gets to the table, will also be vital. In addition, governments should take steps to protect remaining ecosystems to avoid further biodiversity loss and destruction of carbon storage, as well as to rehabilitate land unsuitable for agricultural production to regenerate ecosystems.

Governments should consider prioritising the following actions:

- Consider reforming public support for agriculture, offering incentives to encourage farming practices which reduce GHG emissions, resilience and improve productivity. Public support for agriculture should be based on an assessment of national context, including production and consumption, split between arable and livestock, types and size of producers, ensuring an equitable sharing of public support with smaller-scale farmers.
- Develop plans to extend affordable and micro-finance to small-scale farmers to boost productivity, assess risks associated with the physical impacts of climate change and build resilience.
- Enhance provision of agricultural services, particularly information sharing and communications on changing weather patterns, as well as warning systems, through a variety of accessible formats, to help small-scale farmers understand the risks presented by climate change and respond to

changes, for example, by adopting more resilient seeds and crops, adjusting planting and harvesting schedules, and diversify revenue streams to build resilience.

- Take steps to protect remaining natural ecosystems and rehabilitate land that is unsuitable for agriculture, which can enhance carbon storage.
- Set national targets for reducing food waste, and establish actionable roadmaps to achieve goals, for example, through investment in agrifood processing, cold storage, enhancing supply chain co-ordination and public education programmes.
- Increase funding to research and development, including through partnerships with the private sector focused on adapting traditional farming practices to boost productivity and encourage adaptation and resilience to climate change, but not at the expense of environmental degradation.
- Consider how to strengthen linkages between enterprises, agricultural co-operatives and farmers to enhance participation in value chains, and to facilitate access to technology and knowledge transfer. Cooperation between farmers can serve to boost productivity and increase yields, as well as facilitate connections to markets.
- Support the development of climate change-related insurance schemes for small-scale farmers.
- Strengthen commitments to decarbonisation of the agriculture sector in NDC, and strengthen MRV systems.
- Incentivise the use of renewable energy solutions and decentralised grids in the agriculture sector, rather than thermal power generation.
- Invest in rural infrastructure, including cold storage, transport, energy, flood protection and irrigation infrastructure, to encourage strengthening of regional agricultural value chains.

Advanced and developing economies together should:

- Invest in development and expansion of climate and disaster risk finance and insurance products to protect communities in developing countries, especially those reliant on agriculture from existential impacts of increasingly frequent extreme weather events.

3.2.5. Valuing natural capital to advance the low carbon transition

Alongside deposits of oil, gas and minerals, developing countries are also endowed with significant amounts of natural capital – which can be valued and used to advance the low-carbon transition. Natural capital refers to the approach of attributing economic value to natural assets – including forests, rivers, agricultural land, coral reef systems, and the range of ecosystem goods and services that flow from them (carbon sequestration, clean water, pollination). Placing an economic value on the goods and services provided by nature creates incentives for actors to invest in and conserve them (Bresnihan, 2017[104]). In fact, as natural capital become more stressed and increasingly scarce in the future, it is expected that its value will increase. If irreversible thresholds are passed for irreplaceable ecosystem services, their value may increase exponentially. However, because natural capital and ecosystem services are often not properly valued by the market or adequately quantified in order to be compared with economic services and manufactured capital, they are often not given sufficient weight in policy decisions (Costanza, 1997[105]).

Considerations around natural capital valuation and use are especially relevant for developing and emerging economies, as the consequences of ecosystem degradation and biodiversity loss are experienced more severely in those countries.

A 2020 World Economic Forum study estimated that ecosystem restoration and avoided land and ocean use expansion could deliver 11 million more jobs by 2030 through opportunities such as ecotourism, sustainable forestry management and nature-based solutions for mitigating climate change (Dasgupta, 2021[106]). Developing countries can take advantage of these opportunities by preserving their stocks of natural capital, and then using them sustainably to advance transformational, low-carbon development. In

equatorial countries, this often involves the preservation and reforestation of rainforests, which can then be used to sustain responsible forestry and eco-tourism. For example, Gabon has put in place a number of policies to develop a sustainable forestry sector. In 2002, 13 national parks were created covering 11% of Gabon's territory where logging was restricted. For areas were logging is permitted, Gabon's forestry law stipulates that companies must log sustainably by harvesting trees on a 25-year rotating basis. In 2010, the export of unprocessed logs was banned in order to capture additional value from turning a raw log into sawn sections, plywood or furniture – which can increase its value several fold (FT, 2021[107]).

The development of a responsible eco-tourism sector underpinned by the preservation of natural capital has the potential to deliver substantial economic growth and revenue for developing countries. In 2019, global travel and tourism generated some USD 8.8 trillion, representing over 10% of global GDP. Eco-tourism is only a small proportion of that total but a study found that globally natural protected areas received 8 billion visitors a year (Dasgupta, 2021[106]; WTTC, 2019[108]). In recent decades, Costa Rica has demonstrated that substantive economic growth can be achieved by valuing natural capital and investing in nature conservation. The country was able to triple the size of its economy while doubling the size of its forests and moving to almost 100% renewable energy production. Forests that had shrunk to cover just 21% of Costa Rica's territory in 1987 had increased to 52.4% by 2013, due to a policy of active reforestation, which was funded in part through a carbon tax and by the fiscal space created by earlier policies (e.g. disbanding of the army in 1948). In 1997, a 3.5% carbon tax on gasoline was introduced and the revenues were used to launch a system of payment for environmental services (PES), as well as the expansion of protected areas. In 2018, the carbon tax generated 11% of all government revenue and has funded a PES system for 300 000 hectares of forest. The resulting preserved and reinvigorated natural capital (rain forests, river canyons, waterfalls and coral reefs) is now sustaining an eco-tourism sector that generates tax revenues for the central government while also creating economic opportunities and employment in those regions (Dwyer, 2019[109]).

High-value eco-tourism industries are also expanding in Africa. For example, both Rwanda and Uganda have used their unique biodiversity to develop an eco-tourism sector based around gorillas despite having less than 1 000 mountain gorillas between them. By charging tourists for viewing permits, Rwanda earns USD 300 million a year from gorilla tourism. Since these high-value eco-tourism industries began, gorilla numbers in the area have recovered, demonstrating that valuing natural capital can positively impact preservation (FT, 2021[107]).

Box 3.14. Grande Mayumba project: Using nature-based solutions to generate economic value

The Grande Mayumba project in Gabon is intended to derive economic value from natural capital through the development of sustainable timber, agriculture and ecotourism businesses, supported by regional infrastructure, in accordance with Gabon's Sustainable Development Law.

Over the next few years, more than USD 200 million will be invested in commercial activities and infrastructure at Grande Mayumba, generating around 4 000 new jobs in the coming decade, and providing much-needed socio-economic benefits. Over 25 years, the project is expected to avoid 200 million tonnes of carbon emissions in the area, preventing unplanned development, deforestation and degradation of the ecosystem while delivering sustained commercial value. A sustainable timber business will provide local income and jobs, while a sustainable agriculture business will raise 20 000 cattle, buffalo and other wildlife and improve degraded soil quality, increasing carbon sequestration.

One-third of the project area will be designated for conservation, covering estuarine, montane and savannah ecosystems to ensure that critical biodiversity is protected.

Source: (FT, 2021[107]); (ACDG, 2022[110]).

In some cases, the conservation of natural capital itself can bring financial benefits. For example, 85% of the territory of Gabon is covered by carbon-absorbing rainforest, making the country one of the few net sequesters of carbon globally. In 2019, Gabon entered into an innovative emissions reduction scheme with the Central African Forest Initiative, a Norwegian-backed fund that issues payments in exchange for reducing emissions from deforestation and forest degradation. The agreement provides for results-based payments of USD 150 million over a ten-year period. The first payment was made in 2021 after independent experts verified Gabon's results from reduced deforestation and forest degradation (mainly from forestry activities) in 2016 and 2017 (FT, 2021[107]).

Box 3.15. How can governments use natural capital to generate revenue?

Governments can implement a number of policy instruments to generate revenue from the conservation and the enhancement of their natural capital and ecosystems. Some of these are specifically aimed at revenue generation, whereas others seek to provide incentives for businesses to behave in more environmentally sustainable ways.

- **Environmental taxes** – refer to taxes placed on environmentally harmful activities (for example, pollution, or the use of natural resources), and are based on the polluter pays principle.
- **Fees and charges** – include entrance fees to national parks, fees on hunting licenses, charges on land-based sewage discharge, charges for groundwater abstraction, etc.
- **Tradable permit schemes/cap-and-trade programmes** – include individual transferable quotas (ITQs) for fisheries, tradable development rights, tradable hunting rights and emissions trading schemes. These instruments set a limit on the total amount of a natural resource that can be exploited, and then allocate individual permits to users that they can trade. If the initial permit is auctioned rather than allocated, tradable permit schemes can raise revenue.
- **Biodiversity offsets** –refer to conservation actions intended to compensate for the residual, unavoidable impacts of development projects, after prevention and mitigation measures have taken place, and are based on the polluter pays principle. Depending on their design, biodiversity offsets could also generate revenue for governments.
- **Payments for ecosystem services** – refer to voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services. PES are based on the user- or beneficiary-pays approach and can be used to raise revenues through government interventions.
- **Fines for environmental damage** – generate revenue from environmental infractions that can be used to support projects to restore nature.

Source: Adapted from (OECD, 2021[111]).

Valuing natural capital

In order to contribute to sustainable growth, natural capital first needs to be properly valued. Natural capital valuations can help in calculating the true cost of capital and therefore identifying which projects governments should pursue and which are likely to be unsustainable. If natural capital costs are taken into account alongside existing considerations of capital, labour and technology costs, the market can be incentivised to select inputs where production places far less demands on natural ecosystems (Hodgson and Tarditi, 2021[112]).

Box 3.16. Valuing natural capital in Costa Rica

In 2012, the Central Bank of Costa Rica and the World Bank began a joint project to try to place a value on Costa Rica's natural assets. With cross-government participation (Ministry of Planning, Ministry of the Environment and the Ministry of Finance), the programme intended to enable better measurement and management of the country's environmental policies by establishing monetary values for its forests, water resources and natural energy sources.

Stocks and flows of natural resources (forests, waterways, fisheries, etc.) are presented in physical and monetary terms with a market value ascribed to them. For example, forests are valued by the price the timber would fetch if sold to the market. Valuation of assets and flows that do not have a market value are not included, but future versions of this methodology may include the value of ecosystems and therefore be able to provide value for carbon sequestered by the forests.

Source: (Dwyer, 2019[109]).

One approach to valuing natural capital involves the beneficiaries of ecosystem services paying the providers. This is known as "payment for ecosystem services" (PES). In other terms, PES provides incentives for owners of natural resources, such as farmers and forest owners, to preserve and manage resources in order to provide ecological services. The most common PES schemes relate to payments for the protection of landscapes, the maintenance of habitats for endangered species, and the preservation of hydrological functions related to the quality and quantity of freshwater flows from upstream areas to downstream users. In order to be effective, PES systems must target a well-defined ecosystem service and ensure that payments add to the value of the ecosystem service that would be provided under a business-as-usual scenario. Furthermore, they must be able to monitor the provision of the ecosystem service. PES schemes are not easy to design and implement and require a substantial amount of initial effort. For instance, baselines for ecosystem services must be established in order to determine if PES will provide additional value.

The PES approach was first devised in 1997 by Costa Rica to reverse the severe deforestation that had taken place across the country. The National Forestry Fund made payments to landowners for maintaining their forests due to the external benefits that those forests provided. The PES approach has since been taken up on a global scale by the United Nations in order to reduce GHG emission by paying for forest conservation in developing and emerging economies. The Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) scheme has been part of climate-change negotiations since 2007 (Bresnihan, 2017[104]). It was adopted at the 19th UNFCCC Conference of the Parties (COP19) in 2013 and provides complete methodological and financing guidance for implementation activities in the forest sector that reduce emissions from deforestation and forest degradation, as well as the sustainable management of forests and the conservation and enhancement of forest carbon stocks in developing countries. Thanks to the implementation of REDD+ projects, many developing countries have significantly enhanced forest monitoring and management capacities, which are essential to achieving forest protection over the long term.

Box 3.17. Payments for Environmental Services in practice: the Case of Mexico

Mexico was one of the first countries in Latin America to implement a national Payment for Environmental Services (PES) scheme, which was initiated in response to high deforestation rates and degradation of watershed ecosystem services. Between 1993 and 2 000 crops and pastures grew significantly at the expense of forests and jungles, which were subject to extensive deforestation. Mexico is home to over 60 million hectares of forests and tropical jungles, approximately 60% which are owned by communities and *ejidos*, or organised groups of peasants in an institutional arrangement that involves both individual plots of land and common property areas.

Under the PES scheme, a contractual relationship is formed between the forest owner and the government's forestry department (CONAFOR), whereby the owner receives a payment at the end of each year if the forest is conserved. The payment seeks to cover the opportunity cost for land owners of preserving the forest. The PES scheme is financed through revenues from water fees that are ear-marked and managed in a trust fund. This funding mechanism creates an indirect link between users and providers of the environmental service and also protects the programme from budgetary problems that could arise if the PES programme were financed through the general budget.

The PES scheme was launched in 2003, and by 2013, 4.27 million hectares were enrolled in the programme, benefiting 7 350 private or communal landholdings and representing an investment of USD 651 million. In the years between 2003 and 2007, the PES scheme successfully prevented 18 000 hectares from being deforested. In addition, the PES scheme has encouraged local stakeholders, international agencies, and central and regional government to establish frameworks that account for ecosystem services in a way that includes market alternatives. For example, in Mexico, both city and state governments have recognised that the water they consume depends on upper watershed conditions, which in turns has motivated those entities to take the initiative and pay for such environmental services.

Overall, the success of a PES scheme will depend on the existence of a robust legal framework, financial mechanisms that allow for multi-year projects, transparency and accountable contractual relationships between the government and owners of forested land, dedicated funding sources, and platforms dedicated to increasing local stakeholder participation.

Source: (Romero, 2021[113]); (Cortina and Porras, 2018[114]); (León et al., 2016[115]).

The role of accounting mechanisms in the valuation of natural capital

There are a number of accounting mechanisms that developing countries can use to value their natural capital assets. Natural capital accounting (NCA) refers to the use of an accounting framework to measure and report on stocks and flows of natural capital. NCA covers accounting for individual environmental assets or resources, both biotic and abiotic (e.g. water, minerals, energy, timber, fish), as well as accounting for ecosystem assets (e.g. forests, wetlands), biodiversity and ecosystem services (UN, 2014[116]). The accepted international standard for natural capital accounting is the United Nations' System of Environmental Economic Accounting (SEEA), which provides a framework that brings together economic and environmental information in an internationally agreed set of standard concepts, definitions, classifications, accounting rules and tables to produce internationally comparable data.

To facilitate informed decision making, the SEEA Central Framework brings together information on water, minerals, energy, timber, fish, soil, land and ecosystems, pollution and waste, production, consumption and accumulation. Each of these elements is assigned specific and detailed measurements enabling patterns of consumption and production and their effect on the environment to be clearly understood. The

SEEA can be used as a guidance tool for both policy development and evaluation as well as decision-making processes. Raw data (in the form of aggregates and indicators) can be applied to areas of the environment that are the focus of decision makers. In addition, detailed information, covering some of the key drivers of environmental change can be used to provide a richer understanding of the policy issues and trade-offs. Lastly, SEEA data can be used in models and scenarios to assess the national economic and environmental effects of different policy scenarios in country.

Box 3.18. Policy use of natural capital accounting mechanisms

The European Union's INCA project was launched in 2015 to produce a pilot for an integrated system of ecosystem accounting for the EU, based on the UN SEEA Framework.

The INCA project assessed the EU's ecosystem extent, initial ecosystem condition accounts and produced the first monetary estimate of gross ecosystem product for the EU. The results of this ecosystem assessment have subsequently informed several concrete policy initiatives of the European Commission:

- **The Framework to Facilitate Sustainable Investment** aims to help create the world's first ever "green list", a classification system for sustainable economic activities. This will establish a common language that investors and businesses can use when investing in projects and economic activities that have a substantial positive impact on the climate and the environment.
- **The EU Pollinators Initiative** aims to improve scientific knowledge about insect pollinator decline, tackle its main known causes and strengthen collaboration between the actors concerned. The assessment identified that 50% of demand for pollination services is not met. This means that about 50% of areas where pollinator-dependent crops are grown in the EU (e.g. fruit trees) do not provide suitable condition for pollinators (e.g. nesting sites).
- **The EU nature restoration plan (part of the EU Biodiversity Strategy for 2030)** is supported by the assessment of the INCA project. Under the plan, ecosystem accounts can be used to guide large-scale restoration efforts by mapping where ecosystems are degraded, monitoring the condition of ecosystems following restoration and assessing the benefits of ecosystem restoration through ecosystem services.

Source: (Vysna et al., 2021[117]).

In 2014, the World Bank set up a global partnership to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts. Entitled Wealth Accounting and the Valuation of Ecosystem Services (WAVES), the partnership aims to implement NCA at the national and subnational levels based on the SEEA, and to incorporate NCA into policy analysis and development planning. As a result, several developing countries have used NCA mechanisms in their policy-making process. For example, Rwanda's land accounts are informing its national land management system, allowing policy makers to study trends in land use and changes over time. In the Philippines, NCA mechanisms have provided inputs into tools such as environmental impact assessments and cost-benefit analysis of existing policies, which, in one case, helped institutions make decisions such as setting priority areas for mangrove protection and restoration in South Palawan. In a review of the WAVES programme, the World Bank noted the importance of NCA mechanisms reaching not only environment ministries, but also ministries in charge of economic growth and planning in order to integrate environmental considerations into economic policy (World Bank, 2021[118]).

Governments should consider prioritising the following actions:

- Consider mechanisms that provide incentives to preserve natural capital and global common goods, like forests, rather than just paying for reducing emissions.
- Introduce natural capital into national accounting systems. Increased investment in physical accounts and valuation would improve the quality of natural capital accounts (Dasgupta, 2021[106]).
- Join the World Bank's global partnership, Wealth Accounting and the Valuation of Ecosystem Services (WAVES), in order to incorporate NCA into policy analysis and development planning (World Bank, 2021[118]).
- Communicate the economic benefits of preserving natural capital and natural infrastructure (rivers, forests, etc.). These benefits include the potential to increase resilience to climate change through ecosystem-based adaptation approaches (Burke, Ranganathan and Winterbottom, 2015[119]).

Actions requiring international support in contexts where government capacity is low:

- Launch an ambitious system of payment for global environmental services (PES) where the beneficiaries of global ecosystem services pay the providers in order to conserve existing natural capital.
- Encourage the development of a wider set of indicators of social, economic and environmental well-being. These additional indicators can provide invaluable insights into whether current trajectories of ecosystem condition and resource use undermine future economic development or support a transition to an economy that reduces environmental risks and supports sustainable development (Burke, Ranganathan and Winterbottom, 2015[119]).
- Standardise data and modelling approaches to make it easier to embed natural capital accounting in national economic accounts, and to improve decision making at scale around the world (Dasgupta, 2021[106]).
- Encourage natural capital valuation assessments for public infrastructure projects. Since natural capital valuation includes the costs incurred by nature to produce a public good, these costs must be added to the total costs estimated for executing public infrastructure projects (Modak, Mathur and Vaidyanathan, 2019[120]).
- Encourage the inclusion of natural capital valuation assessments in financial sector reporting. Since natural capital valuation includes the costs incurred by nature to produce a commercial good or service, this information must be transparent and easily available to all stakeholders – regulators, investors and the general public. Companies must be encouraged to file information on their natural capital valuation assessment with the regulators (Modak, Mathur and Vaidyanathan, 2019[120]).

Development finance institutions and bilateral development agencies should:

- Consider providing payments for forest conservation to developing and emerging economies in order to incentivise forest stewardship and sustainable use.
- Provide technical support to developing country governments to make it easier to embed natural capital accounting in national economic accounts.
- Provide access to satellite-imagery that enables the real-time usage of natural resources (Modak, Mathur and Vaidyanathan, 2019[120]).

3.3. Restructuring fiscal frameworks and reforming energy pricing to optimise domestic resource mobilisation, build redistributive taxation systems and correct misaligned incentives

Fossil fuel-producer developing and emerging economies typically have narrower tax bases than diversified economies. This increases the impacts of commodity price volatility on government spending and weakens the social contract between citizen and state, because citizens are less likely to demand adequate and reliable public services from government in return for tax payments. The low-carbon transition presents governments with an opportunity to strengthen fiscal frameworks through progressive reforms that limit impacts on poorer citizens, broaden the tax base to increase domestic resource mobilisation, reduce reliance on few commodities and attract private investment in priority green sectors, such as renewable energy, storage and hydrogen.

In addition, phasing out inefficient fossil fuel subsidies and pricing carbon, either through a carbon tax or an emissions trading scheme (ETS), can be powerful tools to encourage low-carbon technological innovation, deployment and scale-up, as they provide long-term price signals to encourage deployment of renewables, and to incentivise firms and individual consumers to make lower carbon business and lifestyle choices. Without internalising negative externalities of high-emitting fuels, which impose unaccounted for environmental and social costs on society, diffusion of low-carbon substitutes will be all the more challenging. In fact, subsidies and unpriced externalities act as a negative tax on low-carbon products and technologies, distorting price incentives and rendering them uncompetitive against subsidised carbon intensive alternatives, which benefit from energy inputs below market price (Sen, Nepal and Jamasb, 2020[121]). As part of a coherent strategy, removal of inefficient fossil fuel subsidies and introduction of carbon pricing can enable fossil fuel-producer emerging and developing economies to correct misaligned incentives, free up substantial revenue for investment in more productive areas of the economy, and provide a means by which to propel their economies towards low-carbon sustainability, resilience and prosperity.

3.3.1. Addressing misaligned incentives through fossil fuel subsidy reform and carbon pricing

A fundamental driver of fossil fuel path dependency is that incentives which influence the way in which people and businesses invest, produce and consume do not account for environmental, climate and social costs. The most powerful tools to address misaligned incentives and to level the playing field between carbon intensive technologies and greener substitutes are inefficient fossil fuel subsidy reform and pricing carbon to account for negative environmental, climate and social costs. Applied coherently, policies which remove preferential treatment of fossil fuels, for example through consumer or producer subsidies, tax or permitting exemptions, and those which place a price on carbon (through carbon taxes, fuel taxes, environmental taxes, excise taxes or an ETS) on the production or use of polluting products, can gradually help to influence path-dependent consumer behaviour, and accelerate phase-out of fossil fuel use, and scale-up of cleaner substitutes (Alternburg and Assmann, 2017[28]).

However, fossil fuel subsidy reform and carbon pricing may be challenging for many developing country governments from a political economy and administrative perspective. They can also result in negative distributional impacts if poorer households are unable to cope with price increases. Governments should therefore plan to address fossil fuel subsidy reform and carbon pricing in an incremental manner, in line with careful assessment of national circumstances, and paired with progressive expansion of social protection provisions and investment in public services and infrastructure particularly efficient and affordable public transport. Ensuring citizens have affordable and greener alternatives to turn to when prices for established polluting technologies rise, and alleviating the negative impacts on poorer households, will be critical to implementing of reform packages and mitigating the potential risk of public backlash.

Reforming fossil fuel subsidies

Across the world, fossil fuel subsidies remain pervasive. OECD data suggest that fossil fuel subsidies to consumers and producers across G20 economies increased to USD 190 billion in 2021, from USD 147 billion in 2020, given the rebound in global economic activity after the COVID-19 pandemic and rising fossil fuel prices. Support to producers, at USD 64 billion in 2021, was the highest since OECD tracking began, at a 50% year-on-year increase, and up 19% on 2019 levels, while consumer subsidies reached USD 115 billion up from USD 93 billion in 2020 (OECD, 2022[122]).

Developing country governments often find it particularly challenging to implement fossil fuel subsidy reform. Their citizen's inability to absorb higher prices, given a much higher share of household expenditure tends to be spent on energy, can create political economy constraints and negative distributional impacts. Lower middle-income households, which may be struggling to make ends meet, make up a far higher proportion of the population in these contexts than in advanced economies. Increases in energy expenditure caused by fossil fuel subsidy reform could push large swathes of the population into poverty (Finon, 2019[123]).

Fossil fuel subsidies, therefore, are often justified on the basis that they insulate poorer households from unaffordable energy costs, thereby providing them with some form of social protection. Yet the evidence does not support this argument. Research by the Inter-American Development Bank (IDB), for instance, suggests that for every USD 1 delivered to the poorest 20% of the population through petrol subsidies in Ecuador, the government paid USD 20 – mainly because wealthier households use far more gasoline – with this figure falling to USD 10 for electricity, USD 9 for diesel and USD 5 for LPG. This highlights the fact that in some contexts, it may be possible to free up significant budgetary resources, while at the same time improving the livelihoods of poorer households at a fraction of the overall cost of subsidies (Schaffitzel et al., 2019[124]).

The civil unrest which has accompanied attempts to reform fossil fuel subsidies in some countries provides evidence of how contentious it can be if poorly implemented and without adequate social safeguards. This was the case when the Nigerian government attempted to completely remove the subsidy on petroleum products in 2012, and in Ecuador in 2019 when the government announced the removal of subsidies for gasoline and diesel, but was subsequently forced to reverse the policy in the face of protests (Beaton et al., 2016[125]; IISD, 2019[126]). In early 2022, the Government of Kazakhstan's attempt to remove the fuel price cap on butane and propane led to widespread civil unrest, forcing it to reverse the policy.

Box 3.19. **The Extractive Industries Transparency Initiative's typology of fossil fuel subsidies**

Government support for fossil fuels can take a variety of forms, including direct or indirect support to fossil fuel companies, which offset the costs of oil, gas and coal production, as well as reducing the prices consumers pay for fossil fuel products. This makes accounting for the full cost of a government's subsidy regime difficult to fully assess, particularly given that some subsidies can be funded directly by governments through budget allocations, while in other cases they are funded through state-owned enterprises directly or through other policy mechanisms.

Producer subsidies either take the form of direct payments to fossil fuel producers, or tax exemptions, incentives or breaks for companies which result in governments forgoing revenue they would otherwise receive. This might include direct financial support for producers, credit support, insurance indemnification, no or low charges for mineral leases on government land, preferential treatment in government procurement, tax breaks or special taxes.

Pre-tax consumer subsidies consist of subsidised petroleum products, such as diesel, petrol or LPG, to domestic markets or to power plants. They could include direct financial support for consumers, regulated prices below international rates, and the use of government goods and services below market rates.

EITI Standard 6.2 requires governments to report on quasi-fiscal expenditures, or subsidies provided by state-owned enterprises outside of the budgeting process and where no compensation is provided by government.

Source: (EITI, 2021[127]).

How to approach fossil fuel subsidy reform

The OECD provides a four-step sequential approach for governments to approach fossil fuel subsidy reform in its Companion to the Inventory of Support Measures for Fossil Fuels 2021. This provides guidance to governments to identify priority areas for reform based on national circumstances and development objectives, and makes available a range of analytical tools to help governments assess the extent of fossil fuel subsidies and define their own fossil fuel subsidy reform process. The OECD sequential approach is modular, enabling government to pursue reform programmes in parallel to building capacity, while identifying and closing evidence gaps over time (OECD, 2021[128]) The sequential approach is summarised in Table 3.2.

Table 3.2. OECD sequential approach to reforming fossil fuel subsidies with analytical tools

Step in sequential approach	Objectives and description of step	Useful tools
Identify support measures, document their objectives, and estimate their budgetary cost.	Objective Measure the cost to government of providing support for fossil fuels. Understand the objective and intended beneficiaries of support measures. Description The OECD Inventory approach helps governments identify individual support measures to fossil fuels, clarifying their objectives and estimating their budgetary costs. This assists identification of reform priorities and alternative policies which can achieve equivalent outcomes when support is removed. Establishing a comprehensive list of all preferential treatment and benefits for fossil fuel producers and consumers can be challenging, given that subsidies to fossil fuels can be transferred through a variety of mechanisms, including direct spending, tax expenditure and foregone revenue, transfer of risk to government, and consumer subsidies, each of which is applied to different elements of the fossil fuel value chain. Populating the inventory with budgetary costs and estimates can also be challenging. While direct spending is straightforward to quantify, non-direct costs require measurement of the difference between a reference cost and the cost of the transfer mechanism. A comprehensive inventory can be built over time, and quantitative data of subsidies provided in each category added to the list, in order to build an overall picture of the scale and nature of subsidies, as government teams responsible for subsidy tracking obtain more information and data. In parallel, governments can employ the "price gap approach" to assess the overall scale of fossil fuel subsidies. This calculates the difference between the price fuels and electricity are sold at domestically and the deregulated market price, adjusted for local conditions, also called the reference price. The actual domestic price of fuels, which is higher than the reference price in contexts where consumption subsidies are substantial, is subtracted from the reference price, then multiplied by the total number of units consumed to arrive at the total value of consumption subsidies.	The OECD Inventory of Support Measures for Fossil Fuels and country data is available at www.oecd.org/fossil-fuels. The Fossil Fuel Subsidy Tracker (https://fossilfuelsubsidytracker.org), gathers data for 192 countries from key international sources, including the OECD, IMF, and IEA, indexing them in a searchable database by country. The Tracker provides a useful source for policy makers considering fossil fuel subsidy reform, particularly in terms of quantifying government support. Other useful resources include the following: • OECD taxonomy of support measures for fossil fuels • OECD PSE-CSE accounting framework • IEA "price gap" method for estimating consumer price support • G20 and APEC peer review frameworks • IEA subsidies database • IMF (pre-tax price-gap estimates portion only)
Measure the distortionary impacts of support measures,	Objective Rank support measures by their level of distortionary impacts on fossil fuel production, investment, consumption and CO_2 emissions.	Effective tax rates (effective marginal tax rates, effective average tax rates) Sectoral models: extraction model of oil and gas, and a two-sector model of energy-intensive and non-energy-

including their economic, social and environmental effects.	Description Based on the OECD Inventory, governments can rank support measures according to their distortionary impacts on fossil fuel investment, production and consumption, as well as environmental and climate impacts. For example, support to fossil fuel producers can improve project economics, encouraging development of otherwise uneconomic reserves, while lower prices for consumers could lead to wasteful consumption or unfairly benefit wealthy groups who consume more. Key tools to evaluate and rank the distortionary impacts of support to fossil fuels on economic behaviour and consumption of carbon-intensive products include analysing fiscal regime impacts on the cost of capital and the implications on investment decision making. In the upstream sector, for example, the impact of tax exemptions and other preferential treatments on project costs and expected rate of return have significant implications for cost of capital. Policy makers can use comparisons with reference tax regimes where no exemptions are applied, drawing on international comparisons, to build an understanding of how tax regimes impact firms' decisions to invest in exploration, development and production. Similar approaches can be used for assessing the impacts on domestic industrial users of energy, given that public support for fossil fuels has profound impacts on cost of capital in a given sector, and therefore on incentivising fossil fuel use.	intensive industries Inventory beneficiaries' data by broad economic sector
Identify the winners and losers of fossil fuel support reform processes.	Objective Analyse the distributional impact and other potential adverse effects of reforming of support for fossil fuels. Description Governments can model the impacts of price changes on different fuels and electricity resulting from subsidy reform on different income groups, incorporating regional variations on household spending into the analysis. Different reform scenarios can have profoundly different distributive impacts on different groups, and some approaches are likely to be more regressive than others. For example, reforming consumption subsidies on LPG in many instances will impact poorer households hardest, given the prevalence in LPG use in cooking among lower income groups. This risks households simply turning to wood and charcoal for fuel, exacerbating deforestation and health issues if adequate support measures are not put in place. Conversely, subsidy reform on petrol is more likely to impact wealthier households given that they are more likely to spend more on fuel for vehicles, though in practice impacts will vary across different income groups and geographies. Two main analytical approaches can assist governments to understand the distributional impacts of reforms on individuals and firms: empirical and modelling-based tools. • Detailed econometric studies assessing impact on individuals and firms based on household and company surveys can support governments in assessing the potential impacts of reform on energy consumption, as well as on household welfare based on different reform scenarios. Household expenditure and perception surveys, as well as interviews, can help build a granular picture of how different reform scenarios will impact different groups and inform the development of support packages to respond to these impacts, as well as to define what kind of approach will be acceptable from a political viewpoint. • Additionally, structural and computable general equilibrium (CGE) models can be used to analyse the longer-term implications of reforms against a business as usual scenario both at a sectoral and national level, providing greater insights into economic impacts and on GHG emissions.	Micro-simulation models (based on household and firm surveys) CGE models
Evaluate alternative policies with better economic, environmental and fiscal distributional outcomes	Objective Identify policies that increase the efficiency and improve the distributional impact of government intervention. Description The final step involves identifying measures both to offset the negative impacts of reforms, and to divert savings into more productive areas of the economy. In general, a portfolio of measures which build on existing social protection schemes offers the most realistic prospect for effectively targeting support to households which need it in an administratively efficient way. Targeted cash transfers can form part of these measures, though in practice it can be challenging for governments to establish a system which provides good coverage of poorer households. Other support options include transport vouchers, income tax exemptions, free schooling vouchers and fuel vouchers. Extensive stakeholder consultation, including interviews	Micro-simulation models (based on household and firm surveys) CGE models

	and surveys across different geographies, will help to build an understanding of which measures will work in practice. For instance, income tax exemptions are unlikely to benefit households in the informal economy which do not pay income tax, while free schooling vouchers only benefit households who have children of school age, or households which spend little on education.	

Source: (OECD, 2021[128]); (OECD, 2022[122]); (OECD, 2022[129]); (EITI, 2021[127]); (Kojima, 2016[130]); (Schaffitzel et al., 2019[124]).

Governments should consider prioritising the following actions:

- As a first step, work to build a full picture of the extent and nature of fossil fuel subsidies, combining price gap and inventory approaches. This process should be iterative, working initially from the most significant government support to incorporate smaller subsidies over time. The process will require substantial resources and expertise. Subsidy tracking must be an ongoing process with new data and information included as and when it becomes available, as subsidy tracking teams move into new areas of analysis, or prices change. This requires a strong policy mandate and good co-operation across government departments, given that government support for fossil fuels can originate from a variety of public agencies.
- Recognise that dedicated studies may be needed to calculate accurate reference prices adjusted for local conditions across different fuel types.
- In compiling subsidy inventories and quantifying support, prioritise data consistency, use of consistent reference periods and making sources available to build the credibility of subsidy estimates with different stakeholders.
- A critical success factor in building the political feasibility of a fossil fuel subsidy reform programme, and leveraging it to improve the livelihoods of poorer households, is understanding distributional impacts and building a comprehensive package of reforms which avoid regressive effects and can be easily implemented.
- Assess the impact of different fossil fuel removal options on different income groups, including through an assessment of regional impacts and the effects of price changes on different fuel types and electricity. This should be done using Computable General Equilibrium (CGE) modelling, and combined with household surveys and interviews to build a granular understanding of local impacts as well as impacts across different geographies.
- Consider the potential unintended consequences of fossil fuel subsidy reform. For example, in the absence of viable alternatives, removal of LPG subsidies will mean people simply turn to wood for cooking fuels, with impacts including deforestation and health. Increasing prices when no alternatives are available may simply push vulnerable households further into poverty.
- Assess options to support poorer households, recognising that the most successful support schemes build on existing administrative infrastructure ideally, social protection mechanisms.

Development finance institutions and bilateral development agencies should:

- Provide technical and financial support to assist governments in tracking and calculating fossil fuel subsidies, and to model and simulate the impacts, benefits and disadvantages of competing reform scenarios across different timeframes.
- Enhance the availability for governments of comparable data on subsidies across developing and emerging economies to enable comparisons in a centrally accessible database, showing methodologies used.
- Assist governments to utilise available best practice methodologies to identify, quantify and prioritise for reform government support for fossil fuels, for example, the OECD Inventory approach.
- Provide technical support to governments to model the distributive impacts of fossil fuel subsidy reform and build targeted support packages to mitigate regressive and negative distributional impacts.

Managing the distributional and political economy implications of fossil fuel subsidy reform

Support measures should integrate political economy considerations in order to try to address the likelihood that price increases will precipitate protests by certain income or interest groups. Discontent is not necessarily concentrated among the poorest groups in society, and often society's very poorest have limited political capital to protest and limited expectations that their circumstances will change, whereas relatively wealthier citizens who have more to lose or more to gain may be more likely to take to the streets (OECD, 2021[131]).

A comprehensive approach to subsidy reform will therefore have to understand the likely behaviours and perspectives of other groups – particularly lower middle-income groups who have relatively higher energy expenditure and may also be struggling to make ends meet, and who will also be significantly impacted by price rises. In Nigeria, for example, some of the biggest protests accompanying government subsidy reform efforts in 2012 took place in Lagos and Abuja, rather than in the poorer north. Households in Lagos and Abuja, relatively speaking, are wealthier, but were set to see a more dramatic change in expenditure levels because their overall energy expenditure was far higher than households in the north (Beaton et al., 2016[125]).

In addition, support measures targeting special interest groups who have strong capacity to mobilise collectively, for example fuel vouchers for taxi drivers, can also provide relatively inexpensive means to address political economy constraints and smooth the passage of fossil fuel subsidy reform (Schaffitzel et al., 2019[124]). Meanwhile, governments can also use demand-side measures to ease fossil fuel subsidy reform. For instance, the Government of Ecuador's Efficient Cooking Programme subsidises electricity and provides clean electric stoves to households. Residential demand in Ecuador accounts for 92% of LPG use, and the programme aims to gradually shift consumption to alternatives over time, after which, raising prices on LPG will face less public opposition and have fewer distributive impacts (Rentschler and Bazilian, 2017[132]).

Box 3.20. Fossil fuel subsidy reform: Lessons from Indonesia

Fossil fuel subsidies were originally introduced in Indonesia in 1977, and with the country's transition to becoming a net importer of oil and gas in 2012, represented a growing burden on government fiscal resources and balance of trade, and acted as a disincentive to investment in renewable energy. The financial burden from fossil fuels peaked in 2014, and up to this point, budget allocations to fossil fuels were larger than allocations to other priority spending areas, including health and infrastructure. Through gradual reform of fossil fuel subsidies, Indonesia has been able to bring the budget allocation for fossil fuel subsidies down to about 5% since 2015, with savings reinvested in infrastructure spending, which has seen a significant increase since 2015.

Key success factors in Indonesia's experience with fossil fuel subsidy reform include widespread communication as to the benefits of reform, paired with mitigation measures including an unconditional cash transfer programme to alleviate negative distributional impacts on poorer households. Indonesia's Conversion Programme from Kerosene to LPG provided every household with a stove "starter pack", and a 3 kg cylinder of LPG to try to discourage use of kerosene in cooking which is more polluting. The programme resulted in a five-fold increase in LPG use, and a 92% decrease in kerosene between 2007 and 2015. While prices for both kerosene and LPG have remained the same, subsidies for LPG are lower than for kerosene, providing the same amount of cooking energy at lower cost for the government, as well as less pollution and GHG emissions.

Source: (Clean Cooking Alliance, 2020[133]); (Savatic, 2016[134]).

Governments also need to consider the impacts on firm competitiveness of higher energy prices, based on enterprise surveys, interviews and consultations, to develop support packages, where necessary, to support them in adapting to change. Support packages can include compensation to help firms accommodate higher prices and offset losses in the short term, giving companies time to adapt to change. Longer-term grants and subsidies and awareness raising about low-carbon technology and energy efficiency investments can support fuel switching as well (Rentschler, Kornejew and Bazilian, 2017[135]).

Lastly, the way in which governments communicate fossil fuel subsidy reforms and energy price changes is important, and has implications for the ease of reversing such changes. Incorporating reform policy into legislation, for example, will require parliament to change the law to reverse the policy, while including it in regulation will require a ministerial sign off for reversal, which again will be harder to reverse than a simple press statement. Governments should also announce price changes via a government website, rather than relying on press reporting, and ensure announcements are made even if there is no change in energy price. Regular price changes, even if small, can also help acceptance when prices go up, while more irregular changes often lead to very substantial price increases down the line, which will be harder for consumers to absorb, and may generate more opposition. Meanwhile, adopting an automatic pricing mechanism in legislation can help to depoliticise reforms. Governments can also publish transparent formula for setting prices, which can also help convey the extent of the price gap to stakeholders (UN, 2021[136]).

Governments should consider prioritising the following actions:

- Consider the need for interim or bridging financing to give time for inefficient fossil fuel subsidy reform to generate savings for support measures, which need to be in place before reforms come in.
- Build public acceptance through a comprehensive communications strategy, applying multiple platforms and approaches to explain the scale and impact of the existing subsidy regime, and building consensus around the existence of more economically efficient ways to support poorer households. Explain how revenue will be recycled for the public good.
- Consider that lowest income groups may not be the ones to protest and that large segments of the population may be pushed into hardship by fossil fuel subsidy reform because they spend such a high proportion of their income on energy. Assess the political feasibility of reform and the necessity of introducing targeted measures for groups who are likely to mobilise or protest against reform.
- Assess the impacts on private sector/industry through firm surveys, interviews and consultations. Develop a response plan, including compensation payments to help absorb short-term costs as well as financial support for firms to switch fuels and invest in low-carbon equipment and energy efficiency measures.
- Give consumers and firms time to adapt, taking an incremental and phased approach to inefficient subsidy removal.
- Consider financing demand-side initiatives with money saved from subsidy reform, to extend reforms to other areas where reform will have a big impact on prices.

Accounting for negative externalities through carbon pricing

Putting a price on carbon, either through an explicit tax on carbon, taxing carbon intensive products, such as fuel, or establishing an ETS, can form a central pillar of a government's least-cost decarbonisation pathways, nudging firms and consumers to switch to lower cost and less polluting products and practices. ETS tend to be the most effective mechanisms to reduce emissions, especially in industrialised economies, as they ensure environmental effectiveness, and incentivise use of the most efficient technologies and those that cost least. On the other hand, carbon taxation is better suited to the earlier phase of carbon price implementation, when capacity is weaker, institutional frameworks less developed and sectors characterised by distributed emissions sources.

However, as is the case with fossil fuel subsidy reform, pricing carbon can be challenging to implement because of the impact of price increases on poorer citizens, and because it threatens vested interests which benefit from the status quo. It follows that at least initially, governments should consider setting an explicit carbon price at a very low level, far lower than the USD 50 to USD 100 per tonne of CO_2 by 2030 estimated to be required across the world to be consistent with a 1.5 C increase in global temperatures, as recommended by the Paris Agreement High-Level Commission on Carbon Prices (OECD, 2021[137]). Moreover, given that developing countries currently account for a very small proportion of global emissions, as outlined in Figure 3.1, the urgency to introduce a carbon price is felt less, though this will change as these economies grow and urbanise (Alemayehou et al., 2021[138]).

Yet, despite these challenges, carbon pricing should still be considered by fossil fuel producer developing and emerging economies as an integral component of a coherent overall strategy to build least-cost pathways to decarbonisation and systemic transformation. Internalising negative externalities through carbon pricing can help tackle local pollution and support domestic revenue mobilisation to finance vital government services. At the same time, it can reduce the risk of stranded assets, help to future proof investments and set the economy on a more sustainable footing which will enable better integration in the world economy as global decarbonisation gathers pace. However, design and implementation will need to be more gradual and incremental than in advanced economies, carefully attuned to national socio-economic circumstances, and complemented with investments in public services and infrastructure that reinforce and support the case for energy price reform.

Through an incremental approach, which is tailored to country circumstances and incorporates policies designed to offset distributional impacts, governments can gradually begin to price carbon. A core concept is the Effective Carbon Rate (ECR), or the sum of any tradeable emission permit prices, carbon taxes, and fuel excise taxes, minus any fossil fuel subsidies that affect pre-tax prices, which produce an overall price for emissions. Egypt, for instance, in 2018 had net negative energy tax revenue, but has since made substantial progress in closing this gap through fossil fuel subsidy reform and introducing new taxes on petroleum products. Egypt is now close to eliminating subsidies on fossil fuels completely. If Egypt were to raise its ECR to EUR 30 per tonne of CO_2, a common low-end benchmark for OECD and G20 countries, it could free up public funds equivalent to 1.5% of GDP, as well as effectively incentivise low-carbon investments and consumers and businesses to switch to low-carbon alternatives (OECD, 2021[137]).

Yet, progressively transforming the ECR from net negative to net positive will be contingent on governments providing ongoing targeted support to consumers and businesses to offset negative distributive and competitiveness impacts and build public acceptability of carbon pricing measures. At the same time, consumers and businesses must be afforded viable greener alternatives in order for price signals to accelerate the transition. This will require complementary and sustained investments in infrastructure, particularly transformation of public transport and urban spaces to improve accessibility to amenities and services, as well as integrated technology transfer and innovation policy which can encourage diffusion of low-carbon appliances, equipment and technology.

Administratively straightforward carbon pricing via fuel taxes

Initially, governments may choose to tax carbon implicitly through increasing existing taxes on fuels, particularly given that the most polluting fuels, such as coal and diesel, are often the lowest taxed. Most countries already raise revenue through taxes on fuels in some form, normally through an excise tax which has a similar impact to carbon taxes on consumer behaviour.

This can help to incrementally increase the ECR and has the advantage of building on existing tax administration systems, as well as limiting the need to develop sophisticated MRV systems, given a proxy for CO_2 emitted per unit of fuel by type can be used to assess emission reduction gains instead. The process of improving net positive gains on the country's ECR should be incremental, with governments

investing in parallel in infrastructure and public transport to provide citizens with real viable alternative choices once a carbon price is applied, which in turn will enable increases over time.

Building more sophisticated carbon pricing mechanisms and linking carbon markets

As part of a long-term strategy, fossil fuel-producer emerging and developing economies may eventually turn to explicit carbon pricing beyond incremental increases to taxes on fuels, through introduction of a carbon market mechanisms such as an ETS. This could eventually create opportunities to mobilise climate finance. For example, the Clean Development Mechanism (CDM) under the Kyoto Protocol allowed a country with an emissions reduction commitment to implement a mitigation project in a developing country. This allowed it to obtain UN-issued Carbon Emissions Reductions (CERs), or carbon credits, which could be used to contribute to its emissions reduction commitments or sold.

Given emissions abatement opportunities across industries relating to oil, gas and coal, fossil fuel producer emerging and developing economies are particularly well-placed to generate climate finance through carbon markets. Relevant projects might include technologies to reduce carbon intensity of coal mining, oil and gas producers providing carbon storage units for CO_2, gas utilisation projects to reduce flaring or energy efficiency projects.

On the basis of the model established by the CDM, a number of regional economic groupings and in some cases provincial governments, have set up their own ETS. As of 2021, there are 33 ETS schemes in operation around the world (one supranational, eight country level, 18 provinces and states, and six cities). These cover 16% of global GHG emissions and jurisdictions making up 54% of global GDP (ICAP, 2021[139]). Key ETS schemes include the EU ETS (cap and trade, introduced in 2005) and China's ETS (cap and trade, introduced in 2001), which is now the world's largest carbon market (World Bank, 2021[140]).

Box 3.21. Cap and Trade versus Baseline and Credit ETS

ETS can be grouped into two categories: Cap and Trade schemes and Baseline and Credit schemes. In Cap and Trade schemes, a government establishes a threshold for emissions during a predefined time period, and emissions quotas are allocated to industry. In Baseline and Credit systems, an emissions baseline is established for regulated entities and any emissions above the baseline have to be accounted for through credits. Entities which reduce their emissions below the baseline receive credits for these emissions cuts and can sell them to higher emitters.

Source: (Price, 2020[141]).

A rulebook for Article-6 of the Paris Agreement governing the functioning of an international carbon market, which could eventually serve as a replacement for the CDM, was agreed at COP26 in Glasgow in November 2021. The new rulebook establishes a mechanism for carbon trading between governments, and also between companies and governments, as well as a 5% levy to fund adaptation projects. However, while agreement on Article-6 does raise the prospect that increased financial flows will accrue to emerging and developing countries, the extent to which this will take place is not clear at this stage. Sixty-one countries, including major fossil fuels producer countries such as Egypt, Kazakhstan and Nigeria, have signalled their intention to utilise carbon markets to meet their NDC commitments (GDI, 2021[142]).

Key principles to ensure the integrity of ETS include making sure emissions mitigation is real, measureable, verifiable and permanent, which requires effective MRV systems, and environmental integrity is guaranteed (crediting does not result in an overall increase in emissions). Avoidance of double counting (no two entities can use the same emissions reductions or avoidance to contribute to their NDCs) is also key (World Bank Group & Carbon Partnership Facility, 2021[143]). Projects should also be able to

demonstrate conclusively that in the absence of carbon market support, carbon abatement technologies would not have been deployed.

Box 3.22. **Kazakhstan's ETS**

Working alongside the World Bank's Partnership for Market Readiness (PMR) programme, Kazakhstan in 2013 launched an ETS to drive development of low-carbon technology, energy efficiency and investment in renewable energy. Kazakhstan's ETS now regulates 40% of emissions, covering 225 entities with emissions exceeding 20 000 tonnes of CO_2 per year. For Kazakhstan, which is the world's 21st biggest emitter, with 85% of its emissions emanating from its coal intensive energy sector, the ETS represents a first step on the pathway towards net zero, though more needs to be done to achieve this goal by 2060, a target to which it committed in 2020.

Source: (Marteau, 2021[144]).

Governments should consider prioritising the following actions:

- Calculate the national ECR by sector and fuel type and establish long-term plans to transform it to net positive, and improve revenue gains via gradual elimination of fossil fuel subsidies and incremental reforms of existing fuel taxes, for instance, excise taxes. The OECD already publishes the ECR for many developing and emerging countries as part of its Taxing Energy Use project, in which data from 71 economies are analysed (OECD, 2021[137]).For some fossil fuel producer developing and emerging economies, national socio-economic conditions may affect the feasibility of an explicit carbon price in the short term.
- As part of a short- to medium-term strategy, prioritise incremental increases in the national ECR through progressive reform of inefficient fossil fuel subsidies and a rise in existing taxes on fuels, incorporating measures to offset political economy challenges and negative distributional impacts. This will enable governments to leverage existing tax administration systems, thus avoiding the establishment of 1) sophisticated MRV systems, as a proxy can be used to calculate impact on emissions reduction; and 2) an explicit carbon price, which may not be feasible from a political economy perspective.
- Prioritise raising fuel taxes on the most polluting fuels, noting that coal and diesel tend to be the least taxed in emerging and developing countries.
- Communicate effectively to the public the rationale for carbon pricing, explaining the scale and opportunity costs that subsidies and unaccounted for externalities entail, and offering more efficient ways to support vulnerable households and to use revenue in a more productive way.
- Consider that firms and households need time and support to adapt to rising prices. Consider the role of non-price measures, including alternative fuel mandates, performance standards, subsidies and grants, in facilitating improvements in the ECR over time. This can provide an effective means to nudge firms and households towards behavioural change in contexts where there are strong political economy barriers, because costs of compliance are not felt uniformly across income and interest groups.
- As part of a long-term strategy, plan to raise the ECR stating the objective to introduce carbon pricing down the line through an ETS or explicit carbon tax, and outlining the criteria at which point introduction of such systems will be feasible as citizens and firms have access to viable alternatives.
- In parallel, build institutional capacity and expertise to design more sophisticated carbon pricing systems.

- Consider that trial periods can support implementation, giving firms and consumers time to adapt to changes. Political opposition tends to be greatest prior to implementation, and trial periods can help mitigate this risk.
- Establish a habit of making regular adjustments to energy prices, and communicate them regularly, according to a set day of the week or month via a government website. If an announcement is scheduled, but no actual price change takes place, this should still be communicated. This will sensitise consumers to changes and facilitate the process of adaptation. In addition, regular energy price changes mean that changes are likely to be smaller, whereas changes after a long period of time mean that price increases are likely to be much higher, which are more likely to result in civil opposition or have more profound impacts on households and firms.
- Consider the impact of CBAM when additional fees on imports are introduced by the EU on market access and firm competitiveness in trade exposed sectors. Also, consider introducing a limited emissions at source tax, with taxes rising over time. In general, exemptions should be avoided, with revenue from the tax instead recycled back to taxed firms to incentivise fuel switching and investment in energy efficiency and emissions abatement measures to incentivise decarbonisation of industrial production.
- Targeted measures to offset impacts on interest groups who have strong capacity to mobilise can help overcome political economy obstacles.
- Consider where taxes are collected. Fewer taxpayers result in a more administratively straightforward process for tax collection, but taxpayers must be able to pass costs on to consumers for the system to be effective at changing behaviours.
- Consider a range of options for introducing new taxes, for example, fuel taxes, a direct emissions approach, carbon added tax, and a climate damage tax. A decision as to which approach is best suited to the national context should be based on a range of factors, including climate and economic objectives and capacity of the tax administration system. A blended approach of different mechanisms is also an option. Undertake extensive consultations when designing an approach, including with civil society and industry groups.

Development finance institutions and bilateral development agencies should:

- Provide technical support to governments to set energy prices and develop pricing formulas.
- Provide communications and stakeholder support to governments to help build public acceptance of energy price reform and support the development of effective and targeted assistance measures.
- Provide technical assistance to governments considering the establishment of ETS.
- Provide technical assistance to governments in strengthening MRV systems.

Actions where international support would be required where government capacity is low:

- Consider introducing automatic pricing mechanisms in legislation which will trigger a set price increase when certain conditions are met. This can help depoliticise energy price reform. Incorporating energy price reform in legislation can also make it harder to reverse policy because this will require parliamentary approval. Including price reform in regulations, or as a simple announcement will be easier to reverse, requiring a ministerial signature in most contexts, or limited approvals to change policy respectively.
- Publish a transparent price formula which allows consumers to understand the price gap, and presents a clear picture of the incremental increases required over time to bring local prices into line with adjusted reference prices. A publicly available and simple-to-use formula can also be an effective communications tool, enabling government to transparently explain to citizens and firms the scale of subsidies and build a rationale for reform.

- Review and improve existing MRV systems. Carbon crediting relies on establishing credible emissions baselines, and measurement and verification of emissions reduction. Mobilisation of finance at scale requires sophisticated techniques to ensure accurate establishment of baselines, and aggregation of emissions reductions across a large number of entities. Establishment of effective MRV systems is therefore key, in particular using ISO 14064-1 and ISO 14064-2, ISO 14067 standards for carbon management.
- Develop a domestic policy and regulatory framework in line with the agreed rules under Article-6.
- Consider opportunities to collaborate with other governments in obtaining carbon credits. This can make achieving targets more feasible. If one country falls short of its targets, its partner country may have the potential to make up the difference.
- Assess risk of emissions being inflated before crediting mechanisms are introduced to make reductions in emissions easier.
- Review institutional strengthening and capacity building needs if considering the introduction of ETS. Carbon markets are complex to design, including, for example, requirements to establish credible baselines or emissions caps, as well as stabilisation mechanisms to limit price volatility, and require strong institutional capacity to be successfully implemented.

Revenue recycling from fossil fuel subsidy reform and carbon pricing

As revenue or savings from fossil fuel subsidy reform and carbon pricing begin to grow, revenue recycling offers an opportunity to double up on GHG emissions disincentives by reinvesting revenue in a range of areas, including those related to the low-carbon transition. Revenue recycling options include reinvesting revenue in R&D to promote technological innovation, investing in renewable energy and energy efficiency measures, and more general developmental and human capital objectives, such as education, healthcare and infrastructure, or paying off public debt. Some governments choose to ring-fence spending for specific sectors or objectives, a process which can be complex to implement given the requirement to involve a large number of agencies, but one which can tell a convincing story as to how revenue from carbon taxes is being reinvested for the public good.

Ultimately, many countries introducing carbon or environmental taxes choose to recycle revenue across a range of areas. As part of a comprehensive energy sector reform programme following the Fukushima disaster in 2011, Japan introduced a carbon tax in 2012, putting a price on coal and petroleum, which is reinvested in R&D and low-carbon projects. Colombia introduced a carbon tax in 2016 and uses revenue to support the peace process as well as environmental projects (PMR, 2019[145]).

Governments should consider prioritising the following actions:

- Prioritise complementary investments in infrastructure, particularly public transport, and policies to encourage technology transfer and firm innovation as part of a comprehensive, integrated strategy to promote the diffusion of contextually adapted and affordable low-carbon technology and appliances to provide consumers with low-carbon alternatives to switch to when higher prices from carbon pricing eventually kick in. Without viable and affordable alternatives, energy price reform will have limited impacts on firm and household behavioural change and could lead to unintended consequences, such as pushing lower income households into poverty, or incentivising the use of more polluting biomass as cooking fuels.
- Recognise that a stronger social contract between citizen and state will enable the process of energy price reform, and, accordingly, prioritise strengthening trust in government institutions in line with recommendations under Pillar 3, Section 3.1., as well as targeted transfers to vulnerable groups. Governments should understand that energy price reform is often undermined by a lack of public confidence that resources saved will indeed be recycled for the public benefit.

- Carefully consider the range of revenue recycling options, including removing distortionary taxes, investment in low-carbon transition plans, development and human capital objectives, and debt reduction. This should be based on rigorous assessment of country circumstances, as well as on consultations with relevant interest groups.
- Consider establishing a dedicated fund to manage revenue from carbon taxes. This can improve accountability and transparency of reinvestment plans.

3.3.2. Raising revenue collection by addressing tax compliance and restructuring fiscal frameworks

Domestic revenue mobilisation significantly underperforms in many developing and emerging economies, where untapped revenue streams could represent an important tool for governments to manage the impacts of declining revenue from fossil fuels. On average, developing countries mobilise less than 20% of GDP in taxes, with approximately half of low-income countries and lower middle-income countries raising less than 15%, compared with between 30% and 45% in OECD countries (European Commission, 2015[146]).

Domestic revenue mobilisation is more challenging in contexts where informal or subsistence workers make up a larger proportion of the workforce, which is often the case in developing countries where informal labour can account for as much as 80% of the labour market. Governments can take steps to collect more tax by improving tax compliance including by reducing tax evasion, and tax avoidance and cracking down on illicit financial flows, as well as closing the policy gap through mobilisation of untapped revenue streams to diversify the tax base. This might include property taxes, VAT, carbon taxes, or environmentally related taxes more broadly, such as vehicle taxes and excise taxes not aligned with carbon content.

Closing the compliance gap entails bringing taxes actually collected into line with the theoretical amount of tax which could potentially be collected. This will require governments to: 1) build more efficient and effective tax systems, raising human resource capacity and systems efficiency to eliminate loopholes which are often created by complex taxation regimes; 2) fight tax evasion; and 3) enhance regional and international co-operation to limit tax evasion and profit shifting. Developing and emerging economies tend to be more affected by corporate tax evasion than advanced economies, because corporate income tax on average makes up a higher proportion of government revenue, at 16% and 8% respectively (European Commission, 2015[146]). Tax incentives and exemptions deployed to attract foreign direct investment tend to be costly and inefficient, failing to achieve the objectives for which they are designed.

Governments can also review tax policy arrangements to identify additional tax instruments that can help to broaden the tax base and increase revenue collection. The introduction of value added taxes over the last decade in fossil fuel producers, for instance in Bahrain, Egypt and Oman, has presented an effective tool for governments to mobilise revenue (Coplin and Nwafor, 2019[147]).

Taxes that target citizens who are better able to pay, both through progressive personal income taxation or property tax, are underused in many developing and emerging country contexts and can help to make a taxation system more equitable. Property taxes and capital gains taxes in particular tend to be lower as a proportion of government revenue in developing countries, and may present an effective means through which to broaden the tax base in a progressive manner (Coplin and Nwafor, 2019[147]).

Lastly, raising existing excise taxes on polluting energy products, or in some cases introducing environmental or carbon taxes, while reducing taxes on low or zero carbon products, can be an effective means through which to broaden the tax base, raise revenue and internalise negative externalities. However, governments should be conscious of public acceptability issues, as well as the risk of unintended consequences that could push poorer citizens into poverty if no viable and affordable alternatives are available when prices increase.

The Tax Administration Diagnostic Tool (TADAT)[1] is a key instrument that governments can use to assess the health of their tax administration system, and identify strengths and weaknesses, as well as priority reforms to increase revenue mobilisation, improve tax compliance and broaden the tax base. Meanwhile, the Revenue Administration Gap Analysis Programme (RA-GAP), created by the IMF, provides a methodology for governments to estimate the gap between theoretical taxes which could be collected and actual tax collection (European Commission, 2015[146]).

Governments should consider prioritising the following actions:

- Review national taxation systems and performance to assess policy and compliance gaps, and identify reforms to improve compliance, identify untapped tax instruments to diversify the revenue base and increase tax collection. The TADAT and RA-GAP offer important tools to help governments achieve these objectives.
- Consider consolidating all tax incentives for investment under one authority or government body. This can facilitate better management of the net cost of such measures, which should be calculated regularly, alongside more regular monitoring and periodic assessment of performance against objectives.
- Review tax exemption expenditure to assess efficiency against clearly defined objectives. Eliminate exemptions where they are not achieving their targets. This will improve perceptions of fairness and generate revenue.
- Establish a mechanism to regularly review tax expenditure (Mullins, Gupta and Liu, 2020[148]).
- Consider the equity implications of adjusting fiscal arrangements, particularly if introducing consumption taxes, such as VAT, given these measures can disproportionately impact the poorest. If consumption taxes are introduced or increased, they should be paired with spending policies, such as cash transfers, to ensure costs are born principally by wealthier citizens. This needs to be taken into account during assessment of existing tax policy and spending (Coplin and Nwafor, 2019[147]).
- Develop a strategy to effectively communicate the introduction of new taxes or adjustments to fiscal arrangements. This should clearly explain when changes will be taking place, outline why changes are necessary, and point citizens and businesses towards information resources that can support compliance or ensure they are aware of specific exemptions or support which apply to them. The ultimate goal should be to raise customer awareness and achieve structural changes in their behaviours, thus supporting the just transition.
- Strengthen the tax collection capacity of sub-national government. This can significantly increase tax revenue and revenue generation. Strengthening subnational government revenue will ultimately improve the provision of locally administered public services (Coplin and Nwafor, 2019[147]).

Development finance institutions should:

- Provide technical support to governments to assess the compliance gap and develop strategies to raise compliance and collection over time. Donors can support governments to undertake strategic reviews via TADAT and RA-GAP tools.

3.3.3. Spending better through more efficient and redistributive fiscal frameworks

In addition to policies designed to collect more revenue and broaden the tax base, governments should adopt measures to improve the efficiency and fairness of fiscal systems through enhanced spending on expansion of social protection programmes, and improving the strategic allocation of resources. Incremental tax reforms in Latin America, for example, alongside gradual increases in investment in social

protection schemes, including via cash transfers to vulnerable households, has had some success in reducing household inequality and tackling poverty (Bargain et al., 2021[149]).

Governments should consider the net fiscal incidence of taxation systems, which is the combined overall economic impact of government taxation and non-tax revenues (i.e. transfers to government from NOCs) against public spending. Government policy should seek to establish a system in which the net fiscal incidence redistributes towards low-income groups. This might include, for instance, expanding social protection provision, education or healthcare services, particularly in rural areas. While VAT might be regressive in isolation, a good fiscal system would be able to harness the revenue generating power of VAT, whilst compensating poorer households through increased and better targeted spending. Overall, the net effect would be a positive one.

Establishing effective redistributive tax systems relies on governments having a good understanding of the spatial distribution of poverty across a country, both by region and also at a very local level, which can help governments identify groups who will be affected by fossil fuel closure. This requires investment in systems to collect granular level data, such as household data, and a better understanding of informal labour (see Pillar 2, Section 2.2.2).

Effective redistributive fiscal systems are also important for delivering a just and equitable low-carbon transition. In developing countries in which overall levels of poverty can be high, it is important to provide support to communities who are negatively affected by the low-carbon transition, for example, through loss of employment, or higher transport costs owing to subsidy removal. At the same time, this could lead to resentment among other sections of the population, many of whom are also poor, which could be difficult for governments to manage. This is why it is necessary to build an effective pro-poor fiscal system so that all low-income groups receive assistance, while at the same time providing additional targeted assistance to those especially affected by the low-carbon transition.

Lastly, governments should strive to improve the efficiency of public spending, eliminating waste and building mechanisms to improve project and programme prioritisation. The Public Expenditure Financial Accountability (PEFA) programme offers a diagnostic tool for governments to review revenues, public expenditure, procurement and financial accountability mechanisms, with a view to identifying necessary reforms and capacity-building requirements. Key objectives of the PEFA process include aligning government spending with available resources, and improving the strategic allocation of resources via improved budget planning and allocation processes in line with national development priorities in such a way as maximises the public good (European Commission, 2015[146]).

Governments should consider prioritising the following actions:

- Progressively invest in the expansion of social protection systems and coverage in line with incremental increases in tax collected, and broadening of the tax base, in line with recommendations in Pillar 2, Section 2.2.4.
- Review public financial management and budget allocation frameworks to eliminate inefficient spending, and enhance the strategic allocation of public resources. This should include measures to improve data collection on public spending and building capacity to monitor and evaluate results. The PEFA process can support governments in identifying priority reforms and improving budget prioritisation and allocation processes, in line with national strategic goals, available resources and macroeconomic and fiscal policies.

Development finance institutions should:

- Support governments to implement public financial management reforms and the PEFA process.
- Assist developing country governments in analysing the tax gap, leveraging existing systems and experience in calculating and determining both tax compliance and policy gaps.

3.4. Addressing energy poverty and decarbonising electricity systems

With 785 million people worldwide with no electricity access and 2.6 billion without access to clean cooking solutions, the challenge of decarbonising electricity systems and rolling out affordable, reliable and sustainable access lies at the heart of the development challenge for fossil fuel producer emerging and developing economies. It also highlights the global inequalities that are the crux of the low-carbon development challenge for advanced and developing economies alike (IEA, 2021[150]). Despite the recent rising cost of capital driven by inflationary pressure, huge cost improvements over the last ten years in renewable energy and storage technologies mean that these are now cost competitive with fossil fuels, if not cheaper, in most parts of the world, offering affordable and decentralised energy solutions to address energy poverty. They can also play a catalytic role in decarbonising industrial production and other areas of the economy across developing countries and emerging markets.

Yet, developing and emerging economies are lagging behind advanced economies when it comes to building decarbonised, resilient, modern energy systems. Decades of underinvestment in generation, transmission and distribution infrastructure has created a legacy of technological deficiency, resulting in grid absorption issues, financially weak state utilities and perceptions that power projects are too risky for private investment if they are not backed by payment guarantees.

Emerging and developing economies account for just one-third of energy investments, falling to 20% when it comes to clean energy (IEA, 2021[150]). Moreover, clean energy investment in emerging and developing economies is currently declining, contracting by 8% to less than USD 150 billion in 2020, before a modest recovery in 2021 (IEA, 2021[16]).

Failure to ensure that citizens of emerging and developing economies have access to secure, affordable, reliable and sustainable electricity on an equal footing with their peers in advanced economies risks undermining social acceptance of transition policies across developing countries. Emerging and developing economies account for two-thirds of the world's population, and almost all population growth in the next two decades. Per capita emissions are almost one-quarter of what they are in advanced economies, but as they grow and industrialise, the emissions trajectory is set to grow by 5 Gt over 20 years (excluding the Middle East and Eastern Europe), while advanced economies' emissions will fall by 2 Gt and China's will stabilise. This means that failure to address electricity system decarbonisation in emerging and developing economies will cause the world to massively overshoot its climate targets (IEA, 2021[150]).

Reversing this trend will require significant mobilisation of capital, with much of the investment needing to be front loaded, as well as unprecedented technology and skills transfer. The IEA estimates that investment in the energy transition in developing and emerging economies will need to increase by seven times to USD 1 trillion per year by the end of the decade to reach net zero. Meanwhile, the African Union's 2063 Agenda to achieve full electricity access in urban areas, and one-third in rural areas by 2030, equivalent to about 60 million people per year, will require an annual investment of USD 35 billion. About half of this will need to be achieved through off-grid solutions. Meanwhile, providing everyone with clean cooking solutions by 2030 will require an investment of USD 6 billion per year (IEA, 2021[16]).

Failure to address electricity systems decarbonisation and energy poverty could result in a two-track transition, where fossil fuel-based economies continue to produce emissions-intensive products for domestic use and export to other developing countries, while advanced economies decarbonise and invest in frontier low-carbon technologies. A possible option for emerging and developing country producers with cheap and abundant gas is to monetise reserves with production of hydrogen from abated gas while in parallel scaling up investments in renewable energy and storage to produce green hydrogen and establish themselves as green industrial hubs for hard-to-abate sectors such as steel and cement as part of their long-term strategy, as outlined in Pillar 3, Section 3.2.1.

Box 3.23 Considerations for investing in gas-fired power to deal with variability and intermittency

Many developing countries face significant challenges in terms of energy access, with 600 million people in Africa currently lacking access to grid-based electricity. Moreover, financially weak utilities, fuel subsidies and grid absorption capacity issues tend to act as a deterrent to private finance investment in renewables: 90% of investment in renewables in Africa comes from public or multilateral development bank sources. For many developing countries, adding substantial volumes of new renewable energy capacity over a short period of time can cause grid intermittency instability issues given the variable nature of renewables generation technologies. For example, Kenya has experienced severe voltage instability at only about 15% capacity from wind and solar.

Investments in gas-fired-power generation need to be based on a nuanced analysis of country demand and projections under different options, and the cost of gas and related efficiency and abatement technologies, including a balanced assessment of costs versus other technology options. More gas-fired-power generation appears logical for countries such as Iraq and Nigeria, where high flaring rates mean a lot of available gas is currently wasted. In these contexts, investments in abated or highly efficient fossil gas-fired power generation can bolster energy access rates, and can also accelerate the transition towards a renewables-based energy system, acting as a dependable back up when generation from renewables is not possible. This will also enable the deployment of more renewable generation technology to the grid without resulting in intermittency.

Efficient fossil gas-fired power generation can complement wind and solar technology well, given that certain gas turbine and combustion engine technologies can ramp up and stop quickly, accommodating weather variability, at a relatively low fixed cost compared with other fuel types. Owing to their relatively low investment costs and in many regions moderate variable costs, combined-cycle gas turbines (CCGT) can present a financially attractive alternative even if providing power only as a back-up solution.

However, without abatement technologies which will add to the cost of power produced, such infrastructure can also lock in emissions, including local pollution costs, and require long-term fuel inputs. It is therefore critical to fully assess all available alternative opportunities, also taking into account the feasibility and cost of gas abatement. In some regions (e.g. Australia, California, Jordan), it is already becoming apparent that overshoot on thermal capacity can increase either public costs or stranded asset risks or inhibit renewable power investment, given take or pay contracts. A focus on financing thermal power (including with government grants and cheap credit) may also detract from much needed investment in the grid, storage and transformation of the business model to prepare for a lower cost, lower emissions system. Where new gas-fired power plants are developed, they should be designed with increased flexibility in mind, enabling them to transition to back-up power generation when increasing volumes of renewables capacity are added to the grid (IRENA, 2019[151]).

Moreover, given the nature of project financing for power, investment in gas-to-power will leave countries with 40 years or more of gas-fired-power generation. This can appear attractive because gas-fired power is a tried and tested technology that fits current supply-focused energy models. However, building out fossil gas power could potentially lock countries into expensive carbon intensive development pathways for decades, while the cost of more efficient infrastructure, renewables generation and storage are expected to fall, with prices driven down by sustained investment in innovation and energy efficiency improvements. In addition, with time it is likely that technological developments will make electricity storage an affordable alternative, removing the need for baseload power provided by gas-to-power generation. Hydrogen (in particular green hydrogen) offers

opportunities for grid balancing and new production and export potentials for existing fossil gas exporters.

Gas-fired power generation could provide governments with an effective means to bolster investment in renewables, quickly decarbonise, lower the trajectory of power generation emissions over diesel or coal-fired power and expand electricity access. However, there are trade-offs, and governments need to assess available information on national demand trajectories, integrated energy infrastructure and cost options (including health and environmental costs), pricing, levelised cost of electricity (LCOE), risks and future financing landscape, in order to be able to make an informed decision. It is critical that governments also consider the opportunity cost of gas-to-power investments in relation to alternative solutions and to understand how well producing and burning gas for electricity generation serve national domestic energy sector goals.

In many developing countries energy access issues are primarily rural problems, so adding substantial amounts of gas to the grid may not provide an access solution in and of itself. Rather, it may be preferable to encourage off-grid solutions in remote areas given the prohibitive costs of infrastructure development. A mix of efficiency, demand-side management, and strengthened and interconnected local grids, which can accommodate increases in renewables, can help avoid incurring high-cost gas, and storage solutions and may offer far cheaper accompaniment to renewable energy. For example, setting tariffs to encourage matching demand, including by compensating customers for reducing loads when necessary to balance the system, is an effective way to deal with variability. This is usually more economic than building new generation and can be initiated through special tariffs for on-grid industry.

Source: (Thurber and Moss, 2021[152]); (IEA, 2020[153]) .

Advanced economies, development finance institutions and bilateral development agencies should:

- Massively scale up blended and subordinate finance, concessional loans and grants, in line with recommendations in Pillar 2 to de-risk and unlock private investment in the power sector, alongside reinvigorated efforts to establish new, innovative and transformative partnerships for enabling skills and technology transfer, recognising the joint responsibility of importer and producer countries to achieve global decarbonisation. This should be commensurate with emerging and developing country needs for the energy transition, and recognition of existing and future import demand of advanced economies, particularly for renewable energy and hydrogen.
- Recognise the importance of universal access to affordable, secure, sustainable and reliable energy, in line with SDG-7, for generating societal support for transition measures in developing and emerging economies as necessary conditions for achieving global climate targets.
- Recognise the pace of the transition will be different between countries, requiring trade-offs, for example in terms of use of renewable energy for hydrogen production or for raising energy access and storage for grid balancing. For African countries, for example, a globally just transition must recognise the necessity for some countries to monetise their gas resources and deploy abatement technologies, as part of a least-cost and realistic pathway to net zero, commensurate with historic emissions contributions and ability to address the climate crisis, as noted in the AfDB's 2022 African Economic Outlook Supporting Climate Resilience and a Just Energy Transition in Africa (AfDB, 2022[154]).
- Ensure investment in power sector fundamentals, including grid stability and robustness, distribution infrastructure and payment collection mechanisms. Transmission and distribution grids are key to enable the deployment of renewable energy and to manage increased demand for electricity. However, transmission and distribution infrastructure is often considered too late in the process or not prioritised for effective renewable energy deployment. This can delay or inhibit the

addition of renewables capacity to the grid and add more risk for the private sector, making capital more expensive. Regulatory frameworks should also clarify who is responsible for connecting renewable projects to the grid and make provisions to compensate investors in the event of a delay. Meanwhile, investing in payment collection infrastructure and enforcement can improve the financial health of the state power utility, ultimately making it a more reliable off-taker for electricity from renewable energy projects.

- Assess information on pricing and LCOE alongside attendant system costs, wider public health and environmental costs, risks, changing energy generation and distribution as well as the future financing landscape to understand if investment in highly efficient or abated gas-to-power represents a cost-effective solution to deal with variability, intermittency and expanded electricity access. Governments should be clear as to the trade-offs involved, given that they may be locked into carbon-intensive generation pathways when low renewables costs and technological advances in electricity storage may mean cheaper and more sustainable options are available. They should also explore economic options for managing variability, such as tariffs, to encourage matching demand profiles and, where there is hydro, potentially pumped water storage.

3.4.1. Managing power sector planning for least-cost decarbonisation and expansion

Robust power sector planning, capable of identifying the optimum balance of generation and storage technologies as well as of on-grid and off-grid provision of electricity, and translating plans into timely and effective procurement, is of central importance to maintaining and expanding grid flexibility, facilitating scale up of variable renewable energy technologies, de-risking investments for the private sector, and realising least-cost pathways to power sector decarbonisation and expansion. Good sector planning blends dynamic analysis of demand, with identification of required generation, transmission and distribution investments. Through advanced modelling, planners can identify the optimum blend of renewable energy and storage technologies to achieve a balanced system. Additionally, Demand Side Management (DSM) initiatives can enhance grid flexibility, facilitating grid expansion.

Often, however, power sector planning is poorly implemented, and not updated or reviewed regularly enough, with incorrect projections and assumptions leading to the wrong generation capacity being procured, and transmission connections failing to keep pace with generation investments – sometimes resulting in substantial costs for government – or areas with strong renewables resources being overloaded, resulting in procurement delays and raising the cost of connecting to the grid. For instance, the commissioning of the 310 MW Lake Turkana Wind IPP in Kenya, which required development of a 438 km transmission line to connect it to the grid, was delayed by 15 months owing to delays in completing the transmission line. This resulted in the Kenyan government paying the developers EUR 46 million in compensation for the delay. Similarly, South Africa's renewable energy auction process initially required developers to identify locations that would enable them to minimise tariffs under a PPA, but the resulting concentration of projects in the sunniest or windiest areas led to delays and an increase in connection costs, requiring the government to adapt the system (Sachs, Toledano and Brauch, 2021[155]).

The most comprehensive planning tools are Least Cost Power Development Plans (LCPDP) or Integrated Resource Plans (IRP), which over a period of 15 to 20 years, blend transmission and distribution planning, and define the least-cost supply and demand-side investments needed to fulfil power demand, while reducing overall system costs. System planning should also incorporate broader policy objectives, including energy poverty eradication (Eberhard et al., 2016[156]).

Box 3.24. Best practice guidance for developing an Integrated Resource Plan (IRP)

Building a coherent IRP is a complex process, with long project lead times and large investment requirements, plus multiple uncertainties relating to demand forecasts and evolution of the technological landscape, making planning highly challenging, given the risks of over and under investment and the necessity that grid connections keep pace with generation procurement to avoid expensive delays. Scenario modelling and a dynamic approach to planning ensures ongoing performance monitoring against the plan, updates to reflect changing conditions and technological development, plus extensive engagement with a broad array of stakeholders. Government and industry involvement is key to ensuring the process incorporates as broad a range of perspectives as possible, as well as defining contextually appropriate solutions to specific national circumstances. Given the differences in economic and electricity sector circumstances across countries, there can be no one size-fits-all approach to IRP development. The advantage of using such a tool is that planning can be tailored to meet specific national challenges, including energy access and renewable energy penetration, and updated as circumstances change.

Institutional arrangements

The agency responsible for IRP development, often the state power utility, will normally be named in national legislation. It may be helpful for governments to establish an IRP Consultative Committee or Steering Committee with clear terms of reference and clearly defined roles and responsibilities between participants – including who has ultimate decision-making authority over the plan – and a regular schedule of meetings and programme to develop the IRP. Aside from the utility, key institutions who can be involved in such a body include the regulator, given its role in sector oversight, the energy ministry, who sets the policy framework to enable achievement of IRP goals, as well as the economy or finance ministry, which plays a central role in IRP affordability.

Where government capacity to develop an IRP is lacking, there is often a tendency to use external consultants. Relying on third parties exclusively to develop an IRP is not advisable, given the importance of government ownership when it comes to implementation, as well as the need to ensure an IRP can be updated across its full lifetime, in some cases up to 30 years. Where external consultants are used, their terms of reference should incorporate capacity transfer requirements to strengthen government capacity to design and implement a workable IRP.

Key steps in the IRP development process

1. **Objective setting.** Establish the main goals the IRP will aim to achieve, as well as how these will be measured through interim and long-term quantitative and qualitative indicators. Objectives should include national social, economic, environmental development and emissions reduction objectives, and might include targets such as raised energy access, increasing security through reducing use of external resources such as imported fuels, scaling up renewables penetration, and improving utility cost recovery and least cost pathways to decarbonisation and power sector expansion. An IRP needs to be integrated into national development and economic diversification plans and a country's NDC.
2. **Build demand forecasts.** Understanding future energy use and how this will evolve in line with demographic and technological developments across the country is key to understanding how much generation capacity and what type needs to be procured where and when, as well as the transmission infrastructure requirements to enable grid connections and transportation of power to different demand centres. Good data relating to historic electricity sales by location and consumer class, and how the load curve evolves throughout the day, as well as economic and demographic data, can support informed forecasts as to future demand growth. End-use data relating to household use of appliances, and energy intensity data (kWh/year), disaggregated

by household, industrial and institutional consumers, are also key to this process. While sometimes available in national census data and utility surveys, these data can be hard to obtain in some cases, and development financing institution support may be needed to improve data availability in some contexts.

Trend forecasting assumes past trends will continue, but lacks the ability to build detailed and nuanced demand forecasts that accommodate future demographic, economic and technological developments. End-use forecasting, supported by econometric analysis, can paint a more nuanced picture of future demand, and can also be updated and adjusted when new information and data become available. Given demand forecasting is inherently uncertain, multiple forecast scenarios are advisable, for example, a high demand forecast, medium demand and low demand.

3. **Understanding electricity supply options.** Governments should build alternative candidate plans for electricity supply, incorporating a full review of available options, including storage options, and outlining promising technologies which warrant more in-depth assessments, including utility scale, centralised, local and decentralised mini-grid options, as well as requiring a blend of baseload and peak load generation alternatives, alongside incorporation of enabling transmission and distribution options. Preferred supply options can be allocated a score against a range of factors, for example, cost/MWh, fuel use per kW and, emissions per kWh, as well as based on suitability of available sites. This process enables planners to eliminate options which are obviously unsuitable and shortlist others which can then be subject to more detailed analysis such as comparison of life cycle generation costs (cost of capital, finance, operations and maintenance against electricity output), dispatchable power and so on.
4. **Understanding Demand Side Management (DSM) options.** Governments need to understand the suitability of DSM alternatives using information awareness campaigns, variable pricing schedules (higher tariffs for peak times), energy efficiency measures (e.g. housing insulation and more efficient appliances) and fuel switching (moving from gas to solar for heating, for instance), comparing data on feasibility, costs and affordability. As with supply, DSM options can be allocated scores, a key criteria being the lifetime cost of DSM measure per unit of energy saved, versus cost of generating energy which would otherwise be saved, as well as the likelihood of customer acceptance of proposed measures.
5. **Preparation and assessment of candidate supply and DSM plans.** Based on supply and DSM analysis, governments can prepare candidate supply and DSM plans for assessment against different demand scenarios, aiming to shortlist several for final consideration. Key considerations should include which configurations provide least-cost decarbonisation and expansion options, how much spare generation capacity will be needed to keep the system reliable – this is effectively a trade-off between cost of additional capacity and acceptable risk of interruptions – loss of load probability, or the probability that system load will exceed supply in terms of number of days per year, and availability and cost of establishing an interconnection with a neighbouring country to balance the grid where necessary.

   Scenarios can be adapted to model uncertainty, including through stress testing, which can assist in facilitating understanding of what would happen if assumptions are incorrect (e.g. if demand is low in reality when the IRP forecasts high demand). Probabilistic assessments can help assess which scenarios are most likely. Software Tools, including PLEXOS, SDDP and WASP, can facilitate this comparison process, but ultimately personnel involved in the planning process will be key to arriving at an optimum configuration of supply and DSM solutions.

   The preferred IRP should be outlined in detail, including supporting studies and contingency plans, in a detailed document.

6. **Implementation, evaluation, monitoring and iteration.** Adoption of the IRP is just the start of the process and the IRP should be considered as a live reference document by which to judge performance against power sector plans. The IRP should be regularly updated based on a range of evolving factors, such as evolving technology costs, new data on demand, updates to an NDC, performance on generation procurement and transmission development.

Source: (Economic Consulting Associates, 2021[157]); (Tellus Institute, 2000[158]).

Institutional location and capacity is a critical factor in planning effectiveness, as well as in implementation of plans. Often, planning is undertaken by whichever state agency is responsible for transmission infrastructure usually the power utility or dedicated entity responsible for transmission, in many developing countries, depending on the extent to which the sector is unbundled. In theory, this should facilitate coherence between necessary generation and transmission investments. However, in many countries, the financial conditions of the utility mean that it is not in a position to finance investments in transmission infrastructure, which gets left behind, undermining system integrity, limiting the capacity to absorb variable renewables generation and raising risks for private developers.

Government power sector planning functions are often insufficiently resourced in terms of personnel, expertise, software or indeed contracted out to external consultants, often leading to a disconnect in terms of implementation. Resolving these capacity constraints and establishing a clear link with procurement plans, as well as the ability to incorporate views of industry, other government agencies and communities, is a core requirement in expanding and decarbonising the power sector, with significant investments in planning expertise or transfer of planning responsibilities to another agency (e.g. an independent regulator or dedicated planning function).

Box 3.25. Enhancing grid flexibility through electricity interconnections

Electricity interconnections and power pools can support grid flexibility, least-cost pathways to decarbonisation and optimisation of resource use by expanding the complementary blend of power available to the grid at any one time, bearing in mind, sun often shines when the wind is not blowing, and low water levels in terms of hydro may be compensated for by high water levels in neighbouring countries. This can provide the necessary flexibility for the grid to absorb more variable power generation.

The Southern Africa Power Pool estimates that savings in Southern Africa once fully interconnected could amount to USD 1.6 billion per year, while the West African Power Pool estimates potential savings of between USD 5 billion and USD 8 billion. However, fully functioning and efficient interconnections and power pools can be challenging to establish, requiring a commitment to free trade of electricity between countries, regional regulations or a regional regulator that can enforce requirements across borders, and adequate interconnection infrastructure, as well as resolving differences in transmission fees between countries.

In Africa, the African Continental Free Trade Area (AfCFTA), which entered into force in January 2021, can support enhanced electricity co-operation and connectivity between countries, facilitating the alignment of regulations, co-operation between utilities and power pools, and cross-border remuneration frameworks, to enhance energy trading. This can enable some countries which expect to have a surplus of electricity from renewable sources – Egypt, for example, is expected to have a surplus of 74 GW by 2035 – to more easily supply surrounding countries with clean power, as well as aggregating demand from industrial clusters to incentivise investments in power projects which can sell across borders.

Source: (Sachs, Toledano and Brauch, 2021[155]).

Identifying prospective locations for renewables generation and integration with transmission planning can support least-cost systems development, particularly in contexts where the integration of variable renewables generation into a fossil fuel-based system for the first time will have localised impacts. South Africa's Council for Scientific and Industrial Research (CSIR) has identified eight Renewable Energy Development Zones (REDZs), enabling government to plan for least-cost connections to load centres, and providing reassurance for the private sector that necessary transmission infrastructure will indeed be in place (IRENA, 2018[159]). In identifying such locations, governments should consider overall power sector costs, rather than just for a particular power project, entailing a potential trade-off between areas with the best renewables resources and the cost of connecting to the grid. Meanwhile, power system planners will need to consider the implications of the physical impacts of climate change, which could lead to disruptions in supply or increase demand, and build resilience into infrastructure planning (Jin et al., 2021[160]).

In addition to robust investment in transmission infrastructure, which can aggregate distant resources to improve electricity sector functioning at peak times, investments in grid digitisation and storage options can also enhance grid flexibility and facilitate its ability to accommodate more variable energy generation over time. This process will become increasingly challenging and complex as more renewable energy projects are added to the grid, given that many grids in developing countries are already close to voltage capacity. Through predictive modelling, grid digitisation can assist in identifying probable systems failures, enabling investments in equipment to be targeted strategically, which minimises costs, and to reduce overall transmission and distribution losses, one of the primary reasons for power utility financial problems. Moreover, individual smart meters can help utilities better understand customer demand profiles, enabling tariffs to be better tailored to consumer paying power, particularly medium to large consumers. This can assist with cost recovery and ultimately serve to improve overall service for customers (Sachs, Toledano and Brauch, 2021[155]).

As an electricity system becomes more sophisticated, incorporating larger volumes of variable renewable energy generation, it will need additional measures to enhance flexibility and accommodate periods of peak demand when power generation from renewables is low and vice versa. Power sector planning can incorporate storage options and adaptation to thermal generation facilities, as well as DSM techniques, to address these issues. Retrofitting existing thermal dispatchable power generation stock can enable existing gas or diesel power generation facilities to ramp up and ramp down quickly depending on power generation from renewables at a given time, as discussed in Box 3.26.

Meanwhile, electricity storage, either through pumped hydro or batteries, offers options to reduce dependence on fossil fuel generation and deploy clean power effectively to the grid when there is little wind and sun. Batteries offer a preferable alternative to pumped hydro, especially for remote areas, because the latter can take a long time to build, and variable water levels, which are likely to become more pronounced as the physical impacts of climate change worsen, mean sufficient water volumes may not always be available at peak times.

The cost of lithium-ion batteries has fallen 85% on costs in 2010, and is expected to drop a further 50% by 2040 (SE4All, 2020[5]). Government-sponsored demonstration projects, as well as hybrid renewable energy and storage auctions, and suitable regulatory and incentive frameworks are still necessary to encourage investments in battery storage in many developing countries, as costs remain high. For emerging and developing countries whose power sectors run primarily on thermal generation from fossil fuels, incentivising storage investments will be more difficult early on, given that substantial baseload generation will be capable of accommodating small variability from limited renewables generation. How storage is remunerated is therefore crucial to encouraging investment. Viet Nam has identified specific hydro and battery storage sites in its National Electricity Development Plan (2021 to 2030), which includes 2.7 GW of hydro, with 900 MW of pumped hydro storage and 1.2 GW of lithium-ion battery storage (IEA, 2021[150]).

Box 3.26. Energy storage ownership and remuneration options

Energy storage, particularly in developing country contexts where grids may be weak, and transmission infrastructure underdeveloped, with rapid additions in variable renewable energy capacity resulting in high frequency and voltage variations, can provide cost-effective solutions to delivering electricity system flexibility. Storage options, including the variety of technologies available, like battery storage and pumped hydro, should be considered alongside alternative options, such as additional generation capacity and Demand Side Management (DSM) in establishing overall system balance. A key consideration for power system planners is to understand the potential value addition storage can bring to an electricity system based on the different functions it can fulfil, and to design incentive options and remuneration for developers accordingly. This can be more complex for energy storage projects because of the diverse functions they can fulfil in an energy system, including frequency and voltage control and enabling ramping up and down of variable renewable energy capacity.

Power sector planning should consider the range of storage applications for grid stability, comparing costs against alternative measures, and incorporating these considerations into design of a least-cost IRP. This can be assessed by calculating the levelised cost of storage (LCOS), assessing total costs, including CAPEX and operational costs across the lifetime of a storage project. This process can be complicated by the need to understand the various potential applications of storage in a system, given that this can lead to storage projects obtaining a number of revenue streams from different sources. This can improve project economics but make it more challenging to understand the implications on value to the system.

For developing countries, where at least some aspects of the power utility remain vertically integrated and there is just one transmission system operator, two primary options exist for storage project remuneration. A non-market model entails the system operator, for example, the mandated transmission company or utility responsible for grid management, investing in a storage facility and obtaining a return from customers through electricity sales. A market approach entails multiple project developers competing on cost and buying and selling power to the transmission company or utility. This can make defining contractual arrangements for storage projects complicated, given that storage facilities will buy power at times of low demand when it is cheaper, and sell it back to the grid when prices are high.

To facilitate the development of storage projects, key considerations for governments include assessing ownership rules, clarifying what kinds of entities can own and operate storage and what kinds of services they can provide. Similarly, permitting and grid codes may also need to be adapted to accommodate storage projects. Governments should also consider how levies, surcharges and taxes are applied to storage projects, given the fact they both buy and generate electricity, which can pose a risk of double charging.

Source: (World Bank, 2020[161]).

Alongside storage solutions, DSM can assist governments in shaping demand to match system capabilities, as well as reducing overall system costs by matching lowest-cost generation technologies with demand as often as possible. This is best accomplished by incentivising consumers to use electricity at different times to reduce peak demand through peak pricing and time of use tariffs. Extensive customer engagement will help to encourage behavioural change, although governments should be aware that some consumers, both individual and industry, may be unable to adjust demand.

Governments should consider prioritising the following actions:

- Well-resourced planning functions in terms of expertise, people, modelling tools, software and ability to engage with stakeholders, are key to designing LCPDP and IRP which integrates generation, DSM, transmission and distribution infrastructure investments to build least-cost, dynamic power sector investment plans. Consider moving the planning function to an independent regulator, or dedicated planning agency, and ensure that the power utility or dedicated transmission company invests in plans, as well as ensuring plans are regularly updated.
- Establish strong links between power sector planning and procurement of new generation facilities, including decisions on technology based on least-cost solutions, and determine where, when, and who is best placed to invest between public investment and the private sector.
- Identify renewable energy zones, based on connection costs, as well as power generation potential based on solar and wind and other solutions, and the investments required to get electricity to demand centres. Factor this into auction and permitting plans, and consider tariffs which reflect this trade off, for example, higher tariffs for developers in areas with slightly lower generation potential. Planning must recognise that it is the overall system costs which count, not the individual generation cost at one particular point in the system.
- Progressively incorporate storage options as renewable energy is added to the grid, while considering the need for demonstration projects to bring costs down to commercial levels. Include also incentive mechanisms, hybrid auctions with renewable energy, retrofitting and repurposing, as outlined in Pillar 2, Section 2.3, and concessional finance to facilitate investments in storage.
- Consider how to shape demand through DSM, reducing demand at peak times by incentivising electricity usage where possible at non-peak hours when power will be cheaper. Recognise that this will require engagement with industry and consumers to achieve, as well as clear messaging.

Actions requiring international support in contexts where government capacity is low:

- Prioritise transmission and distribution investments based on least-cost planning (IRP or LCPDP), noting that utilities are unlikely to be able to invest in this alone. Significant investments in core trunk infrastructure and grid digitisation may need to be financed via development finance institutions in order to ensure scale-up of renewable energy and that storage is feasible.
- Prioritise grid digitisation (seeking development finance institution assistance where investments cannot be covered by the utility), which can optimise investments in equipment, smart metering and predictive failure modelling. This can help minimise transmission and distribution losses, enhancing sector integrity and power utility financial health, as well as providing a more nuanced picture of customer usage profiles, including potential to pay (based on medium-sized or large-sized customers). Ultimately, this approach can assist governments to in revising tariffs to improve cost-reflectiveness to ensure that customers with higher paying power are asked to pay more, and higher costs are not paid by poorer households who lack the ability to do so.
- Explore opportunities to retrofit thermal generation to ramp up and ramp down quickly, for use when there is no renewable energy generation. Factor this into planning, alongside the need to ensure incentives for operators, or compensation because over time they will generate far less power. This requires careful co-ordination of scaling up of renewables generation and storage over time, phasing out plants which are at the end of their lives, so as to minimise stranded assets.

Development finance institutions and bilateral development agencies should:

- Where data relating to demand and energy end-use are lacking, help the utility obtain data through household-level and firm surveying.
- Provide technical assistance to the power sector planning function in order to build institutional capacity to undertake and maintain comprehensive electricity sector development plans.

- Where applicable, consider providing technical assistance to support the establishment of an independent regulator.
- Provide technical assistance for governments to conduct analytical assessments of transmission and distribution networks and to assess power generation and storage options. Governments should avoid outsourcing technical studies and planning to consultants, given the importance of government ownership in updating, maintaining and evaluating plans.
- Provide technical support for governments to identify business models and remuneration options to encourage private investment in electricity storage.

3.4.2. Attracting private sector participation through reform of the power sector

For fossil fuel-producer emerging and developing economies, and particularly for those whose credit rating is below investment grade, attracting private investment in clean energy, or independent power projects (IPPs), is one of the greatest challenges in achieving systemic decarbonisation and expansion of the electricity sector.

State-owned power utilities have played a dominant role in investing in generation and transmission infrastructure for the last 50 years. Many of these companies are financially weak and debt laden, on account of considerable transmission and distribution losses, lack of cost-reflective tariffs and poor management, and as a result have chronically underinvested in power infrastructure over the past four decades, a fact which has further contributed to their financial difficulties, and undermined consumer confidence and customer payment discipline.

Box 3.27. Utility financial health and de-risking projects for the private sector

Project finance for IPPs is normally based on a long-term power purchase agreement (PPA), and requires revenue predictability. The creditworthiness of the off-taker, normally the state utility or dedicated transmission company, is therefore key, and in many developing and emerging country contexts, a project will be unable to reach financial close because of perceived payment risk without a development finance institution or state guarantee.

Key reasons why state power utilities are financially weak include high transmission and distribution losses and low payment collection rates, which together account for over half of turnover deficits in 21 utilities, and three-quarters in 13 utilities in Africa. For example, transmission and distribution losses average 23% in sub-Saharan Africa, compared with 10% in advanced economies; while average payment collection rates are 88.4% in sub-Saharan Africa, against 100% in advanced economies. The fact that tariffs are not cost-reflective, because governments are unwilling to agree to sufficiently high and regular increases for fear of impacting consumers who would struggle to pay, alongside inflated public wage bills, also plays a big role in utility financial weakness. Many public power utilities are also poor technical and operational performers, as well as being hamstrung by unsustainable debt, all of which contributes to decades of underinvestment in transmission and distribution infrastructure needed to build a balanced and reliable grid which can accommodate the addition of new variable renewable energy generation capacity as well as roll-out of the grid to unserved areas. For many public power utilities, financial challenges are self-perpetuating because poor customer service affects payment discipline, and the longer the system goes without repair or upgrades, the more expensive such investments become.

PPAs which adequately balance risks between private and public sectors, development finance institutions and sovereign payment risk guarantees, can help to mitigate risks for developers. However, in reality, few such mechanisms are ever used. As part of a longer-term strategy to boost the integrity of the power sector, governments can look to improve utility financial health through improvements in

technical and operational performance to reduce transmission and distribution losses, accompanied by initiatives to improve cost recovery, including gradually raising tariffs, especially for medium and large customers who can afford to pay more, and raising payment collection rates. Debt restructuring, which normally requires the involvement of a development finance institution, can help to alleviate the burden of very high debt service payments, while corporate governance reforms, including managerial incentives, board autonomy and makeup, and fiduciary accountability can improve overall performance.

Source: (Eberhard et al., 2016[156]); (Sachs, Toledano and Brauch, 2021[155]).

The solution to this issue for many governments, encouraged by guidance from international development organisations such as the World Bank, has been the unbundling of vertically integrated power utilities, separating out generation, transmission and distribution functions, encouraging improved financial management and facilitating private sector participation. Unbundling can eventually lead to a situation in which government oversees a competitive power market capable of crowding in private capital. In many emerging and developing countries, particularly in Latin America, the process of unbundling, combined with the development and implementation of a long-term vision for transmission and distribution infrastructure expansion, proved successful, leading to substantial private sector participation and power sector expansion (Eberhard et al., 2016[156]). Elsewhere, however, and especially in Africa, unbundling has been only partially completed. Just 10 out of 54 countries have vertically unbundled utilities, and these have a far worse track record of planning for and investing in transmission and distribution infrastructure for the long term (Sachs, Toledano and Brauch, 2021[155]).

Box 3.28. Achieving utility cost recovery through a combination of tariff increases and efficiency improvements

Enhancing cost recovery for utilities is an important factor in strengthening the integrity of the power sector, facilitating investment in transmission and distribution expansion, and attracting private capital to generation projects. Improving cost recovery of tariffs over time, particularly for larger and industrial customers who can afford to pay more, is key to cost recovery, while cross-sectoral subsidies can be used to make electricity more affordable for less well-off customers, a strategy which also helps to insulate policy makers from political resistance to tariff increases.

Achievement of cost recovery requires more than simply increasing tariffs. It also necessitates greater attention to reducing transmission and distribution losses and raising bill collection. However, costs for utilities are not static, and change based on currency fluctuations, fuel prices and debt service costs. This means that while a utility may achieve, or come close to achieving cost recovery in one year, this may not last as conditions evolve. Colombia, for example, was able to achieve cost recovery between 2011 and 2016, but failed to do so in 2010 because low rainfall impacted hydropower availability.

Progressive tariff setting can help to alleviate the financial situation of utilities. Pakistan's approach to tariff setting, for instance, incorporates an allowance for transmission and distribution losses, while Ugandan electricity distribution company UMEME updates its tariffs annually, making a quarterly adjustment for inflation. This has enabled it to finance expansions in distribution infrastructure, as well as raising efficiency levels and abiding by its debt service payment commitments. Moving towards better cost recovery requires utilities to adopt a constantly evolving and holistic approach, adapting to changing conditions, raising tariffs sufficiently regularly, constantly driving to improve efficiency, reducing transmission and distribution losses, and improving payment collection, planning for least-cost generation solutions and connections to the grid, while striving to improve service provision and

employing a hedging strategy which utilises cheaper electricity imports to use least-cost generation solutions to deliver cost-effective generation.

Source: (Foster and Rana, 2020[162]).

In many African countries, the public utility competes with the private sector in power generation projects, while also being responsible for sector planning and investment in transmission and distribution infrastructure, and in some cases also being the power off-taker. In this context, the financial challenges of many utilities create a number of problems. Long-term underinvestment in transmission and distribution infrastructure adds a layer of risk for private developers and makes it more challenging to add renewable energy resources to the grid. Because they are considered non-creditworthy or risky power off-takers, IPPs find it hard to reach financial close without payment guarantees. These factors add complexity to the challenge of scaling up private investments, and for the most part, arranging project finance for IPPs, which relies on long-term revenue predictability, will be difficult to organise without payment guarantees and a robust power purchase agreement (PPA), which requires strong government legal capacity to negotiate.

Box 3.29. The role of Power Purchase Agreements in allocating costs and risks between public and private entities

A power purchase agreement (PPA) is a contract normally signed between a public off-taker, such as a utility or mandated transmission company, and a private developer or IPP. A PPA aims to balance risks and costs between public and private partners, enabling project developers to raise project finance based on predictable revenue streams. It is considered a key component of achieving project bankability, while providing the off-taker with the certainty to obtain a pre-agreed amount of power to meet demand and provide grid stability.

A PPA normally contains two pricing components:

- An availability or capacity charge, payable by the off taker for the developer making electricity available, even if it is not purchased. The capacity charge normally provides a revenue stream for recouping CAPEX investment on a project.
- An output charge is paid for electricity provided.

A PPA can also include clauses which cover sales to third parties. This can enhance project bankability, as well as provide a safeguard that the PPA will not get in the way of energy trading if the sector is liberalised during the project lifetime.

PPAs typically include provisions detailing penalties for poor or non-performance by the developer, such as too little electricity produced or failure to complete construction on time. Key areas of contention in PPAs are often what constitute force majeure, for instance, if project operations are disrupted by events which are beyond the control of the developer. A PPA should also cover penalties for government, for example, if delays to completion of transmission connections mean the project cannot begin delivering power at a certain date as planned, as well as what will happen in the event that mechanisms to set tariffs are changed. PPAs should also detail allocated time frames for maintenance when the project will not be producing electricity, as well as details of the testing regime to assess project capacity and performance.

Source: (World Bank, 2021[163]).

Additionally, an independent, well-resourced and professional electricity sector regulator can help provide the private sector with the assurance that disputes will be dealt with fairly and predictably, which will lower perceptions of risk. Over time, as governments are able to bring more IPPs online, perceptions of risk will lessen, to the point where fewer, or no guarantees will be necessary. However, this will also be contingent on there being sufficient and carefully planned investments in transmission and distribution to facilitate an expansion in renewable energy generation.

Governments have a range of options to incentivise private sector participation and to assess bids and proposals for renewable energy project development. Governments across the world have used feed-in-tariffs as an effective way to provide revenue predictability to private investors and bring costs down over time. However, setting tariffs at the right level can be challenging for governments with low capacity, leading to windfall profits for companies if too high, or deterring investor interest if set too low. Regulators should also scrutinise any private investment in the transmission and distribution network given it is essential infrastructure.

An alternative approach is renewable energy auctions, as a mechanism to drive prices down and procure the necessary generation facilities across a range of technologies on the basis of an Integrated Resource Plan (IRPs) or Least Cost Power Development Plans (LCPDP). Renewable energy auctions have the advantage of delivering least-cost power and can also be used to signify intent to procure more renewables generation to the private sector, helping to build a rationale for private companies to invest time and resources based on the potential of there being further projects down the line. Aside from delivering lowest-cost procurement, auctions can also help to take renewable energy technologies over the risk curve, eventually removing the need for guarantees, and can be paired with initiatives to bring battery storage technology to commercial levels. South Africa's Renewable Energy Independent Power Producer Programme (REIPP) is a good example of a government using an auction process and reforming the regulatory framework to provide clear signals to the market, which creates competition and increases investor confidence in the sector. Ultimately, REIPP has driven down electricity prices and put South Africa in a strong position to attract the required private investments in renewables to gradually replace its coal generation capacity.

Box 3.30. Design considerations for procurement of renewable energy generation capacity through Feed-in tariffs (FITs), auctions and unsolicited proposals

Feed-in tariffs

Feed-in tariffs (FiTs) provide developers with long-term price predictability, offering an off-take agreement based on a given price for electricity per kWh. They can be effective in facilitating the rapid scale-up of renewable energy generation capacity because developers can raise finance based on a predictable revenue stream from electricity generation, while also obtaining an acceptable profit.

Two pricing structures are common: A fixed FiT price offers the same price for the duration of a contract, while a premium price FiT combines the market price with a premium payment which can be fixed for the duration of the contract, often between 15 and 20 years, or can decline over time.

For governments, and especially those with limited capacity, setting a FiT at the right level is the biggest challenge. If too low, it can deter investment, while if too high it can result in inflated profits for developers and poor value for money for consumers, not least because auctions can offer a more effective means to procure least-cost power, and provide better safeguards against corruption risks (see below). A FiT needs to be adapted to technology type and project size, with the most typical approach to setting payment levels based on assessments of levelised cost of renewable electricity, or a per kWh cost which incorporates project capital, cost of finance, and operational and maintenance costs against projected sales of power. Tariffs should also be aligned with resource quality, with higher

tariffs potentially required for sites with lower resource quality in terms of wind and solar, but where governments want to incentivise development, for example, because of existing transmission infrastructure.

Additional design considerations include the need to reduce tariffs over time, in line with declines in technology costs. This is a key factor in ensuring consumers do not pay over the market price for power as well as overall least-cost pathways to power sector decarbonisation and expansion. However, this must be achieved transparently and predictably, and in such a way that investor confidence is maintained. Pre-determined annual adjustments, plus more substantial assessments and revisions every three to five years, based on detailed appraisals of technology markets and prices, can be helpful in this respect.

Governments must also consider overall FiT costs. They can do this by setting a limit for FiT deployment, for example, when a pre-specified volume of generation capacity has been procured or funding for the FiT has run out, cognisant also of the need to honour electricity purchase agreements already signed.

Renewable energy auctions

As an alternative to FiTs, renewable energy auctions offer an effective means through which to procure least-cost power, as well as achieving additional objectives, in line with national development goals. They also have the advantage of real price discovery, given a competitive process can drive down prices and reduce the asymmetry in information between government and the private sector.

At a basic level, governments invite developers to submit bids to develop renewable energy projects with a commitment to provide electricity at a certain price per kWh. Bids are assessed on price and other predetermined criteria – potentially including the requirement to provide electricity storage. Then governments, in emerging and developing economies, often the power utility – sign a PPA with the winning bidder.

Renewable energy auctions can be technology and location neutral, which can often result in the lowest electricity prices, as developers can select locations with the best generation conditions and also choose which technology offers least-cost solutions. Governments can also specify technology requirements as well as specific sites for development if they want to scale up deployment of certain technologies or deploy projects at points on the grid where connection costs will be lowest or transmission infrastructure is already in place.

Governments have a choice as to how much generation capacity to procure at one time, although this is also contingent on the absorption capacity of the transmission infrastructure. Countries with significant power deficits or facing power crises may be tempted to procure large amounts of capacity all at once to meet growing demand. However, the steep learning curve for renewable auction first rounds should be taken into account. This normally means later auctions will benefit from significantly more competition, leading to lower prices as well as other improvements on initial iterations. Trying to procure too much power in a first auction can result in higher prices, leaving consumers paying more for power than they need, and failing ultimately to benefit from cost reductions in later rounds. For example, South Africa’s first renewable energy auction round in 2011 failed to generate sufficient competition, but subsequent rounds, based on improved learnings from the first and through generating progressively more competition, have succeeded in consistently driving down prices. Governments can also consider setting a maximum threshold in terms of price per kWh above which bids will not be considered to ensure value for money.

At the end of 2021, a total of 131 countries implemented renewable energy auctions. This is higher than the total number of countries that still rely on some level of direct support through feed-in tariffs (92 countries), and is twice the number of countries that have used renewable energy auctions in 2015.

Using auctions has brought notable benefits since the underlying principle for any bidder to win a project is generally cost. The objective of achieving least-cost projects has helped to accelerate innovation, further improving technologies and corresponding efficiency levels. A consequence of technological maturity and experience accumulated about investing in bankable projects is that financiers now provide loans with much better conditions. Data from the IRENA show record prices for utility-scale solar PV projects at an average price of USD 0.04 cents per kilowatt-hour. The same data highlight that this is 27% less than the average price for coal-fired power plants.

The design of effective renewable energy auctions is key to their success and to real price discovery. Well-designed auction volume and clear criteria for entry of bidders, supported by clearly stated commitments of project stakeholders and a transparent procurement process, all contribute to high levels of competition. These help to ensure that implementation of the projects, once won, fulfil the project requirements. Investors and financiers also benefit from a predictable and certain investment environment with clear signals on prices and quantities of future auctions. In general, the greater the competition, the more competitive the prices, which gives governments an incentive to lower barriers to entry. Yet, lowering them too far can mean firms that lack the requisite technical, legal and financial capacity to realise the projects may win, or bid with unrealistically low prices, often resulting in significant under procurement. To an extent, this risk can be mitigated through a two-stage process that includes an initial round to qualify bidders based on project experience, and technical and financial capacity to limit participation to developers who in reality will be able to deliver on commitments.

Additional design considerations include compliance rules such as bid bonds and delay penalties, which fine winners if they do not adhere to agreed development schedules or if the resulting project underperforms. Allocating responsibility for transmission connections is also key, something which is normally the responsibility of the utility, and developers need to be entitled to financial compensation in the event of a delay to transmission connection. Bid bonds or completion deposits can also reduce the risk that the winning bidder fails to deliver on commitments, given that a PPA will not introduce legally binding commitments until after the auction has been completed, and can also reduce the risk of under procurement of generation capacity.

IRENA's *Renewable Energy Auctions: A Guide to Design* provides useful guidance on this topic.

Unsolicited proposals

Countries with significant power deficits or power crises are likely to be approached with unsolicited bids by developers who see an opportunity to make a decent return. In general, governments should try to avoid direct negotiations and unsolicited bids for power projects, because they rarely result in lowest-cost power and can fuel perceptions of undue influence. When a government does decide to engage in direct negotiations, rigorous and independent assessment criteria should be applied. Kenya Power, for example, used to employ a system to assess unsolicited bids which required an open book assessment, where developers were expected to outline expected returns on debt and equity against a pre-specified capital structure. This approach helped avoid overly inflated profits, and enabled comparison of prices offered to benchmarks such as a FiT or auction prices, where available. It is also imperative for an independent and competent regulator to conduct its own assessment to determine value for money.

Source: (Eberhard et al., 2016[156]); (IRENA, 2015[164]).

Governments should consider prioritising the following actions:

- Set up an independent regulator, or if there is one, ensure it is strong, independent, professional, and well resourced, with a clear mandate that frees it from undue influence from the power utility or energy ministry. The regulator needs to be capable of making fair, predictable decisions and

enforcing competition, especially around auctions. This is vital for investor and private sector confidence.

- Identify investment opportunities for the private sector based on renewables potential and connection costs, and translate these into procurement plans.
- Assess the merits of encouraging private investment through a feed-in-tariff or a renewables auction, or a combination of both, noting that these options will require specialist government skills and competencies to design. Auctions are better at delivering lowest-cost electricity, but require sufficient competition in the market to be successful. Feed-in-tariffs may present a preferable option for countries with initially limited renewables penetration in the grid.
- Deploy sovereign risk guarantees strategically, recognising they are treated as contingent liabilities on the government balance sheet and are therefore limited in availability. Consider that large-scale renewables demonstration projects which are successful can serve to de-risk the sector overall, reducing the need for guarantees through the long term.
- Avoid unsolicited bids for renewables projects because they are likely to result in higher electricity costs and risk perceptions of undue influence or malfeasance. Where a government does accept to negotiate with a private developer, rigorous proposal assessment criteria should be applied to assess the bid, which should also be reviewed by an independent and professional regulator.
- Clarify which entity a PPA will be signed with. This entity is normally the utility or dedicated transmission operator. The nominated entity should also be responsible for grid management and therefore connection of projects to transmission infrastructure.

Actions requiring international support in contexts where government capacity is low:

- In partnership with industry, work to develop a standardised PPA for different types of renewable energy generation projects. This will help to clarify off-take requirements for private investors, cut deal times and mitigate corruption risks.
- Invest in government and public utility or distribution company legal capacity to negotiate PPA terms with private developers. This is often a key weakness in getting IPPs off the ground in developing countries.
- Review the status of sector unbundling, recognising that the power sector reform can be a politically contentious process. Ultimately, a long-term and carefully developed programme for transmission and distribution infrastructure expansion, plus an independent, professional regulator are the key ingredients for encouraging private sector participation and adding renewables generation to the grid.
- Recognise the importance of strengthening utility and transmission company financial health, and in partnership with development finance institution partners, pursue multiple avenues to improve performance. A holistic strategy to achieve this would include addressing transmission and distribution losses, raising payment collection rates, grid digitisation, making tariffs cost-reflective, debt restructuring, corporate governance reforms, and revising managerial incentives to enhance operational and technical performance and improve fiduciary management.

3.4.3. Tackling energy poverty through decentralised energy access

Governments need to integrate considerations around the optimum balance of on-grid and off-grid power solutions into the development of least-cost energy sector development plans. They also need to consider trade-offs between investing in industries such as hydrogen with substantial power demand, and investing in improved energy access.

Advancement in technologies for mini-grids have played an important role in facilitating access for rural communities, with 5 544 mini-grids in operation in sub-Saharan Africa, Southeast Asia, Small Island Developing States (SIDS) and Latin America (SE4All, 2020[5]).

Box 3.31. Leveraging mining projects as anchor off-takers

Forecast growth in the mining sector in developing and emerging economies on account of demand caused by the low-carbon transition raises the potential for mines, as well as other industrial centres in remote locations, to provide anchor off-take agreements for renewables projects, as part of efforts to increase the commercial viability of connecting remote communities. In fact, it is important for governments to consider how mines and industrial centres can be incentivised to use renewable energy generation, in order to avoid power demand at these sites massively contributing to national emissions, while other cuts are made elsewhere in the economy. Governments should ensure that energy, mining, and economy and planning ministries co-operate closely to identify where mining can play a role in electrifying local communities via renewables, and that these requirements are integrated into mining permitting requirements accordingly.

Source: (Sachs, Toledano and Brauch, 2021[155]).

However, achieving SDG-7 by 2030 will require the connection of a further 238 million households across sub-Saharan Africa, Southeast Asia and SIDS, equivalent to 60 million people per year. Though some of these people will be connected through expansion of the grid, some 111 million households will need to be connected through off-grid solutions, owing to their remote or low-density location (SE4All, 2020[5]).

One of the core challenges in connecting these communities is their limited power demand, accompanied by often low and unpredictable incomes, which limits their ability to pay for electricity. This can make mini-grids and remote connection projects unviable as commercial endeavours. For the most part, most rural connection projects are based on development finance institution or foundation funding, rather than representing viable investments for the private sector.

Some initiatives have sought to raise local demand through financing roll out of appliances, while others have identified innovative business models that are able to accommodate longer pay-back periods. Mining projects, or industrial centres, have also been used as anchor off-takers, providing a commercial basis to roll out electricity to surrounding communities and households.

Whereas mini-grids until relatively recently tended to be based on diesel generation, the substantial drop in cost of solar PV and battery storage, and the potential of green hydrogen to transport electricity from renewables over long distances, mean that decentralised, low-carbon technology solutions now offer the lowest-cost pathway to rural electrification.

Governments should consider prioritising the following actions:

- Assess the regulatory framework to facilitate private investments in mini-grid and rural connection projects. Key issues include regulations to compensate mini-grid operators if the main grid is extended to areas in which they operate, and if they are not allowed to sell to the grid. Enable flexibility in mini-grid tariffs to support developers to set tariffs in a manner consistent with local payment power and commercial requirements.
- Consider the deployment of subsidies to incentivise private sector investment in mini-grids. The most typical mini-grid subsidies are either up-front CAPEX subsidies to support grid development, or results-based payments, disbursed based on verification of an electricity connection.

Actions requiring international support in contexts where government capacity is low:

- Consider establishing an energy access fund, capitalised with development finance, institution finance and fossil fuel export revenue, to roll out energy access programmes via mini-grids.

Development finance institutions and bilateral development agencies should:

- Accelerate provision of concessional finance and grants for governments to roll out energy access projects through mini-grid initiatives consistent with achievement of SDG-7.

3.5. Encouraging low-carbon technology transfer, innovation and diffusion through science, technology and innovation policy

Integrated science, technology and innovation policy making is key to encouraging diffusion and innovation in low-carbon technology, processes and products, as well as their deployment at scale. To build achievable low-carbon transition pathways which enable them to take advantage of opportunities presented by the transition, fossil fuel producer emerging and developing economies will need to set the enabling conditions and establish incentive structures to encourage technology transfer and innovation, as well as emissions reduction, across a range of sectors and industries.

At a global level, there have been significant advances in driving down the cost of low-carbon technologies and scaling up their deployment, especially in high-emitting sectors such as energy, transport and buildings. To limit global temperature increases to 1.5°C by 2050, most of the global reductions in CO_2 emissions between now and 2030 must come from technologies which are readily available today. However, almost half the low-carbon technologies needed to achieve required CO_2 reductions in line with net zero pathways by 2050, such as advanced batteries, electrolysers for hydrogen and direct air capture and storage, are still at the demonstration or prototype phase (IEA, 2021[20]).

In addition, many lower middle-income countries and developing economies, particularly those whose development models rely on revenue from or cheap access to fossil fuels, are highly constrained in terms of access to low-carbon technologies, including technologies which can already be readily commercially deployed elsewhere, for instance, renewables technologies, low-carbon materials and buildings, electric public transport and trains. Low-income countries, for example, accounted for just 0.01% of low-carbon technology exports and 0.3% of imports between 2015 and 2016. Lower-middle-income economies accounted for 1.9% of low-carbon technology exports and 6.2% of low-carbon technology imports during the same period, while figures for upper middle-income economies stood at 25.2% and 31.6%, respectively. High-income economies accounted for 73% of low-carbon technology exports between 2015 and 2016, and 61.9% of low-carbon technology imports during these years, highlighting global inequities in access to technology required for the low-carbon transition (Pigato et al., 2020[165]).

Fossil fuel producer emerging and developing economies which lack a strong non-fossil fuel private sector capable of absorbing skills and know-how as part of the process of technology transfer, followed by innovation, will rely, at least initially on low-carbon technology transfer through foreign direct investment or imports from advanced economies or emerging economy technological innovators such as India and China. Based on this, domestic firms can then reproduce, adapt and improve imported technology to reflect local circumstances, and at a later stage move towards innovating themselves and exporting through integration into GVCs.

This process can support the development of affordable contextually appropriate technology which can be deployed at scale, further driving down costs and supporting the gradual transition towards a net-positive Effective Carbon Rate (ECR), as firms and consumers are presented with lower carbon lifestyle and business choices.

Successful low-carbon technology transfer, however, requires a more integrated approach than simply importing the technology itself. For example, it necessitates that countries build the necessary human capital through investments in education and training programmes to enable domestic firms and workers to understand, use, and then improve and adapt imported technologies. It also relies on the existence of enabling infrastructure, and regulatory incentives to accelerate low-carbon technology deployment and

incentives at scale and to encourage foreign direct investment in the first place. Governments also need to ensure low-carbon technology and products can compete with incumbent fossil fuel-based industries through the introduction of and incremental improvements to the ECR. The OECD Recommendation on FDI Qualities and the related Policy Toolkit can provide guidance on implementing such measures to attract sustainable investment that supports low-carbon technology transfer (OECD, 2022[166]).

Firms and the labour force in fossil fuel producer emerging and developing economies, and especially those with heavily subsidised fossil fuels, may lack the incentives, technical competencies and capacity to innovate. For these countries, addressing the low-carbon technology gap requires investment in education and training, as well as supporting firms to build competencies to absorb and adapt low-carbon technology through subsidies and grants to research and development. Foreign direct investment also provides an effective way to support this process, as it can require skills intensive partnerships which can be effective at facilitating transfer of technologies and know-how. Governments should also prioritise long-term investment in sustainable infrastructure which maximises the positive impacts on sustainable development, increases economic efficiency through the life cycle of the project, integrates environmental considerations, builds resilience against natural disasters and integrates social considerations. Reliable and available electricity, broadband coverage and low-carbon public transport, both to encourage foreign direct investment and also to progressively offer firms and consumers lower carbon and green alternatives, are particularly important in this regard. Meanwhile, employment of risk mitigation measures – for example, sovereign guarantees, political risk insurance, subordinate finance from both governments and development finance institutions, in line with recommendations in Pillar 2, Section 2.4 will be central to encourage investment and facilitate knowledge spillover.

In parallel, governments should adopt a coherent set of demand and supply-side measures to incentivise firms to innovate and adapt low-carbon technology to national circumstances, over time nudging firms towards lower carbon choices. Standards and regulations, including energy efficiency standards for buildings and transport, green certification, fuel and technology use mandates, and bans on the highest emitting technologies, introduced in a gradual and well-signalled manner, can support the incremental process of phasing out carbon-intensive and high-emitting technologies. In parallel, governments can deploy measures to incentivise firms to innovate and adapt technologies to meet changing market demand through grants, loans and subsidies. Grants and subsidies to both firms and individual consumers can offset costs accrued as they transition to lower carbon alternatives, as well as to build demand to further incentivise firms to develop low-carbon products and services. Incentivising firm and consumer behavioural change through mandates, grants, loans and subsidies will only have a limited impact if the negative externalities of burning fossil fuels are not incorporated into energy pricing. Governments will need to determine what kind of incremental approach to carbon pricing is feasible and warranted based on affordability and the availability of viable alternative choices, and to eventually complete the process of redirecting incentives fully away from fossil fuels.

Governments should consider prioritising the following actions:

- Adopt integrated innovation policy making, leveraging an optimum combination of measures, including long-term price signals, regulatory requirements and standards (e.g. emissions and building standards) subsidised loans and grants, green public procurement and fiscal instruments.
- Prioritise investments in education and training, as well as partnerships between the private sector and educational institutions to build human and firm capacity to absorb technology transfer and adapt and improve technologies to local conditions. This will require long-term vision and programming to support the gradual diffusion and scale-up of least-cost technologies for decarbonisation.
- Deploy risk mitigation instruments strategically to de-risk and encourage foreign direct investment in priority areas to take low-carbon technologies over the risk curve to the point where they are self-sustaining and to build economies of scale (refer to Pillar 2, Section 2.4.2 for further guidance).

- Consider revising import rules. Tariff barriers on low-carbon technologies can raise project costs, potentially deterring foreign direct investment, while non-tariff barriers to doing business can also have a detrimental impact on investment.
- Consider establishing publicly funded technology and innovation incubators and accelerators which can bring together industry and educational institutions and promote research and development in priority areas.
- Introduce parallel non-price measures, such as grants, subsidies and loans for low-carbon technologies and research and development, alongside the progressive introduction of performance standards, fuel mandates and bans on high-emitting technologies, to complement incremental increases in the ECR. This can provide incentives and support for domestic firms to innovate and produce affordable low-carbon technologies, products and materials, because it will gradually create a market for these goods, and firms will direct research and development spending to meet this demand.
- Consider establishing or mandating a dedicated government agency to undertake strategy development, to conduct targeted and bespoke studies into technological development and innovation and domestic opportunities in target sectors, and to play a role in tracking domestic innovation and technology transfer, as well as looking at international technological trends and how they relate to the domestic market.

Actions requiring international support in contexts where government capacity is low:

- Consider reviewing and revising intellectual property legislation, noting that if it is too stringent it may prevent domestic firms from replicating and improving imported low-carbon technologies, while if it is too weak, it may deter foreign investment because of the risk of leading to replicated products.
- Leverage international agreements and trade deals to include technology transfer components in priority sectors, for example between importer and producer countries to encourage skills, knowledge and technological development in the hydrogen industry.

3.6. Enhancing low-carbon mobility and decarbonising transport

Fossil fuel-producer emerging and developing countries facing rapid population growth and urbanisation have an opportunity to leapfrog systems design, delivering benefits to citizens at scale, particularly in fast-growing small- to medium-sized cities where large segments of the population lack access to mobility and energy. A systems approach to decarbonising the transport sector, alongside strategies to enhance access to mobility and proximity to amenities and services, which integrate energy, transport and urban planning, would enable governments to achieve substantial emissions reduction goals, alongside enhancing citizens' well-being.

Key tools in this regard include geographic information systems (GIS) that can map mobility demand and facilitate planning, avoiding gridlock and congestion. Such tools can assist the design of cities with sustainability in mind, situating amenities and services closer to demand. This would result in citizens travelling shorter distances and taking more sustainable transport options to do so.

A central weakness of current thinking on transport decarbonisation is its focus on decarbonisation of individual components of the transport system, particularly cars, and replacement with electric vehicles (EVs), as opposed to a more holistic approach which reduces the overall need for individual vehicles through better designed cities and improved public transport. This approach negates the transformational potential of systems thinking, which can provide a far more efficient way to achieve simultaneous decarbonisation and achievement of socio-economic development goals in developing and emerging economies. Global transport development policy to date has to a large extent equated well-being with

access to mobility, ignoring the importance of proximity to well-being at the same time. Well-being is not about being able to travel long distances to access services; rather, it is reinforced by access to necessary services and amenities via relatively short trips (OECD, 2021[167]).

Urban renewal policies, which seek to spread out amenity and service hubs across cities, rather than concentrating them in central areas, and which connect them with efficient, quality and affordable public transport, can support improved citizen well-being and decarbonisation in existing large and mega-cities. However, overwhelmingly, the opportunity to decarbonise and build more balanced urban spaces with citizens' well-being in mind, lie in developing and emerging economies. This is particularly the case in intermediary cities, small and medium-sized agglomerates which act as bridges between rural and urban areas which tend to expand quicker than mega-cities but are characterised by low-quality infrastructure, along with poor planning and weak governance structures. It is also the case in fast-growing smaller cities of between 300 000 and 1 million people (OECD, 2021[167]; SE4All, 2021[168]).

More than two-thirds of the world's population will live in urban areas by 2050, when 58% of global emissions are expected to come from cities. Moreover, of all the infrastructure expected to be built by 2050, almost 75% will be in cities that have yet to be built (OECD and Harman, 2021[169]). Most of this growth will be in emerging and developing countries. Nigeria, for instance, is expected to be the world's third most populous country by 2050. Half of Nigerians are under the age of 18, and between 2010 and 2030, 77 people will move to Lagos every hour (Dunne, 2020[170]).

Many fossil fuel-producer emerging and developing economies, therefore, have an opportunity to leapfrog systems design, avoiding cities that are trapped in high car demand scenarios, with sprawled and congested systems, that lock in carbon-intensive development pathways and undermine citizens' well-being and access to services.

To take advantage of this opportunity, governments can steer urban, energy and transport planning towards a systems approach to urban development. This can break down the silos between energy, transport and planning ministries, and municipal and urban authorities', to enable and incentivise them to undertake joint systems planning for better, more sustainable urban development, and to upgrade citizens' access to decent services, amenities, employment opportunities, and sports and cultural facilities. This approach can limit and even reverse the spread of urban sprawl, and avoid new cities being organised around dense central urban areas, largely inaccessible to surrounding residential areas except via car access (OECD, 2021[167]).

An "Avoid, Shift, Improve" approach to integrated urban planning and sustainable mobility seeks to avoid unnecessary journeys, including through the promotion of walking, cycling and electrified two- and three-wheeler transport options. Shift policies meanwhile aim to encourage users to move towards more efficient modes of transport from car use. The greatest decarbonisation gains for emerging and developing countries are likely to lie in a combination of these measures. Meanwhile, improve policies aim to reduce the carbon intensity of existing modes of transport and fuels, eventually replacing them with low-carbon alternatives (OECD, 2021[167]; SE4All, 2021[168]).

Shift policies can be enabled by effective municipal urban and public transport planning, optimising public transport routes to build convenience and provide better options than taking a car. Public transport systems in many developing and emerging economies tend to be chronically underfunded, run on old and polluting diesel bus fleets, and are in need of route optimisation. This creates a vicious cycle in which consumers turn to individual cars, as a more reliable and convenient transport option – a trend exacerbated by the COVID-19 pandemic – undermining public transport operators' ability to recover costs and invest in fleet renewal or an improved service. Substantial investments in fleets, as well as operator and municipal capacity to put public transport on a sound financial footing, can encourage investments which will improve services and attract customers. Gradual tariff rises are key to enabling improved cost recovery over time.

Investments in urban light rail, metro and tram systems can provide viable long-term solutions to public transport performance in densely populated areas. However, CAPEX requirements can be prohibitively high and project economics can be challenging given uncertain passenger demand in some developing and emerging country contexts, the dominance of cars and the inability of some passengers to afford higher fares necessary to raise finance.

Instead, Bus Rapid Transit (BRT) schemes, which tend to be between 1.5 and 2.6 times cheaper per kilometre than light rail, may present a more affordable and realistic option for some governments facing rapid population growth and urbanisation. BRT systems use right–of-way systems and bus corridors to improve the efficiency of bus routes, thereby giving buses an advantage over other traffic, and can help to ensure public transport is a preferable option over car travel (IRENA, 2021[171]).

Lastly, fee-charging congestion zones, and additional traffic circulation fees for car users linked to vehicle performance standards or age, as well as tighter parking restrictions and enforcement in densely populated areas, can help nudge car users towards public transport, walking and cycling, as car use becomes less affordable in comparison. Complementary increases in petrol and diesel prices, in line with longer-term plans to raise the national effective carbon rate (ECR), as outlined in Pillar 3, Section 3.3.1, can also enable these shift policies.

Improve policies represent the least effective means to decarbonise urban mobility, and are likely to be less feasible in developing and emerging country contexts where lower citizen purchasing power means that the roll-out of electric vehicles, at least initially, will be slower. Lack of demand makes the economics of investing in extensive charging infrastructure challenging, and where the penetration of renewables in the energy mix is relatively low, a mass transition to electric vehicle use may result in limited emissions reduction gains.

Box 3.32. Electrification of two and three wheelers can bypass the high costs of electric vehicle charging infrastructure and address affordability constraints

While rapid expansion of electric car markets in many developing countries may be unrealistic in the medium term given the high cost of rolling out charging infrastructure and affordability barriers, which create challenges in building market demand, the electrification of two and three wheelers can offer an affordable alternative for consumers, with substantial decarbonisation impacts, particularly in urban areas. Unlike electric cars, charging for electric two and three wheelers can be done relatively quickly through a household plug connection, rather than requiring expensive national charging infrastructure. Moreover, though currently more costly than two or three wheelers running on internal combustion engines, electric two and three wheelers are far more affordable than electric cars, with costs expected to come down further as the market grows.

Moreover, in many developing countries, two and three wheelers are already a dominant form of transport in many cities. Two and three wheelers, according to the World Bank, account for three out of four vehicles in Ouagadougou and two out of three in Bamako, accounting for 50% of CO_2 emissions from vehicles and 60-75% of pollution in these cities. The transition to electric two and three wheelers could contribute to a 30% reduction in the life cycle emissions of a motorcycle and 50% for a scooter. However, if 70% of the current two- and three- wheeler fleet were to switch to electric today, they would account for 19.5% of the total electricity production of Mali and 82% in Burkina Faso, demonstrating the importance of integrated transport and power sector planning, and the vital role electricity sector decarbonisation can play in rolling out decarbonisation of other sectors. Of course, the higher the penetration of renewables in the grid, the greater the decarbonisation gains of switching to electric two and three wheelers.

Source: (World Bank, 2022[172]).

Yet, policies to electrify public transport, particularly municipal buses and mini-buses, which make up the bulk of public transport in many developing and emerging country contexts, can have a profound impact, especially in tandem to the avoid and shift policy options outlined earlier in this section. In the absence of established charging infrastructure, however, innovative charging approaches will need to be identified.

For emerging and developing economies, the predominance of mini-buses in public transport offers a major opportunity to transition a substantial part of the public transport fleet to run on electricity (IRENA, 2021[171]). However, in most contexts, this is complicated by the dominance of informal firms in this area. These may be resistant to change and in any event are more likely to lack the substantial volumes of capital required to make the investments in fleet renewal or adaptation.

Biofuel blending mandates and biomethane in public and municipal fleets can also support improve policies, initially at relatively low cost, given that 20% blends can normally be accommodated without engine modifications, but raising the proportion of biofuel in the mix will eventually require more investment. In this context, it will be critical to ensure the sustainability of the biofuel production supply chain. As with shift policies, gradual improvements in fuel performance standards, alternative clean fuel use mandates, and incremental increases in fuel prices can also support the implementation of “Improve” policies. Some emerging and developing economies may want to consider import restrictions based on the age and emissions intensity of vehicles, given that they are often prime targets for exports of high-emitting and old second-hand cars. Governments, however, should also consider the risk of unintended consequences, as this approach could remove access to mobility for many citizens who have no alternative.

Box 3.33. Use of sustainable biofuels offers low hanging fruit to decarbonise transport sector

The use of sustainable biofuels in vehicle engines offers low hanging fruits to decarbonise the transport sector and offers some potential to decarbonise transport systems at limited cost, while also providing benefits in terms of reduced air pollution in cities. Biofuels can normally be blended with fossil fuels at 10% or sometimes higher such as in Brazil which has a blend mandate of 27% ethanol in gasoline. Over 70 countries worldwide have introduced some kind of national mandate for fuel blending, though just seven have biofuel levels of more than 10%. Though higher levels of biofuel content blending in fuel mixes inevitably have greater decarbonisation impacts, blending above 10% may require engine modification, which may create affordability barriers. At the same time, “flex fuel” technology, allowing for any mix up to 100% biofuel use, is readily available and widely used in countries like Brazil, confirming the viability of its use as a transition to low carbon automotive transportation that tends to be less costly than the electrification of the fleet.

Blending mandates can serve as an effective means to decarbonise transport systems, especially if paired with complementary Avoid and Shift measures which aim to reduce journey frequency and distances, and utilise more efficient modes of transport such as public transport, walking, cycling, and electric two and three wheelers. Particularly in municipal public transport, investment in engines able to run entirely on biofuels can support decarbonisation in cities. For example, the Brazilian city of Curitiba, through its Biocidade programme, implements a 100% biodiesel mandate for its municipal bus fleet.

Replacement of fossil fuels with biofuels produced either from crops or waste products can be not only a valuable source of cleaner energy, but also of income and employment, particularly in rural areas. In considering biofuels production and bioenergy use as part of an integrated and just low-carbon transition strategy, governments must also consider the social and environmental risks such as biodiversity loss and elimination of natural carbon storage, if forests and grasslands are cleared for crop production or production of biofuels displaces food production from arable land, particularly at a time of global food shortages. At the same time, if adequately managed, the combination of biofuels and food

production may provide for greater economic sustainability over the long term and be mutually reinforcing.

Biofuel production currently accounts for around 4% of arable land worldwide, corresponding to 22% of world sugar production, 12% of corn and 15% of vegetable oils. According to the IEA, global demand for biofuels will grow by 41 billion litres, equivalent to 28% between 2021 and 2026. This growth must be managed sustainably, reducing competition for land use with food production, avoiding biodiversity and natural carbon storage loss and an overall net increase in emissions. The IEA's Net Zero Scenario envisages a rapid increase in the use of biofuels to replace fossil fuels by 2050, with deployment increasing 10% per year by 2030. However, this scenario involves no expansion of cropland for bioenergy nor conversion of existing forested land into bioenergy crop production, with 60% of bioenergy supply coming from waste and residues which do not require land use.

Raising the proportion of biofuels produced from waste and residue, including cooking oils, animal fat waste and agricultural waste, as well as from dedicated crops that are complementary with food production, can help achieve this balance.

Carbon content of biofuels throughout the value chain also varies significantly, depending on production technologies, and whether crop growth eliminates ecosystems whose vegetation would otherwise provide carbon storage if it were left in place. In some cases, the production of biofuels can therefore result in a net negative impact on climate change.

The production of conventional biofuels from crops is achieved through well-established technologies and processes, while the production of biofuels from waste and residues for the most part is in the research and development stage, and faces scalability challenges given that feedstock is more limited. Technological innovation will be required to enable commercial production. Currently, for instance, cellulosic ethanol and biomass to liquids technologies based on non-food feedstock cost double or triple their fossil fuel equivalents.

Thus, in implementing policies to support biofuels production or importation, governments should:

- Consider the sustainability implications of producing biofuels from arable land, integrating social and environmental considerations into biofuels production and bioenergy policies. In line with the IEA's Net Zero recommendations, biofuel production should avoid expansion of arable land or conversion of existing forests for crop production, as well as avoiding a net increase in emissions through elimination of natural carbon storage.
- Consider adopting policies and tax regimes to maximise the collection and valorisation of organic waste, residues and used oils to create circular value chains for the production of sustainable biofuels.
- Promote the integration of electricity co-generation from waste in biofuel producing units.
- Sustain the development of smart agriculture techniques that include low-Indirect Land Use Change (ILUC) crops to generate vegetable oils, thus avoiding competition with food chains and making use of poor quality land not suitable for food production.
- Finance studies assessing the potential for production of biofuels from food and agricultural waste, as well as from land which is unsuitable for food production.
- Introduce certification for biofuels produced sustainably.

Source: (IRENA, 2021[171]); (World Bank, 2022[173]); (OECD/FAO, 2021[174]); (IEA, 2022[175]); (IEA, 2022[176]).

Governments should consider prioritising the following actions:

- Consider establishing a ministerial co-ordination agency or function to better integrate urban, energy and transport planning, and establish linkages with relevant urban and municipal planning authorities, to facilitate joint systems planning and leapfrogging urban design.
- Identify new, growing and intermediary urban areas which can benefit from an integrated approach to urban development. In tandem, identify areas of existing large and mega systems in which services and amenities can be brought closer to densely populated areas in parallel with policies that promote the renewal and revival of affordable, efficient and quality public transport, walking and cycling as preferable alternatives to car use.
- Invest in government and municipal planning capacity and ability to collect and interpret data to map the spatial dimensions of demand growth.
- Recognise that well-being and equality are best served by a combination of mobility and proximity of demand centres to necessary services, amenities and job markets, and build a national vision for urban development on this basis.
- Adopt an "Avoid, Shift, Improve approach" to urban mobility decarbonisation and urban planning, recognising that policies which avoid the need for journeys will have the most transformational impacts on decarbonisation and well-being, implemented in parallel with shift policies that enable the transition to public transport alongside improvement to quality and reliability of services.
- Consider population purchasing power in assessing electrification of transport options. In many emerging and developing country contexts, a lack of affordability and high investment costs to install the extensive charging infrastructure required means a mass switch to electric vehicles may not initially be feasible, and may not have the desired decarbonisation impact if there is limited renewables penetration in the grid. As an initial step, electrification of buses and investment in Bus Rapid Transport (BRT) systems can provide a more cost-effective alternative which, if combined with policies to increase proximity of demand and services, can encourage user uptake and result in substantial emissions reduction gains.
- Integrate electrified two- and three- wheeler options, walking and cycling into systemic mobility planning. These can provide effective means to reduce car use as avoid policies to bring consumers closer to demand bear fruit, but will require substantial investments in pavements and dedicated cycle lanes in many emerging and developing countries to avoid safety risks. Policies which build market demand for electric two- and three-wheelers can also support domestic manufacturing (see Pillar 3, Section 3.2) (SE4All, 2021[168]).
- Consider options for pricing car use in densely populated areas and explore how this can support an increase in the use of public transport and uptake in alternatives, such as walking and cycling. Options include incremental increases in fuel prices, in line with the recommendations in Pillar 3, Section 3.3.1, congestion zone fees, fees for high-emitting vehicles within certain zones, peak charges and vehicle performance standards.
- Consider incremental increases in requirements to incentivise fuel switching to hybrid, low-carbon fuels or blended fuels, alongside vehicle performance standards, congestion pricing and tighter parking restrictions in densely populated areas to encourage low-carbon fuel take up and use of alternatives. However, these tools need to be gradually built up in parallel to the proliferation of alternative options, such as cycle lanes and expanded public transport choices and efficiency. Import restrictions on older, more polluting vehicles can also help developing countries divest themselves of their role as major destinations for second-hand car exports, though this approach risks removing mobility options from some citizens if alternatives are not available.

Actions requiring international support in contexts where government capacity is low:

- Build investment strategies for municipal public bus transport, over time, seeking to modernise and decarbonise fleets, optimise routes and bring them to a point where tariffs can be cost-reflective. These measures will be key to encouraging use of public transport and generating revenue which can be further invested in improvements. This will also facilitate a reduction in car usage and congestion, and help shift public bus transport away from the low-cost, low-revenue, low quality trap in many developing and emerging economies (OECD, 2021[167]).
- Build long-term strategies for investment in light rail, trams and metro systems.

Development finance institutions and bilateral development agencies should:

- Invest in and support investments in light urban rail, metro systems and BRT through feasibility studies, as well as risk mitigation instruments; finance high upfront costs; and grant support to municipalities and transport providers to build more effective plans and strategies.

3.6.1. Decarbonising freight transport

Modernising freight systems is a key part of transport system decarbonisation. Globally, international freight accounts for 9% of all transport emissions, with road freight, comprised of both short- and long-distance haulage, making up 15% of total freight, but comprising 44% of freight emissions (IRENA, 2021[177]; ITF, 2021[178]). For many developing and emerging economies which lack established rail freight infrastructure or large-scale internal waterways for movement of goods, and where the proliferation of smaller and sometimes informal freight companies means the use of more, older and smaller trucks, the share of road freight and its emissions tends to be far higher.

Long-distance road freight is challenging for developing and emerging economies to decarbonise because long distances and heavier loads mean low-carbon and electric alternatives are not yet available as commercial replacements to engines running on petrol and diesel, though this is likely to change as costs for hydrogen production gradually fall. Moreover, smaller firms, which make up a large bulk of haulage companies in developing countries, are less likely to be able to make the significant investments required to upgrade fleets to low-carbon alternatives.

Decarbonisation of freight, therefore, for fossil fuel-producer developing and emerging economies, will require a combination of measures. These may include sustained and long-term investment in rail freight and inland waterway routes to facilitate a shift to lower carbon freight modes through long-term subsidies and grants, progressive implementation of fuel economy and emissions standards, and gradual rises in fuel pricing.

In parallel, governments can look to incentivise freight companies to implement short-term measures to improve efficiency and reduce emissions, supporting investments and introducing performance standards for aerodynamic retrofits, reduced rolling resistance of tyres, measures to reduce vehicle weight and partial inclusion of biofuels where feasible. Meanwhile, collaboration incentives and digital platforms to encourage collaboration on freight between firms can optimise vehicle use and minimise emissions (Transport Decarbonisation Alliance, 2019[179]).

Governments and urban planning authorities, however, should also incorporate strategies to decarbonise urban freight into urban planning systems, particularly for urban developments which are yet to be built. Urban freight accounts for a relatively small proportion of overall freight volumes, but disproportionately high emissions given the high number of short journeys by multiple smaller vehicles. This means urban freight and carriers may be more receptive to incentives to switch fuels, or adopt hybrid vehicles, given the costs of doing so are lower, and technologies are already commercially available. Zero emissions zones for freight in urban areas can also incentivise uptake of low-carbon fuels and vehicle models, though this must be implemented gradually to give firms time to adapt their fleets. This can be carried out in parallel

to grants and subsidies to offset the costs of switching, while increasing collection points and route optimisation, and implementing fuel pricing rises (see Pillar 3, Section 3.3.1).

Governments should consider prioritising the following actions:

- Carry out a stakeholder mapping of freight firms across the value chain and develop effective stakeholder engagement strategies to design workable policies and a realistic timeframe for implementation, while determining what kind of support firms will need to invest in low-carbon alternatives.
- Consider establishing a zero emissions zone for freight building targets, implementation timeframes, regulations and support measures in concert with urban freight companies. Pilot implementation can help to improve policies and build acceptance, as well as giving firms time to adapt.
- Municipal authorities should review their powers to restrict traffic and may need to collaborate with other regional or other local authorities to this end, particularly in establishing zero emissions zones for freight.
- Invest in the expansion of rail and inland waterways to displace road freight where possible.
- Consider the potential of low hanging fruit of aerodynamic retrofits, reduced rolling resistance of tyres, measures to reduce vehicle weight and partial inclusion of biofuels through performance standards and grants.
- Raise regulatory and performance standards and fuel switching and blending requirements, in parallel to progressive rises in fuel prices to incentivise decarbonisation.

3.7. Decarbonising the buildings and residential sector through energy efficiency and renewable installations

Representing almost one-third of total global final energy demand and about 15% of direct CO_2 emissions, decarbonising buildings and construction represents an area of enormous emissions reduction potential, as well as an opportunity to reduce air pollution and improve citizen well-being (IEA, 2021[180]). Despite significant advances in building and materials efficiency, however, emissions from this sector continues to rise, and according to the IEA, the rate of building energy intensity reduction needs to five-fold as quickly over the next ten years to be on track to achieve net zero by 2050 (IEA, 2021[181]).

The challenge is particularly acute in many emerging and developing countries, which will experience rapid population growth and urbanisation over the next two decades, with enormous volumes of building construction to meet rising demand. In many developing countries, much of the building stock is old, dilapidated and in need of repair, and for the most part built prior to the introduction of building efficiency standards. Moreover, lower average purchasing power and fewer available affordable energy efficiency options in developing and emerging economies mean that dwelling owners, businesses and indeed governments can less afford to make the upfront investments required in energy efficiency or renewable energy installations than in advanced economies.

Moreover, given emerging and developing economies will be hardest hit by the physical impacts of climate change, particularly by rising temperatures and more frequent heatwaves, energy demand from cooling appliances, particularly air conditioning, is set to expand rapidly over the next two decades. As more and more households invest in air conditioning in line with rising temperatures and population growth, this is likely to compound the buildings sector decarbonisation challenge in countries experiencing rising temperatures and more frequent heatwaves. Just 15% of households in Southeast Asia have an air conditioning system, for example. Yet, electricity demand for cooling in the region has grown seven-fold since 1990, to 8 TWh in 2020. The IEA estimates that without mitigating actions to encourage efficiency

improvements, energy demand from cooling could rise to 300 TWh by 2040, equivalent to the combined total electricity consumption of Singapore and Indonesia today (IEA, 2022[182]).

Despite these challenges, decarbonisation of the residential, building and construction sectors can also be an opportunity for emerging and developing economies. The scale of expansion in building stock required to meet the needs of growing and urbanising populations in emerging and developing economies means that the policy focus is more likely to be geared towards efficiency in new buildings, rather than retrofitting older stock, though of course it is important that this issue is not neglected.

Developing and emerging economies, therefore, are likely to make the greatest decarbonisation gains in setting performance standards for new buildings, incentivising on-site and cluster-based renewable energy solutions, as well as innovation in low-carbon materials production and construction techniques. Given 37% of a building's carbon footprint is typically embodied carbon, or emissions from extraction and manufacturing of building materials, the construction process and demolition, focusing on these segments of the value chain could result in the greatest emissions reduction gains. This will also help to build a substantial domestic market for low-carbon materials production and construction techniques, which can create quality jobs and boost economic growth (IEA, 2021[181]).

Indeed, given the majority of the remaining energy consumptions from buildings tends to be from electricity consumption – though many buildings also use gas – decarbonisation of the national power system is a major component of buildings and residential sector decarbonisation. For countries with high renewable energy penetration, therefore, there will be an even greater benefit from focusing on materials and construction processes, given that embodied emissions will represent a far greater proportion of overall emissions from buildings stock.

As a priority first step, policy making should seek to require greater energy efficiency in buildings before considering renewable energy solutions, on the basis that this will provide the least-cost pathway to decarbonisation, as well as alleviate pressure on the national electricity system as a whole. Once efficiency improvements have been exhausted, policy making should look to incentivise on-site renewable energy solutions, either for individual buildings or clusters of buildings, given that this will add to overall renewable energy installed capacity, rather than place an extra burden on the national grid. Lastly, where on-site cluster-based solutions are not considered feasible, connecting buildings to the grid via a PPA can be considered (Becque et al., 2019[183]).

For new buildings, design innovations and building energy codes are the primary tools to incentivise and require improved operational energy efficiency. Fossil fuel-producer emerging and developing economies have an opportunity to leapfrog buildings design, borrowing from techniques which optimise use of space and provide passive solutions to cooling, heating and lighting, such as use of shade, reflective surfaces and optimisation of air flow, to reduce demand for high-emitting cooling and heating appliances. Governments can set minimum energy efficiency and thermal performance standards, ensuring they cover all new buildings, including both residential and non-residential, in building energy codes. These should get incrementally stronger in line with progress towards net zero and as competencies in low-carbon building design and installation of domestic architecture and construction firms gradually improve in response to market demand.

Policy making to improve the operational efficiency of existing buildings will be more challenging for emerging and developing country governments because absence of data as to the condition and needs of existing buildings makes identification of the least-cost approach to retrofits challenging. In addition, a lack of domestic experience in deep energy retrofits, at least initially, may make improvements at scale difficult to achieve. In many instances, building owners may also be unwilling or unable to invest the significant sums required to improve energy efficiency, meaning that governments will need to provide subsidies and incentives to encourage investment, which may not be affordable.

Decarbonisation objectives asides, refurbishing and retrofitting existing building stock, including improving sanitary conditions, will be an important component of livelihood improvements, while measures to increase the energy efficiency of buildings, such as envelope renovation (windows, roof and walls) and service systems improvements (cooling, heating and ventilation) can be pursued in parallel.

Governments can support municipal authorities to undertake studies of existing buildings stock, using it to identify key challenges and needs to address. The results of these studies should also inform the development of a strategy which combines a range of elements to incentivise and require improvements to existing stock. This could include information-sharing and education campaigns as to the benefits of energy efficiency, and research and development grants and subsidies to construction and architecture firms to develop new products and services. Additionally, training and education to enable companies to move into this space, and financial incentives such as tax rebates, low interest loans and grants to assist buildings owners pay for retrofits and improvements, can support gradual energy efficiency improvements of buildings stock. The introduction of certification standards, in line with building energy codes for new buildings can also support consumers to make more informed choices about buying or renting buildings, particularly if they are able to access information on the impact on energy bills (IEA, 2021[181]).

Raising the energy efficiency of appliances (e.g. air conditioning and fans, lighting and cooking appliances), particularly in the context of rising population and urbanisation, should represent a core element of efforts to decarbonise the buildings and residential sector, in addition to improved design, building energy codes and retrofitting the buildings themselves. Additionally, systems innovations and improvements which can optimise overall energy use in a building, for example, switching lighting off when a room is not in use, can also help to improve energy efficiency and reduce bills for consumers. Progressive improvements to appliance and systems efficiency also benefit from the advantage that replacements and updates are required over much shorter timeframes than a buildings own life' cycle, therefore presenting more regular, short-term opportunities to decarbonise and improve energy efficiency in the sector, through progressively more ambitious policy making and technological advances.

For energy consuming appliances, particularly those which account for a high share of energy consumption, such as air conditioning, governments can introduce mandatory minimum energy performance standards (MEPS), to eliminate the worst performing products and appliances from the market. Efficiency labelling and consumer awareness campaigns can enable customers to make more informed choices to reduce their energy bills. As outlined above, such approaches need to be complemented with policies to incentivise firms to produce improved, low-cost appliances for the domestic market. This might include subsidised research and development to focus on energy efficiency improvements, alongside "pull" incentives, such as scrappage schemes for old appliances which include zero-interest or low interest loans or on-wage or on-bill finance to assist consumers in replacing them with more modern and efficient alternatives. This can help create a market for appliances with high energy efficiency ratings and further encourage firms to invest in improvements.

In some contexts, governments will also need to consider citizens and households who lack the means to switch to more efficient appliances, where introduction of MEPS or outright bans on higher emitting products could push them towards higher emitting alternatives.

Additionally, systems improvements, particularly for larger buildings can entail substantial efficiency improvements and emissions reductions. For larger, higher-emitting new buildings, for instance, BECs can require automated lighting or cooling systems to improve efficiency, or the employment of buildings efficiency managers. Establishing a legislative and enabling environment conducive to the development of an Energy Service Company (ESCO) market can also support energy efficiency improvements.

Box 3.34. Facilitating energy efficiency and renewable energy solutions through Energy Service Companies (ESCOs)

Energy Service Companies (ESCOs) offer energy efficiency and renewable energy solutions, normally to non-residential buildings or industry, via Energy Performance Contracts (EPCs). Savings are generated for the energy user, and remuneration for the ESCO is based on performance and paid for based on savings delivered and reductions in energy bills.

Development of a thriving ESCO sector can overcome a range of market failings and make it easier for businesses lacking expertise and knowledge in energy efficiency and renewable energy to reduce their energy demand and bills at the same time. ESCOs can overcome an absence of upfront capital and facilitate financing for retrofits, energy efficiency measures and renewable energy solutions, either through providing the required capital themselves, or through established links with lenders, who recoup capital through energy savings. They can also overcome a lack of expertise in energy efficiency design among businesses or awareness of options to reduce demand by providing easily understandable products for businesses who can outsource the design and implementation of energy efficiency services.

In advanced economies and China, the market for ESCOs has grown rapidly, mainly thanks to an enabling environment which allowed ESCOs to thrive by strengthening energy efficiency targets and environmental targets in the country's 13th Five Year Plan (2016-2020). However, in developing and emerging economies, the model has been less successful. This is mainly because ESCO firms lack strong balance sheets or domestic financiers do not offer appropriate financial products, as well as a lack of firm expertise and accreditation to support and encourage consumers to make informed choices. Governments can work to incentivise and strengthen the ESCO market, by setting enabling policies and legislation, as well as encouraging domestic banks to offer new financing products for firms. They can also take a lead in use of ESCOs to encourage energy efficiency in public buildings, leveraging public procurement power to build a thriving local ESCO market, and encouraging domestic firms to diversify and strengthen their product offerings which can then be deployed in the private sector.

Source: (World Bank, 2016[184]); (IEA, 2021[185]).

Governments should consider prioritising the following actions:

- Strengthen collaboration between national government policy makers, who normally set energy efficiency policies such as building efficiency codes (BECs) and the regulatory framework for renewables installations, and municipal and local authorities, who play a central role in enforcing and administering national policies at a city and building level. Feedback from municipal authorities can also support improvements to national-level policy making and identify areas where local government requires national-level support for effective implementation, for example, guidelines on buildings inspections, and communication of changes in building efficiency standards with dwelling and business owners.
- Consider national circumstances, particularly the extent of existing renewable energy penetration in the electricity system, and the scale and timing of future building stock expansion in the light of population growth and urbanisation. The financial willingness and capacity of business and dwelling owners to make investments in energy efficiency and renewable solutions retrofits (for existing stock), and the existing capacity of domestic architecture and construction firms to respond to new energy efficiency requirements will also be key to designing financial incentives to encourage energy efficiency measures and sustainable building design.

- Countries with a high proportion of renewables penetration already may find that embodied emissions from buildings occupy a far greater share of overall emissions from the sector, and may therefore be better off focusing on policies to incentivise efficiency and the decarbonisation of materials extraction, and manufacturing and construction methods, and setting protocols for demolition to encourage recycling, reuse and repurposing. Where countries are fiscally constrained and savings are low, yet face rapid population growth and urbanisation leading to substantial construction of new buildings stock, it may be preferable to focus on introducing BECs which become incrementally stricter, and incentivising new firms to produce more efficient designs and construction techniques.
- Support municipal authorities to undertake detailed studies of the residential and buildings sector to establish baseline data for energy consumption and GHG emissions, and to identify barriers and potential incentives for energy efficiency improvements. This can be a planning tool to assist municipal and national authorities to gather insights in to how they can deploy limited financial resources and build workable strategies for buildings decarbonisation which conform to realities on the ground.
- Adopt mandatory and incrementally strengthening BECs for all new buildings. These should include minimum energy and carbon performance standards. In some instances, BECs can also integrate design components, such as reflective surfaces and optimisation of air flow, which provide passive solutions to cooling and lighting and limit demand for energy use. Governments should also provide clear guidance and training on BEC implementation and enforcement to municipal authorities.
- Alongside BECs, consider introducing building labelling standards which provide information to prospective buyers and tenants as to a building's energy efficiency and the associated impact on their bills. This will support greener choices and help build the market for retrofits and new buildings designed with sustainability in mind.
- Prioritise policies which incentivise building, appliance and systems energy efficiency over renewables installation as a first step, on the basis that this will provide the least-cost pathway to buildings and residential sector decarbonisation, and will also alleviate overall pressure on the electricity system. Renewables installations should be considered once energy efficiency options are exhausted (Becque et al., 2019[183]).
- Recognise the importance of scaling up the use of energy efficient appliances, phasing out high emitting alternatives, and the ways in which this can support progressive decarbonisation alongside changes to building stock given their shorter life cycles. To incentivise diffusion of more energy efficiency appliances, consider the introduction of mandatory and incrementally strengthening Minimum Energy Performance Standards (MEPS), combining this with a labelling programme and information sharing with consumers to raise awareness of how adopting such appliances can have a positive impact on their energy bills. In parallel, scrapping schemes, which subsidise consumer purchases of less energy-intensive appliances can help build market demand and facilitate a mass switch to low-demand alternatives, incentivising firms to produce more efficient, improved products for the domestic market. In parallel, highly subsidised or free replacement of appliances may be necessary for the most vulnerable households, and policy makers should be aware of the risk of unintended consequences if poorer consumers are pushed towards more polluting appliances or those which damage health as a consequence of government policy, for example, users of LPG for cooking switching to charcoal owing to rising costs (IEA, 2022[182]).
- To support innovation in appliance manufacturing, governments can provide innovation grants to firms, enabling them to invest in staff, training, new equipment and design. Continuous strengthening of appliance MEPS will require constant communication with suppliers and manufacturers to ensure they understand and can respond to new changes to MEPS, and to

provide an opportunity for feedback and requests for support to meet new standards (IEA, 2022[182]).

- Public procurement can also drive market innovation given its scale. Approved equipment lists, for example, for air conditioning and lighting, which conform to MEPS, can have significant signalling power, encouraging firms to invest in product improvement and innovation.
- Where renewable energy solutions are required, incentivise on-site or new off-site solutions, rather than connections to existing electricity made available through the grid. This will increase overall installed capacity from renewables and build increased energy security and resilience for both cities and buildings (Becque et al., 2019[183]).
- Consider subsidies, low-interest and interest-free loans, grants and tax rebates to incentivise building owners to invest in energy efficiency retrofits which conform to BEC standards. For both appliances and retrofits for buildings, support may need to offset high initial investment costs for consumers. This can be done through on-bill or on-wage, low-interest financing programmes, or through incentivising use of ESCOs which can bear the upfront costs.
- National and municipal governments can lead by example, retrofitting existing buildings for energy efficiency and where necessary adding renewables. This can provide an important signal to domestic construction and architecture firms to incentivise them to invest in low-carbon design and construction capacity which other building owners can then benefit from.
- Consider reducing any remaining electricity subsidies, in line with the recommendations in Pillar 3, Section 3.3, given that subsidised electricity will reduce incentives to invest in energy efficiency measures to reduce bills.
- Invest in communications and information-sharing campaigns to highlight and make citizens aware of the impact of energy efficiency on bills, as well as to raise awareness about government schemes and support that can offset the cost of efficiency and renewable investments.

3.7.1. Incentivising renewable energy auto-generation for buildings

As a complementary set of measures, renewable energy deployment can be considered once all options to encourage energy efficiency through building design, retrofit improvements, and appliance and systems efficiency improvements have been exhausted, enabling buildings owners to capitalise on the highly competitive costs of renewables against other generation fuels. Policy making should aim to incentivise on-site renewable energy generation (e.g. solar thermal systems, air-sourced heat pumps or distributed solar PV). If a suitable location for a renewable energy installation is not available on site, off-site renewables installations (e.g. as renewables solutions for entire districts) can be considered, as they may be more suitable for buildings clusters, rather than a connection to the grid. This approach can also enhance energy security in buildings and urban areas during a period in which electricity system stability may be fragile, as new renewables capacity is added during the process of energy sector decarbonisation (see Pillar 3, Section 3.4).

Governments can take steps to incentivise smaller-scale renewable energy solutions for buildings or clusters of buildings, for example, by offering tax exemptions for buildings which install renewables, streamlining the permitting process for smaller projects, and offering a stable FiT to sell excess power to the grid. BECs and building standards can also incorporate requirements to ensure new buildings, where possible, are renewables ready. Examples include structural integrity requirements consistent with solar, or rooftop facilities organised to maximise the available space for solar installations. In Singapore, for example, all rooftops over 400 m_2 should be solar ready (IEA, 2022[186]). Lastly, to overcome upfront financing costs and limited renewables knowledge among businesses and consumers, governments can encourage and set a legislative environment for ESCOs.

Governments should consider prioritising the following actions:

- Ensure energy sector regulation and policies enable and incentivise buildings or sets of buildings to set up renewable energy solutions. Potential policy options are available in Pillar 3, Section 3.4 and might include stable FiTs, self-generation licences, enabling groups of buildings to aggregate demand and sign a PPA, and streamlining the permitting process.
- Consider what kind of incentives can encourage on-site renewables solutions, for example, tax rebates for building owners where renewables are installed, or enabling building owners to sell excess electricity back to the grid at a fixed price. Buildings and business owners must be aware of these incentives, which they should be able to take advantage of in a straightforward manner. Consider provisions within BECs that will ensure new buildings are designed with possible renewable energy installations in mind, for example, maximising roof space and structural integrity requirements.

3.7.2. Addressing embodied carbon emissions in buildings

Reducing embodied emissions from extraction and manufacturing of materials, construction and demolition of buildings, will be key for developing and emerging economies to decarbonise the residential and buildings sector, particularly in countries with an already high penetration of renewable energy in the grid and where embodied carbon represents a much higher overall proportion of the sector's carbon footprint.

Cement and steel are some of the hardest materials to decarbonise, at least in the short term and will remain so until hydrogen and CC(U)S are available at commercial costs to decarbonise these and other hard-to-abate sectors. Government strategy, therefore, can focus on encouraging a life cycle approach in these sectors over the short to medium terms. Measures may include efforts to encourage greater recycling, collection and use of scrap steel, through the promotion of re-use and remanufacturing options, and incentivising repurposing of buildings. Efforts should also begin to design policies that will help meet the longer-term needs of these sectors, such as ensuring the availability of low-carbon resources for steel and cement production, enabling access to funding for the transition to low-carbon production in these sectors, and ensuring robust markets for low-carbon materials. In parallel, governments can provide research and development financial support to firms to lower the carbon intensity of manufacturing and construction processes, as well as to develop alternative low-carbon products and materials, and efficiency processes, and support collaboration and partnerships between educational institutions and industry. This can be an important factor in building capacity and competencies in the construction sector to respond to low-carbon requirements of new building codes.

In parallel, long-term strategies to decarbonise hard-to-abate sectors via hydrogen and CC(U)S, as well as power sector decarbonisation, will be required to provide future steel and cement in the buildings sector.

Governments should consider prioritising the following actions:

- Introduce demolition protocols which ensure alternatives such as repurposing have been considered, as well as mandatory re-use and re-cycling requirements at the end of a building's life. This will require governments to also invest in recycling facilities to support the re-use of materials such as steel whose production has high carbon contents.
- Consider developing materials efficiency standards and labelling.
- Invest in training and education programmes, as well as partnerships between educational institutions and industry, to encourage the development of low-carbon design and materials manufacturing competencies in the market place. This will build the capacity of firms to respond to changing needs and to innovate to produce greener materials and products.

- Consider publishing efficiency guidelines for new buildings, materials manufacturing and demolition, including how to design and build new structures which limit the use of carbon-intensive materials such as cement and steel.
- Incentivise firms to invest in research and development to innovate and design new products which are bio-based and can replace where possible the use of cement and steel, in parallel to encouraging re-use and re-cycling.

Notes

[1] The TADAT was set up as a collaborative project between the IMF, the World Bank, and the governments of France, Germany, Japan, the Netherlands, Norway, Switzerland and the UK.

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Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT)

How can fossil fuel producers and mineral-rich developing countries design realistic, just and cost-effective low-carbon transition pathways? Taking into account the heterogeneity of low-carbon trajectories, the *Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT)* provides options for policy makers, industry and finance institutions in search of the answers. The report aims to help them seize the transformational opportunities linked to sustainable, low-carbon growth. It identifies ways of mitigating the transition's impacts on fossil fuel industries, workers and poor households, and of preventing the risks of high-carbon lock-in and stranded assets. Recognising the shared responsibility of consuming and producing countries in reducing fossil fuel production and use, EFFECT advocates for transformative partnerships for technology transfer, green finance and capacity building. Ultimately, it supports an equitable sharing of the transition's benefits and costs, both across and within countries.

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