Employment analysis methodology

Jobs analysis

To estimate the employment impacts of the Covid-19 pandemic and the proposed economic recovery and stimulus packages, the IEA developed a new methodology to estimate employment in energy-related sectors. This analysis estimates:

- The number of people employed before the Covid-19 crisis in major energy supply and end-use sectors, including electricity, oil, natural gas, coal and biofuels.
- The number of jobs likely to be lost in these sectors due to the Covid-19 crisis and the number of jobs that could be created by government support for the energy sector in recovery packages.

The analysis primarily relies on the use of "employment multipliers" which estimate how many jobs are created or maintained per million US dollars invested in new infrastructure or spent on certain goods. This technical annex describes:

- How employment is defined and the scope of calculations, together with the rationale for the approach adopted.
- The methodology used to assess the multipliers.
- How multipliers were developed.
- The use of multipliers within the IEA World Energy Model.

Definition and scope of employment

The definitions used in this report are:

- **Direct**: Jobs created to deliver a final project or product.
- **Indirect**: Supply chain jobs created to provide inputs to a final project or product.
- **Induced**: Jobs created by wages earned from the projects and spent in other parts of the economy, thereby creating additional jobs.
- **Cost savings re-spend**: Jobs created by reduced customer energy costs being spent elsewhere in an economy. These jobs, also referred to as second-order jobs, can also be negative, if, for example, the cost of energy were to rise for consumers in the wider economy, leading to a reduction in spending in other parts of an economy.

Employment encompasses all direct jobs and the indirect jobs from suppliers providing immediate inputs to the production of the primary sector. Induced jobs and jobs that may be created from re-spend are not included. This sets a clear boundary around the jobs that the upfront investment would pay for to deliver the project. Where possible, we highlight where jobs created are high paying and in low cost areas, meaning that there is likely to be a high level of induced jobs. We also highlight where investments pay back quickly and

produce cost savings over their lifetime, potentially giving consumers increased scope for spending in higher value-added sectors.

Jobs are normalised to full-time employment (FTE) for consistent accounting. An FTE job represents one person's work for one year at regulated norms (e.g. 40 hours a week for 52 weeks a year, excluding holidays). Two separate, six-month jobs would be counted as one FTE job.

Jobs are reported as either job-years or jobs. The "job-years" term is used to report the cumulative years of FTE over a period of time. The term "jobs" is used to report employment during a single year or an average over a period. Job-years accounts for total employment created directly by a project making comparable employment that may spike during construction phases, then level off at much lower levels during operation, which may continue for 20 years or more. Jobs indicate how many people will be employed in certain industries during a specified period of time.

The use of job-years or jobs does not imply anything about the permanency of the jobs. This is understandably important to policy makers who want to avoid creating jobs that disappear once recovery plan funding stops. We avoid classifying jobs as permanent or temporary because many jobs that are technically classified as temporary (i.e. predicated on the demand for projects and production or construction) may in fact offer long-term employment opportunities by leading to jobs working on future projects after the economic recovery spending dissipates.

Where possible, the jobs created are classified as:

- **Manufacturing**: Jobs producing direct inputs to an energy project.
- **Construction:** Jobs installing, constructing and commissioning energy projects.
- **Operations and maintenance** (O&M)**:** All ongoing jobs required to support the proper operation of an energy project.

Manufacturing and construction jobs are calculated over the lifetime of the production and construction phase of projects, while O&M jobs are calculated over the usable lifetime of the energy project. O&M jobs are always accounted for separately from the jobs created by economic stimulus spending, since they are not paid for by the initial stimulus investment.

We report only the gross number of job-years or jobs created. Gross effects include only the positive impact on employment associated with the investment. Net job creation considers job losses in other economic sectors that may occur by redirecting investment away from these areas. We focus on gross job creation to reflect the current job market, where job losses are occurring in many sectors, and where increased spending will likely be necessary to sustain jobs. The gross number of jobs created or sustained by spending in the energy sector provides a clear point of comparison to weigh job creation benefits in energy relative to other sectors.

Choice of methodology

Employment is most commonly calculated using one or a combination of three techniques:

- Computable general equilibrium (CGE) modelling.
- Input-output (I-O) modelling.
- Employment multipliers.

We used employment multipliers because we wanted to provide detailed employment numbers for specific energy technologies, and CGE or I-O models are generally unable to provide this level of granularity. The use of employment multipliers also means that employment created by an investment can be isolated from other macroeconomic factors that could otherwise impact the levels of job creation.

Although employment multipliers were primarily used to calculate employment figures for this analysis, the other methods helped to calibrate employment multipliers for subsectors, and served as points of comparison. For example, I-O tables from the Organisation of Economic Co-operation and Development (OECD) were used to verify and provide estimates of indirect jobs in certain industries.

Employment multipliers

The database of multipliers was compiled based on existing literature, industry engagement, surveys of government statistical accounts and macroeconomic modelling. It represents a state-of-the-art database of subsectoral employment levels across the energy sector. The method to produce the full subset of multipliers is described below (data sources are listed by sector in section 1.3). Broadly, the method was based on:

- Gathering employment multipliers at regional or global levels.
- Filtering and adjusting multipliers to ensure consistency in the types of jobs included, adjusting for inflation and eliminating older references where prices and labour efficiency have changed significantly.
- Estimating multipliers for regions and technology types where insufficient primary estimates exist.

Gathering multiplier input data

Measures use one of two types of multipliers: those whose denominators are in million US dollars invested, and those whose denominators are in million US dollars spent on final goods. The denominator used is dependent on the nature of the measure, and in particular whether it aims to encourage investment in assets or consumer purchases.

We focus on new employment multipliers. These give the number of new jobs created by an incremental investment of $1 million or an increase of $1 million in final goods. They differ from active employment multipliers, expressed as jobs per million dollars of existing revenue, which more closely reflect O&M employment.

The primary sources used include:

- I/O tables, employment requirement matrices and national accounts.
- Academic, intergovernmental research and modelling results.
- Individual company and industry group estimates.
- Calculated multipliers from legal financial filings that provide information on employment and revenue, cost breakdowns for projects and average wages.

I-O tables and government surveys of businesses were prioritised, when available with sufficient detail, to support the subsectoral analysis (e.g. the North American Industry Classification System (NAICS) codes or the European Nomenclature of Economic Activities (NACE) codes), which provide detailed data at the level of pumps and compressor manufacturing). If these were not available, the master NAICS or equivalent codes were used to guide our multipliers (e.g. is the multiplier for electric chargers within two standard deviations of the generalised multiplier for electrical equipment manufacturing). These were used to filter out other multipliers that vary too far from the average.

Employment and financial information were extracted from the annual reports of major companies in each sector. Data for different years were used to estimate how changes in investment levels (derived from the IEA's *World Energy Investment 2020* report[1]) impacted changes in employment. This method could only be used for sectors with a high degree of consolidation in major firms that are publicly listed.

Material from academic and industry sources was screened to ensure harmonised definitions and reference values were adjusted to adhere to the framework described. In other words, if there was insufficient information to make adjustments, sources that did not adhere to these definitions were removed. It is worth noting in particular that:

- Direct component manufacturing is often included in direct employment instead of indirect. Where possible, manufacturing jobs are reclassified as indirect, or have not made a distinction between direct and indirect jobs for that multiplier.
- Estimates of indirect jobs sometimes include jobs created to support the operation and maintenance of the project or equipment. These are reported separately to clarify that they are not paid for by the Covid-19 stimulus investment.
- Indirect sometimes includes jobs "supported" by the purchase where the equipment is a key enabler for another job, for example, automobile manufacturing is a key enabler for delivery and taxi driving jobs. These "supported" jobs are not included in our analysis.

Where values from these sources were unavailable, estimates were based on employment multipliers for similar technologies. Cost breakdowns for building new projects or the production of one unit were used to estimate how much of the million dollars spent went

[1] https://www.iea.org/reports/world-energy-investment-2020.

to labour or materials. Based on available wage information for subsectors, direct labour was calculated by dividing total labour cost contribution by average wages. For indirect multipliers, the amount spent on materials in the original project was multiplied by an average multiplier from direct supplier industries. If it was not possible to isolate primary supplier industries, or their multipliers were not available, multipliers were used from higher level NAIC codes as a proxy for the indirect labour multiplier.

Once these multipliers were assembled, historic values were adjusted to express them in 2020 US dollars. Weighted averages of the full list of associated references were taken, basing those on the relevant and rigour the source material, to control for outliers.

Multipliers were tested with companies within IEA's Energy Business Council, peer reviewers, experts from academia, industry groups and other international organisations (such as the International Monetary Fund and International Labour Organization).

Regional multipliers

Employment data is not available for all regions and so regional multipliers were constructed based on wage differences for the standard regions in the IEA World Energy Model (WEM).These regional multipliers were arrived at by a variety of means, but most were created through the use of wage adjustments. This process involved:

- **Identifying the cost contribution breakdown** for $1 million spent on new projects or products for regions with existing multipliers (e.g. 10% labour, 50% materials, 10% equipment costs). These breakdowns were derived using detailed manufacturer surveys, primarily from the US Annual Manufacturer's Survey data which provide information on the contribution to costs of average wages, labour and materials. Industry evaluation and heuristics were used to confirm breakdowns or provide more granular breakdowns for specific technology types.
- **Adapting the cost contribution breakdown to each region**, taking specific account of how differences in wages and material costs shift the relative shares of labour and material. Average wages and basic material costs were indexed on the basis of US costs, and these were applied to the labour and material costs for a $1 million project or purchase to calculate how much that same purchase would cost to produce in a low-wage economy. For example, in the United States $1 million spent on batteries represents roughly $140 000 for labour costs, but when adjusting for low-wage economies, producing the same amount of batteries would only be $3 000 in labour costs. We then need to adjust the amount of batteries back up to arrive at a $1 million purchase in low-wage economies. If labour is much cheaper than project inputs, then the percent contributions of labour and material costs shift in low-wage economies. We provide an example calculation below in Table 1.1. We utilised local wages, average cost differential of input materials, share of imports in production and the costs of those imports to arrive at adjusted cost contribution breakdowns for various regions. These inputs were derived from the global balance of trade in value added. In

lower cost economies, the labour index is lower than the material cost index, resulting in the proportion of total project or product cost accounted for by labour costs going down, and the proportion of total cost accounted for by input materials going up.

- **Finding average wages for relevant jobs in a region** by using national average salary information specific to a subsector. Where information on wages specific to a subsector was not available, average wages from salary reporting websites were used, splitting the labour costs to distinguish between those associated with production and manufacturing and those associated with overheads (e.g. research and development, procurement and marketing). To calibrate the correct weighting of various salary types, average wages were used for generalised sectors (e.g. manufacturing of durable goods, construction) to provide guidance. For technologies that have a relatively globalised market (e.g. solar photovoltaic panels), a global average of salaries is assumed based on each countries' share of total production. This provides an indirect multiplier that can be applied to all regions.
- **Calculating jobs per million dollars** for the expenditure by dividing the portion spent on salaries by average salaries. The indirect multiplier for advanced economies was used as a basis for indirect jobs, and the rectification multiplier for each country was applied to calculate indirect jobs. Since inputs for industries can be diverse across the entire economy, the rectification multiplier, which uses generalised wages, reflects economy-wide cost differences and does not need to apply specific wage types to arrive at more exact direct jobs numbers.

Table A.1 ▷ Example calculation of labour contributions in different regions

	Base ($ million)	Cost adjustment index	Low-wage economies ($ million)	Low-wage economies, rescaled to $1 million
Labour	0.15	0.1	0.15*0.1= 0.015	(0.15+0.5)/(0.015+0.3)*0.015 = 0.031
Materials	0.5	0.6	0.50*0.6= 0.3	(0.15+0.5)/(0.015+0.3)*0.3 = 0.62

Calculating total employment

The final employment multipliers were integrated with the WEM by applying the multipliers to the appropriate sector and regional investments.

These multipliers were used to:

- Support the calculation for total jobs pre-Covid-19 crisis in key energy sectors.
- Calculate new jobs created by Covid-19 recovery and stimulus spending.
- Calculate jobs lost or at risk due to decreased investment in subsequent years.

In all cases, the multipliers were applied to investment or changes in investment, not revenues or total assets, to calculate the number of jobs created by or necessary to support the level of new investment. When providing jobs within a single year, we considered for

how long and when an investment or purchase creates those jobs. For instance, investment in a new hydroelectric dam would create some jobs in the planning and preparation phase prior to the investment: when financial close occurs, these jobs disappear, but construction and equipment manufacturing jobs are created; when construction is completed, these jobs disappear, but O&M jobs begin. Jobs are assigned to the relevant years to understand total employment on an annual basis.

Pre-Covid-19 crisis jobs

Pre-Covid jobs include both O&M jobs associated with the existing asset base and jobs supporting the investments made in the preceding years:

- O&M jobs associated with the existing asset base were estimated using employment surveys and census data, annual reports of major companies, academic research, and multipliers derived by estimating the number of employees associated with different facilities and scaling them up in line with total facilities globally. There were substantial gaps in current employment data, and these were estimated and these estimates were tested with experts.
- Jobs supporting the investments made in previous years were calculated by applying the multipliers to new investment in the immediately preceding years, using data on new investment from the IEA's *World Energy Investment 2020* report This is used to estimate how many manufacturing and construction jobs were supported by projects underway or in the pipeline prior to Covid-19 related stimulus responses.
- The two totals were added together to produce the total pre-Covid jobs figure for energy industries used in Chapter 1.

New jobs

Multipliers were applied to the level of investment included in the plan for each year to calculate total jobs in 2021, 2022, and 2023. Figures for the jobs created take account of the timing delays between investment and job creation for each subsector. They also take account of minimum lead times for projects already through the feasibility study phase to move from plan to financial close.

Investment numbers were produced for each region and subsector, and the corresponding multipliers were applied for each region. For investments in which figures for manufacturing, construction and O&M jobs are available, a breakdown was produced of the types of skills needed for those jobs and the regions where those jobs would be created. For technologies with a highly globalised supply chain, manufacturing jobs are divided across regions according to current production capacities. For technologies that have very localised production, such as building materials and biofuels, all manufacturing jobs were assumed to be created locally.

Jobs lost

Multipliers were applied to the decline in the level of investment between 2019 and 2020 to calculate how many jobs in construction and manufacturing are likely to have been lost in the long-run due to structurally decreased demand if investment levels are not bolstered. These job numbers are different from many of the job numbers that have been reported in the press, which are often based on unemployment filings and reflect workers who may be on temporary furlough or whose wages are hourly and are forgone during lockdowns. Press reports also often use information from industry associations and companies, many of which report "jobs at risk" on the basis that projects that are stalled will not proceed after lockdowns have been lifted, and that all jobs connected with such stalled projects will be lost. These two types of numbers do not reflect structural losses, and are therefore not considered in our analysis. As a result, the jobs lost estimates provided are much lower than those that have been reported in the press. Our estimates provide a more accurate reflection of the number of jobs truly at risk as a result of decreased investment.