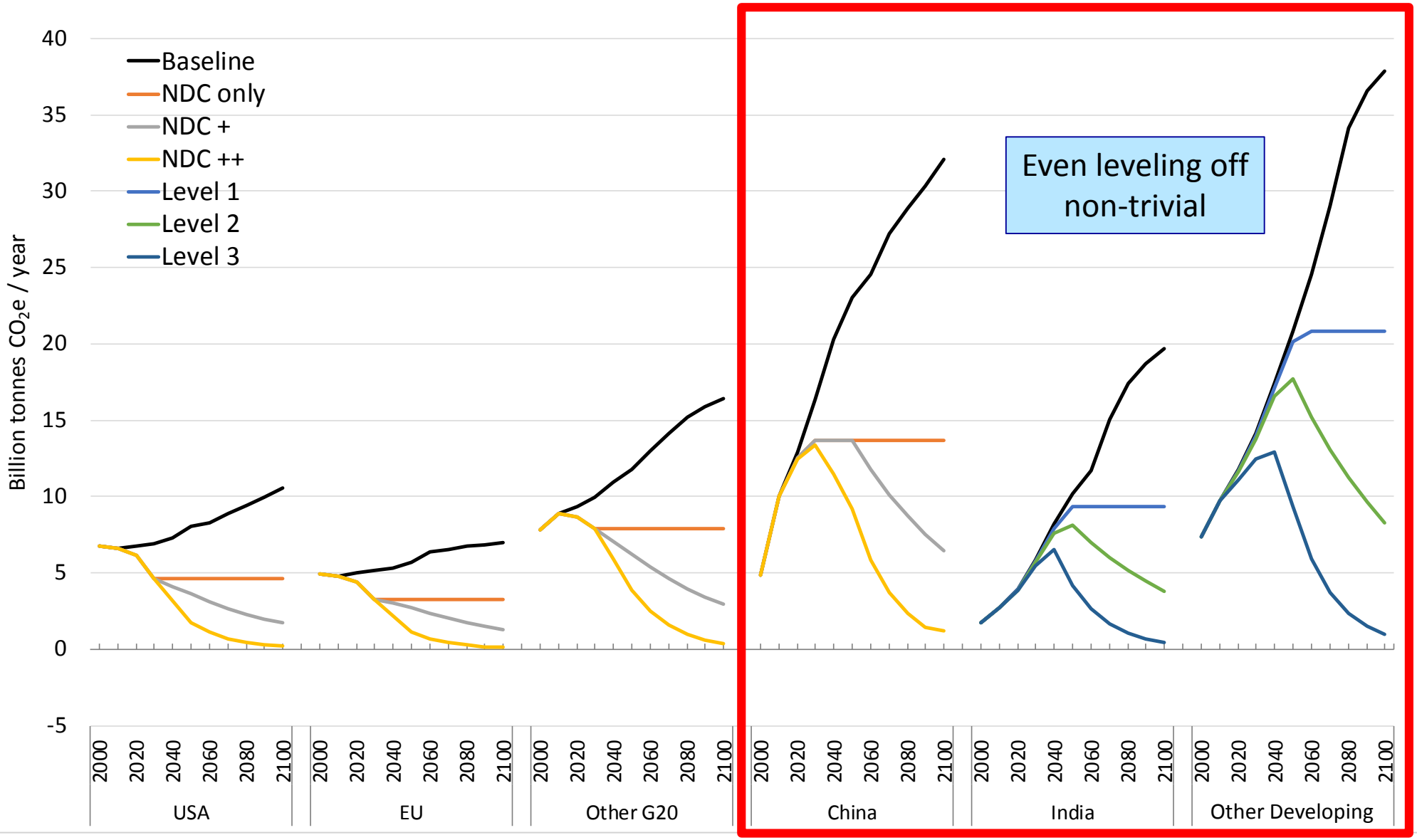
Global Climate Goals and Developing Country Electrification

Steven Rose

2017 Energy Information Agency Energy Conference
June 27, 2017

Potential Regional Emissions Constraints



Rose et al. (2017)

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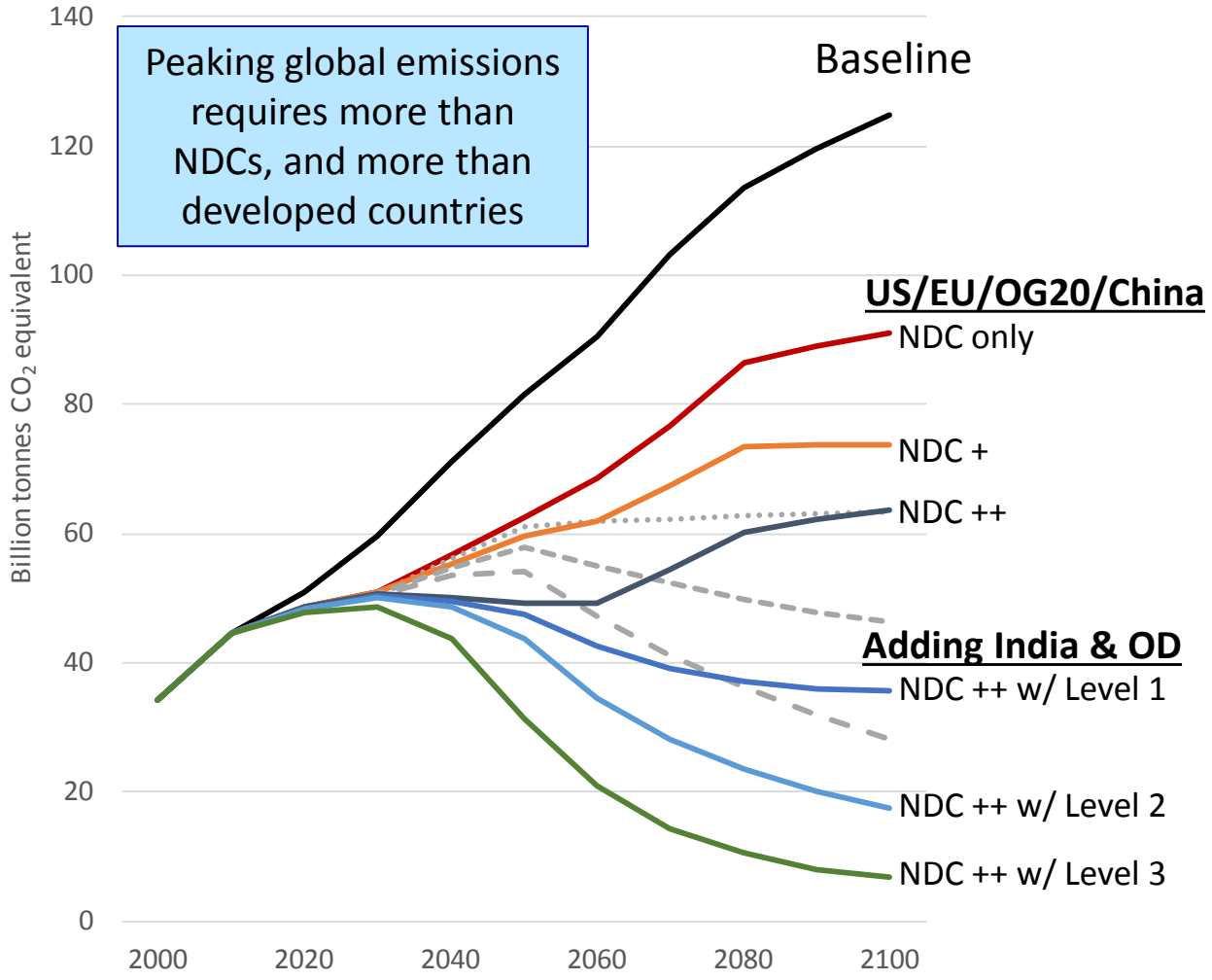
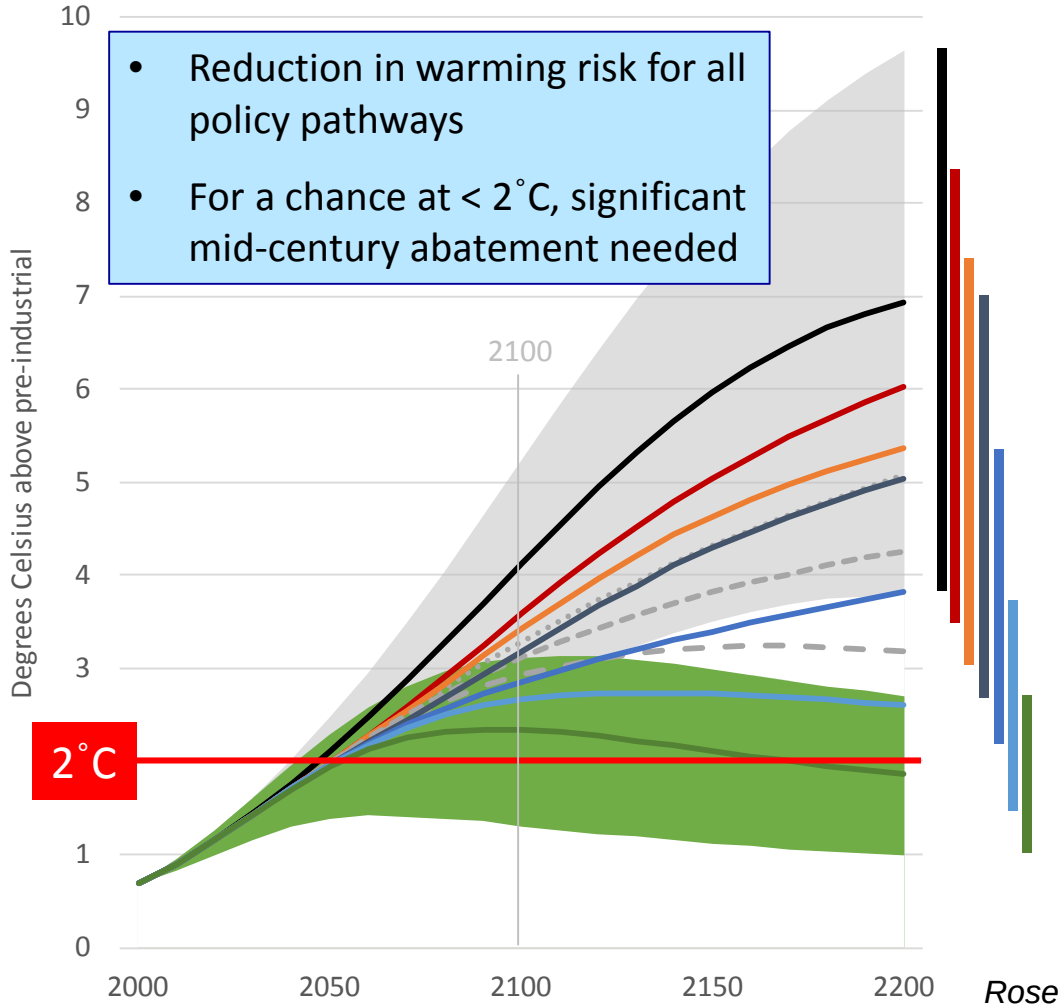
Global Emissions & Temperature Implications

Shading reflects some of the uncertainty in the climate response to emissions (shown for only a few scenarios)

Global Emissions



Global Temperature



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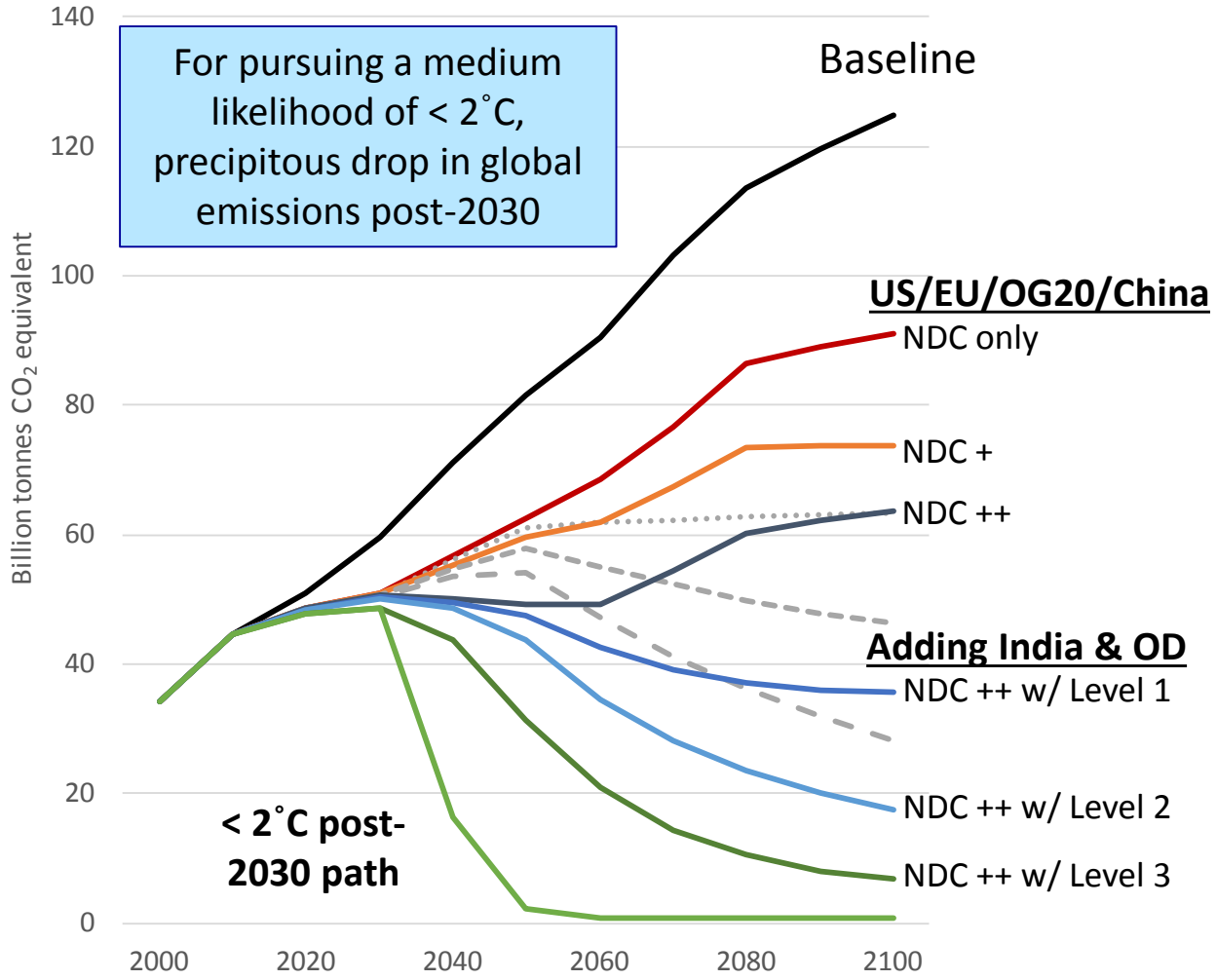

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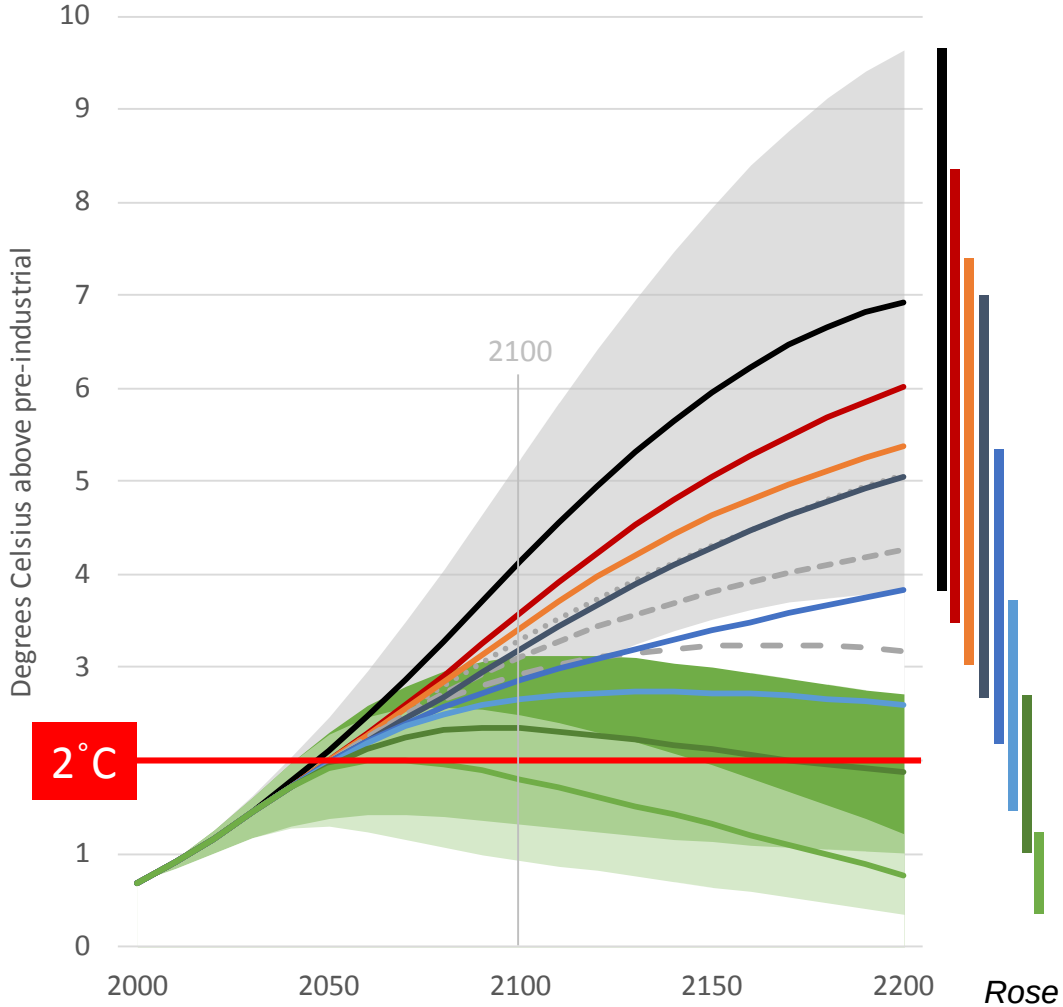

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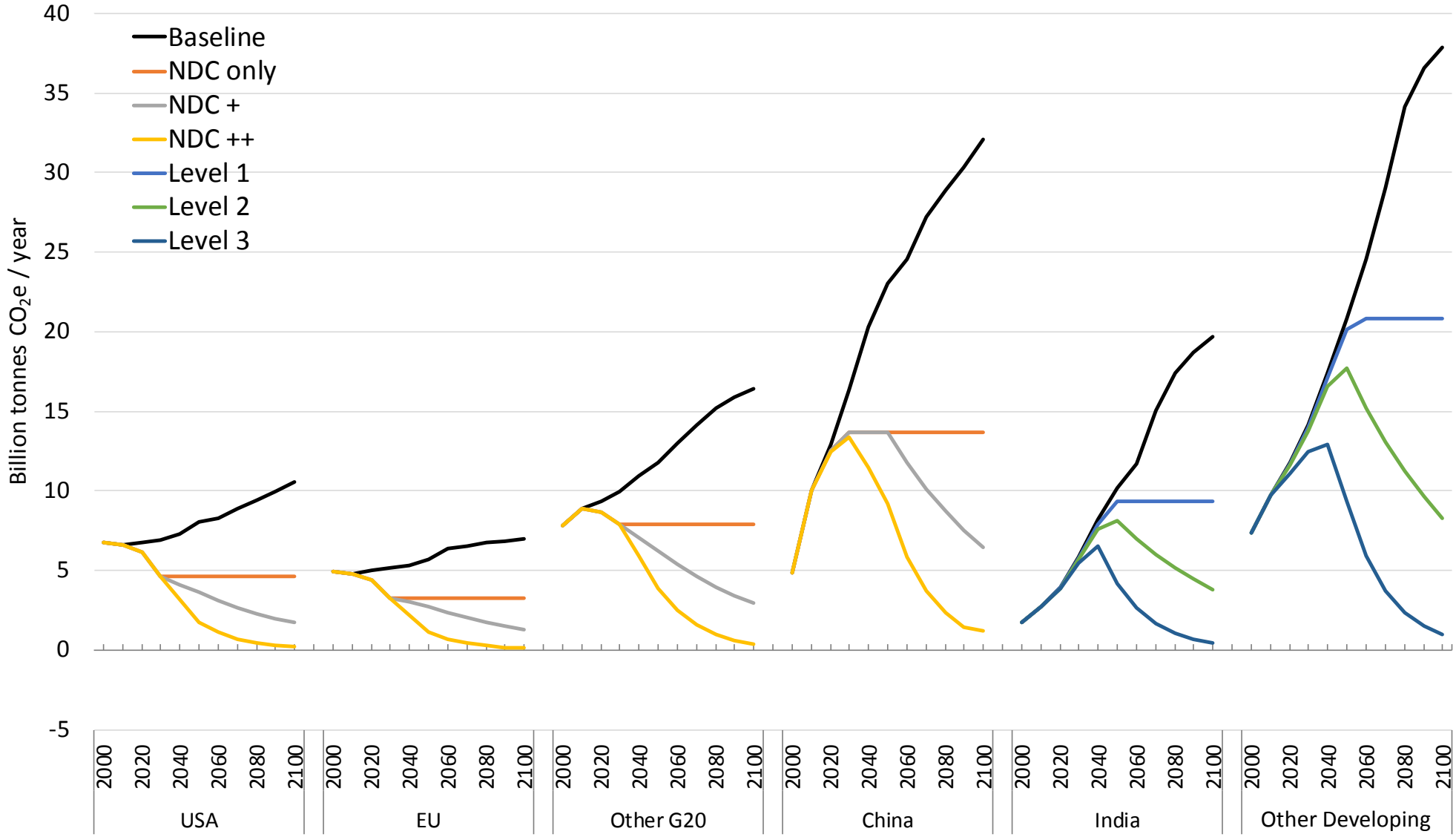

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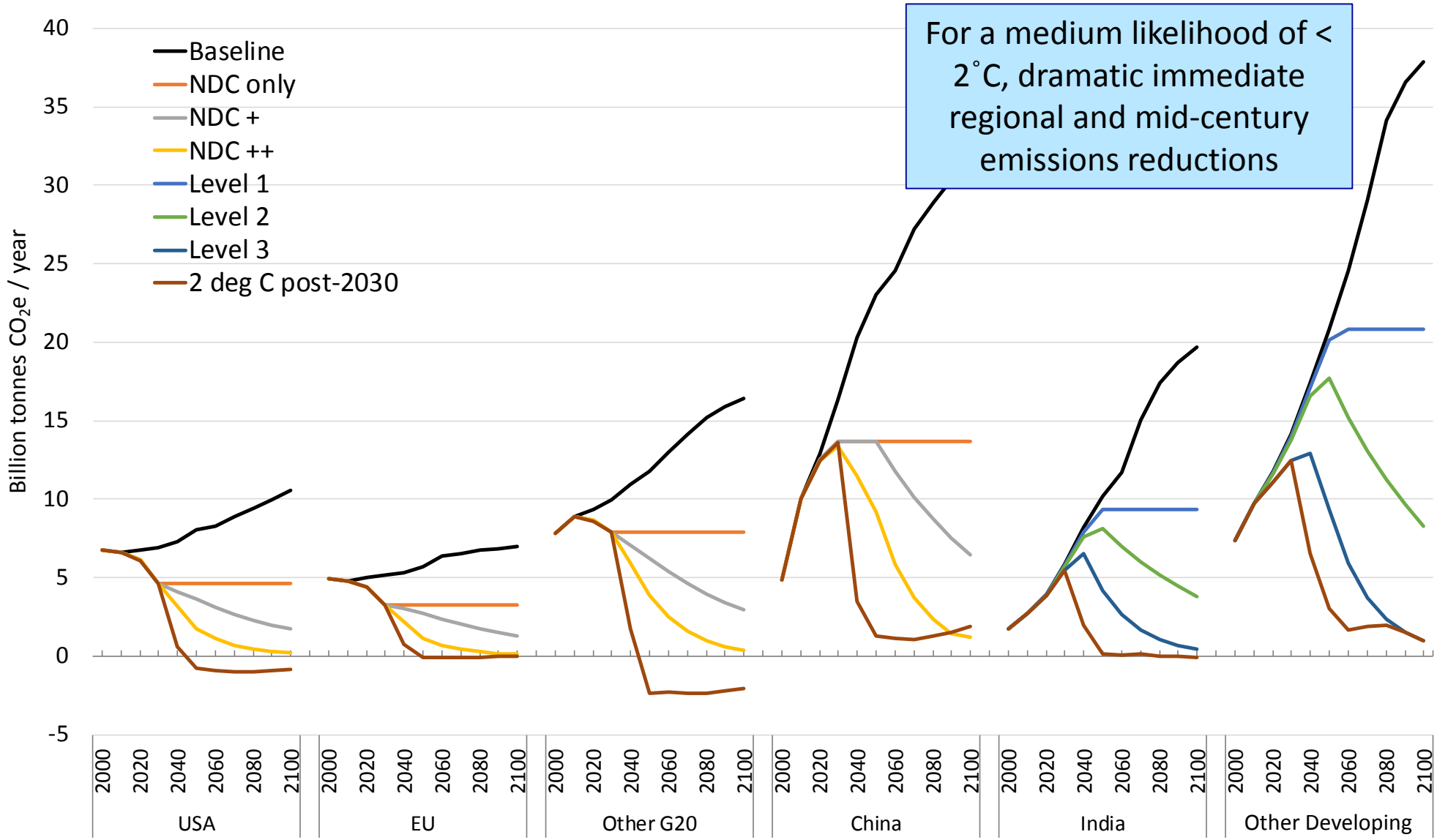
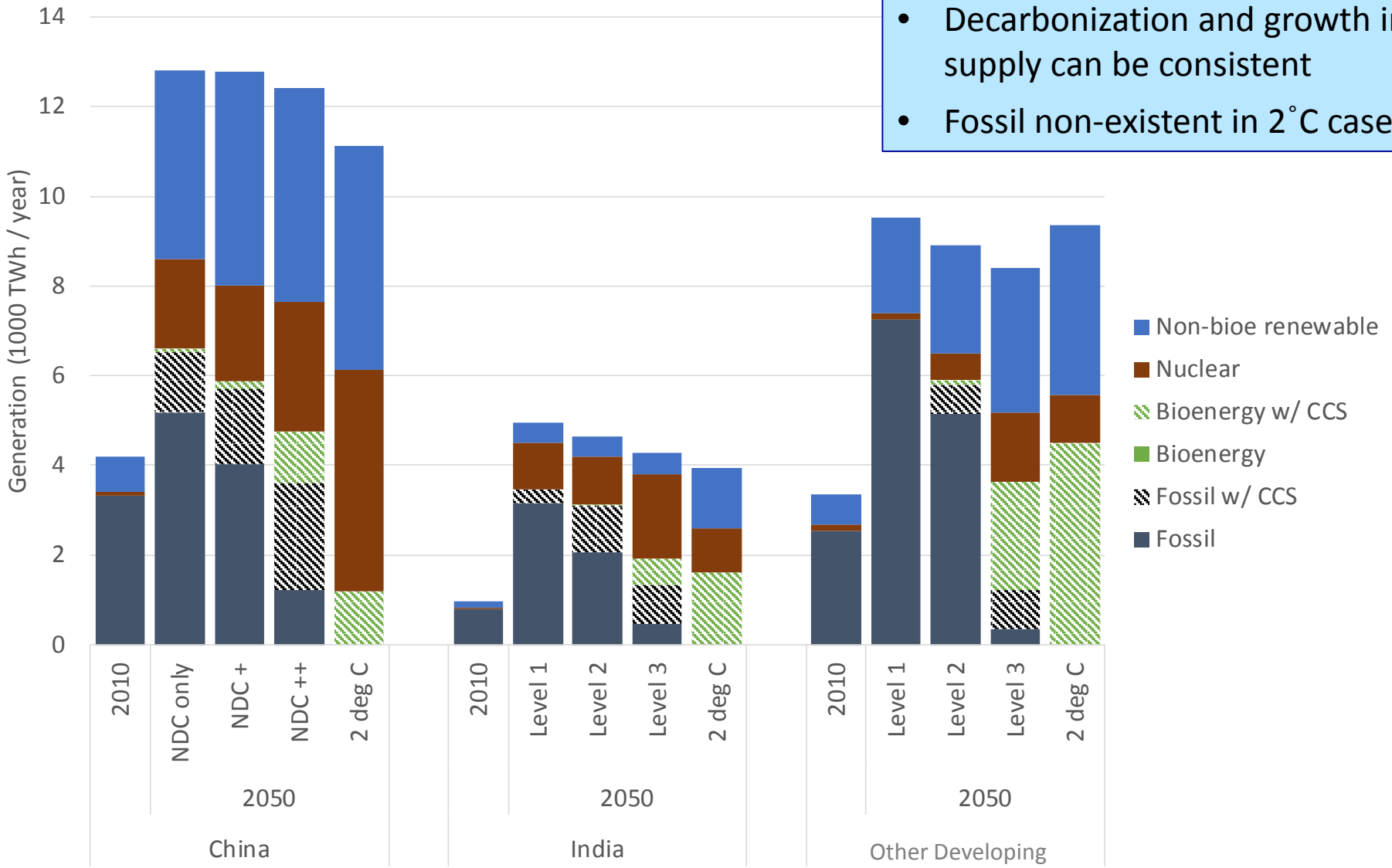


Rose et al. (2017)

Regional Electricity Supply Transformation by 2050

- Decarbonization and growth in electricity supply can be consistent
- Fossil non-existent in 2˚C case



Rose et al. (2017)

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Costs Increase with Stringency at an Increasing Rate

(% loss in present value per capita consumption through 2100)

Table 2 Regional cost, global welfare losses, and maximum global mean temperature by climate policy

Scenario	Reductions in discounted average per capita consumption through 2100 (%)						Global welfare loss (%)			Max °C
	USA	EU	Other G20	China	India	Other Countries	Utilitarian ($\sigma = \infty$)	Inequality averse ($\sigma = 2$)	Inequality averse ($\sigma = 0.5$)	
S2: NDC only | Base	0.2%	0.3%	0.3%	1.4%	0.1%	−0.2%	0.3%	0.3%	0.0%	6.0 (3.4–8.3)
S3: NDC + | Base	0.3%	0.4%	0.6%	2.3%	0.0%	−0.5%	0.5%	0.4%	−0.1%	5.4 (3.0–7.4)
S4: NDC ++ | Base	0.5%	0.7%	1.1%	4.8%	−0.1%	−0.7%	0.9%	0.9%	−0.1%	5.0 (2.8–7.0)
S5: NDC ++ | Level 1	0.5%	0.7%	1.0%	4.8%	0.8%	−0.6%	1.0%	1.1%	0.2%	3.8 (2.2–5.3)
S6: NDC ++ | Level 2	0.5%	0.7%	1.0%	4.9%	2.0%	0.2%	1.3%	1.6%	0.9%	2.7 (1.6–3.8)
S7: NDC ++ | Level 3	0.5%	0.8%	1.0%	5.1%	4.3%	2.1%	1.9%	2.6%	2.5%	2.3 (1.4–3.1)
S8: 2 °C post-2030	2.1%	2.2%	5.2%	12.3%	14.1%	6.5%	5.7%	7.6%	8.5%	2.0 (1.3–2.6)

Negative values imply benefits. Max temperature results first for climate outcomes with 3˚C equilibrium climate sensitivity, and then, in parentheses, outcomes with 1.5˚C to 4.5˚C sensitivity.

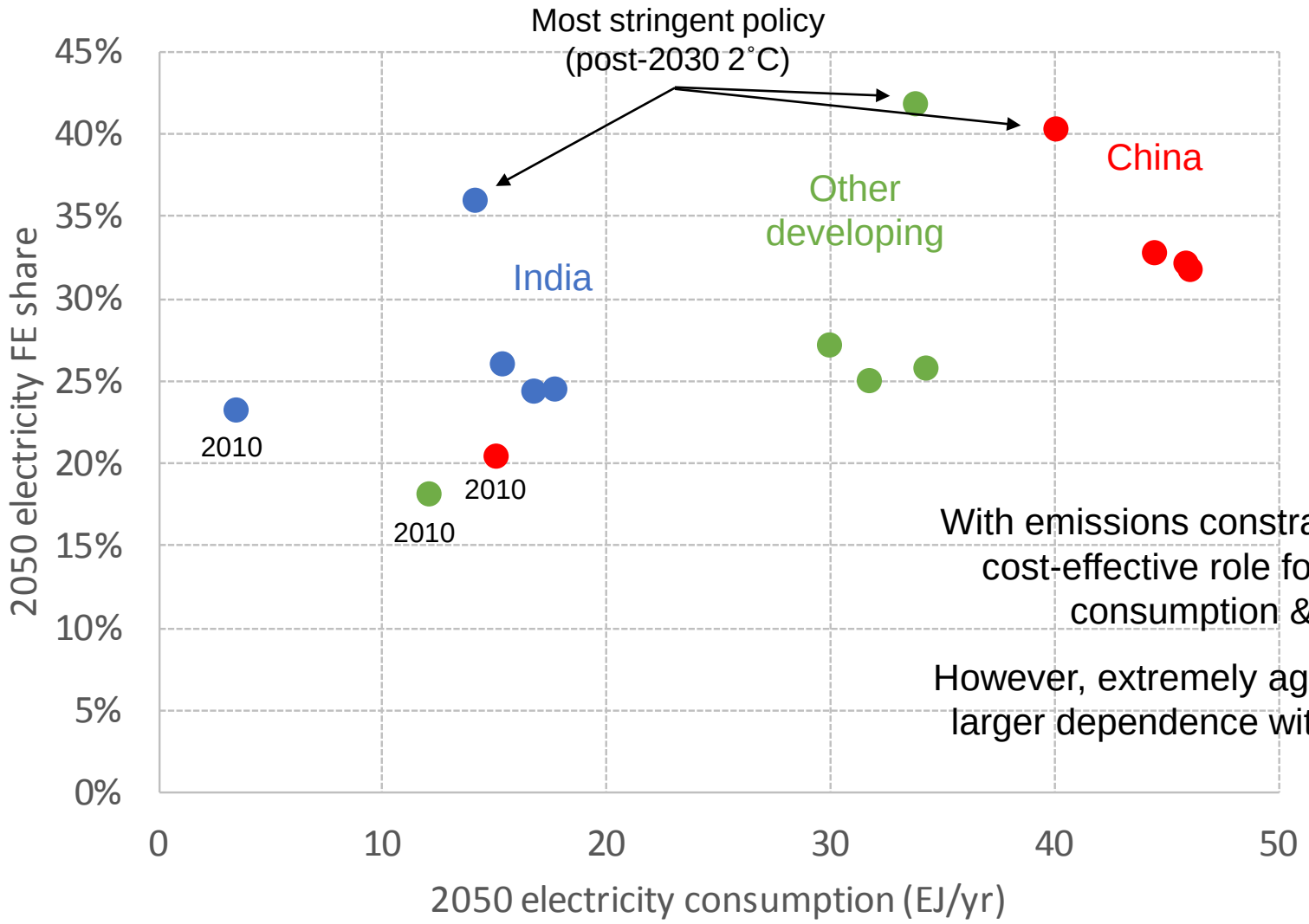
Rose et al. (2017)

Various Factors Shape Regional Electrification

- **Policy**
  - Stringency
  - Design
- **Technology**
  - Electricity generation options
  - End-use technologies – electric and non-electric availability and efficiency
- **Investment environment**
- **Other**
  - Preferences – demand for services
  - Fuel markets

- **Net electrification response a function of the above**
  - Determining electricity prices, price elasticity, and electricity demand

Electrification and Climate Policy Stringency

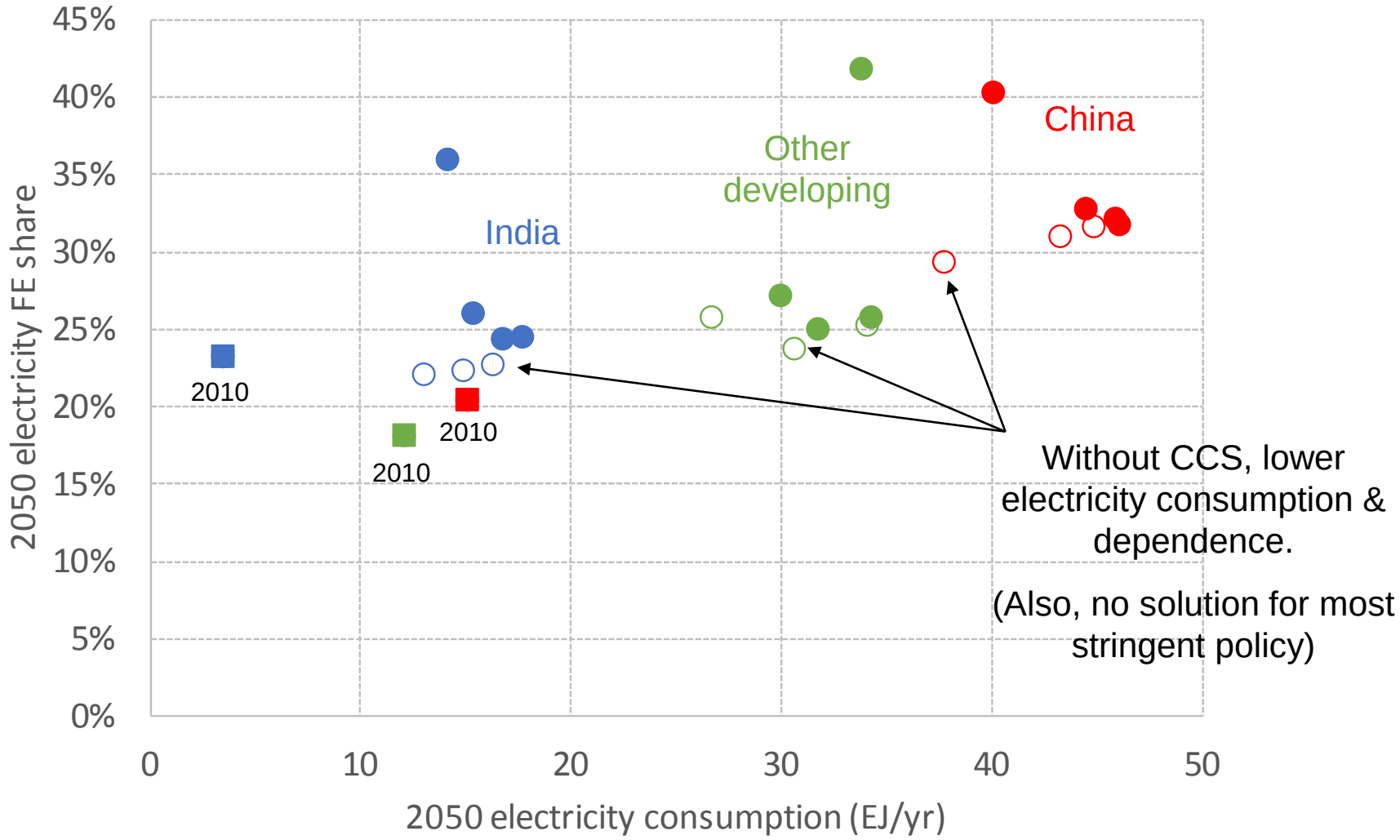


With emissions constraints, potentially larger cost-effective role for electricity (greater consumption & dependence)

However, extremely aggressive policies imply larger dependence with less system growth

Electrification and Low-Carbon Electricity Supply Options

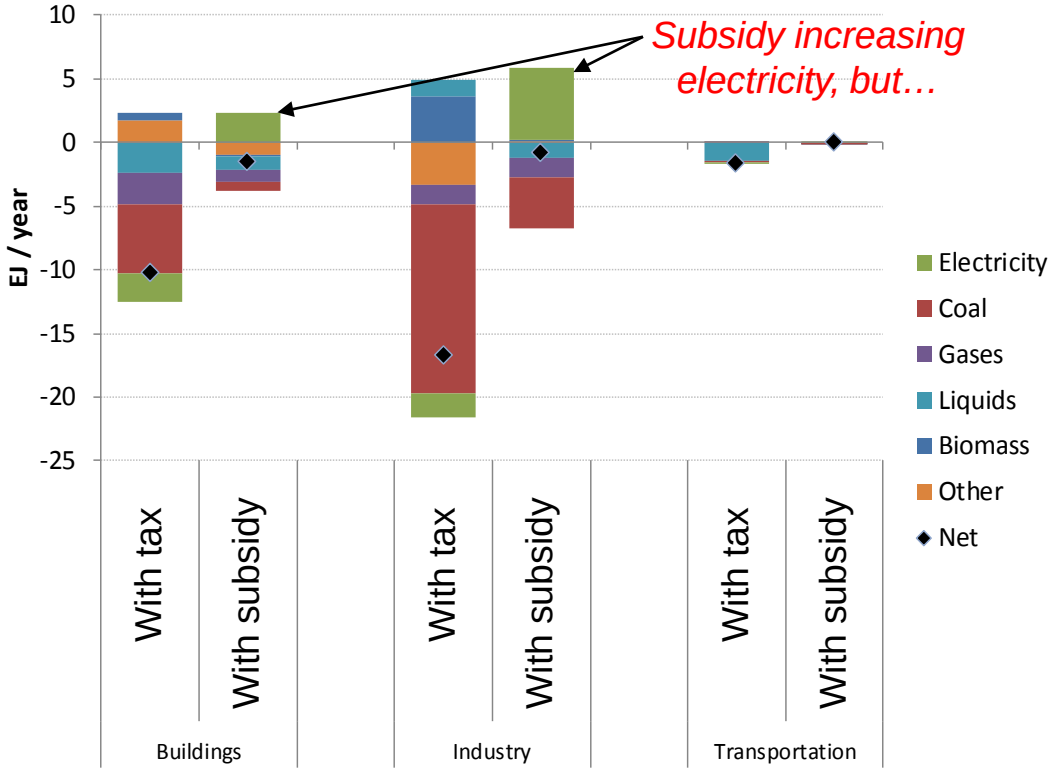
e.g., CCS unavailable (fossil and bioenergy)



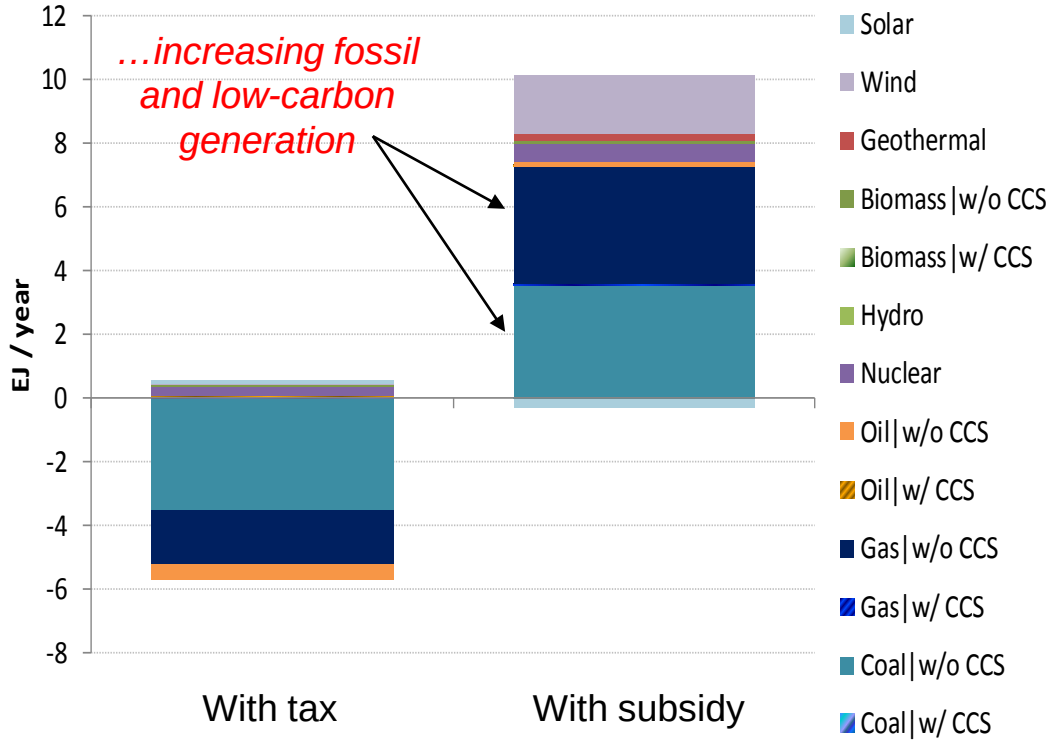
Electrification and Policy Design

e.g., emissions tax vs. low-carbon generation subsidy

Change in International (Non-US) Final Energy Consumption in 2020 by Sector and Fuel (relative to baseline) with $20/tCO$_2$eq



Change in International (Non-US) Electricity Generation from Reference in 2020



A separate issue: sector specific policies can preclude cost-effective cross-sector mitigation (e.g., electrification)

Rose et al. (forthcoming), Calvin et al (2015)

Electrification and End-Use (Technologies and Demand)

- Cars and Light Trucks
  - ICEV
  - PHEV
  - EV
  - FCV
  - Autonomous Vehicles
- Bus and Passenger Rail
- Aviation (domestic)
- Aviation (international)
- Light Commercial Trucks
- Heavy Trucks
- Freight Rail (non-energy)
- Shipping (domestic)
- Shipping (international)
- Military
- Fuel Transport (rail)
- Pipeline

Residential and Commercial

- Space Cooling
  - Central A/C
  - Window A/C
  - Air-Source Heat Pump
  - Ground-Source Heat Pump
- Space Heating
  - Electric Furnace/Resistance
  - Gas Furnace
  - Oil/LPG Furnace
  - Wood Furnace/Stove
- Water Heating
- Clothes Dryers
- Cooking
- Lighting
- Other Appliances
- Electronics
- Ventilation
- Other Building

- Agriculture
- Construction
- Mining (non-energy)
- Non-Building Commercial
- Water Services
- Bulk Chemicals
- Iron and Steel
- Paper/Pulp/Wood
- Food
- Cement
- Other Manufacturing
  - Boilers
  - Co-gen Boilers
  - Process Heat
  - Motor Drive
  - Feedstocks
  - Facilities
  - Off-Road Transport
- Refining
- Upstream Energy Extraction

SECTORS / ACTIVITIES → **END-USES** → **TECHNOLOGIES**

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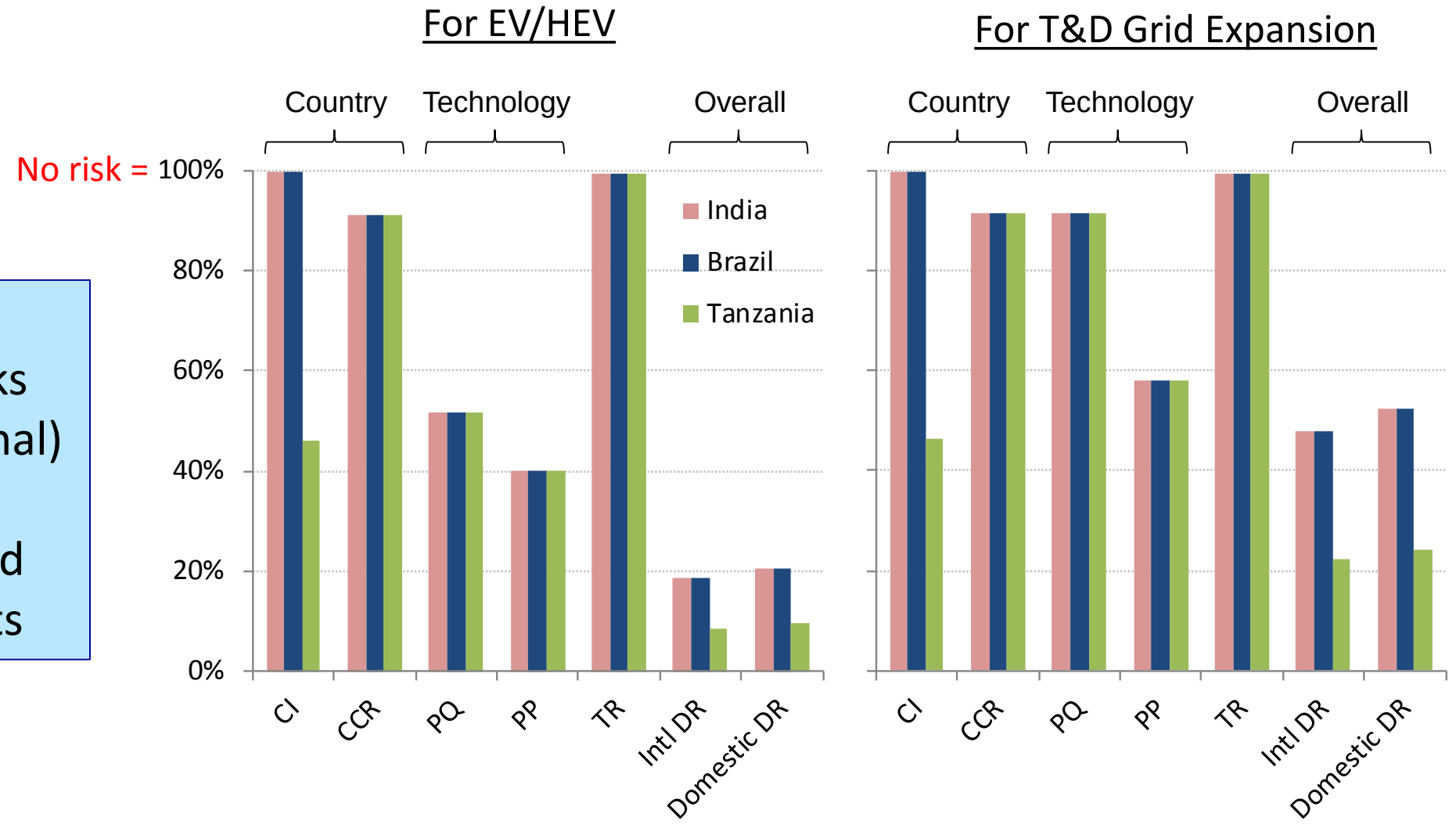
Electrification and Investment Risks

Country and technology risks (some institutional) represent uncertainty and additional costs

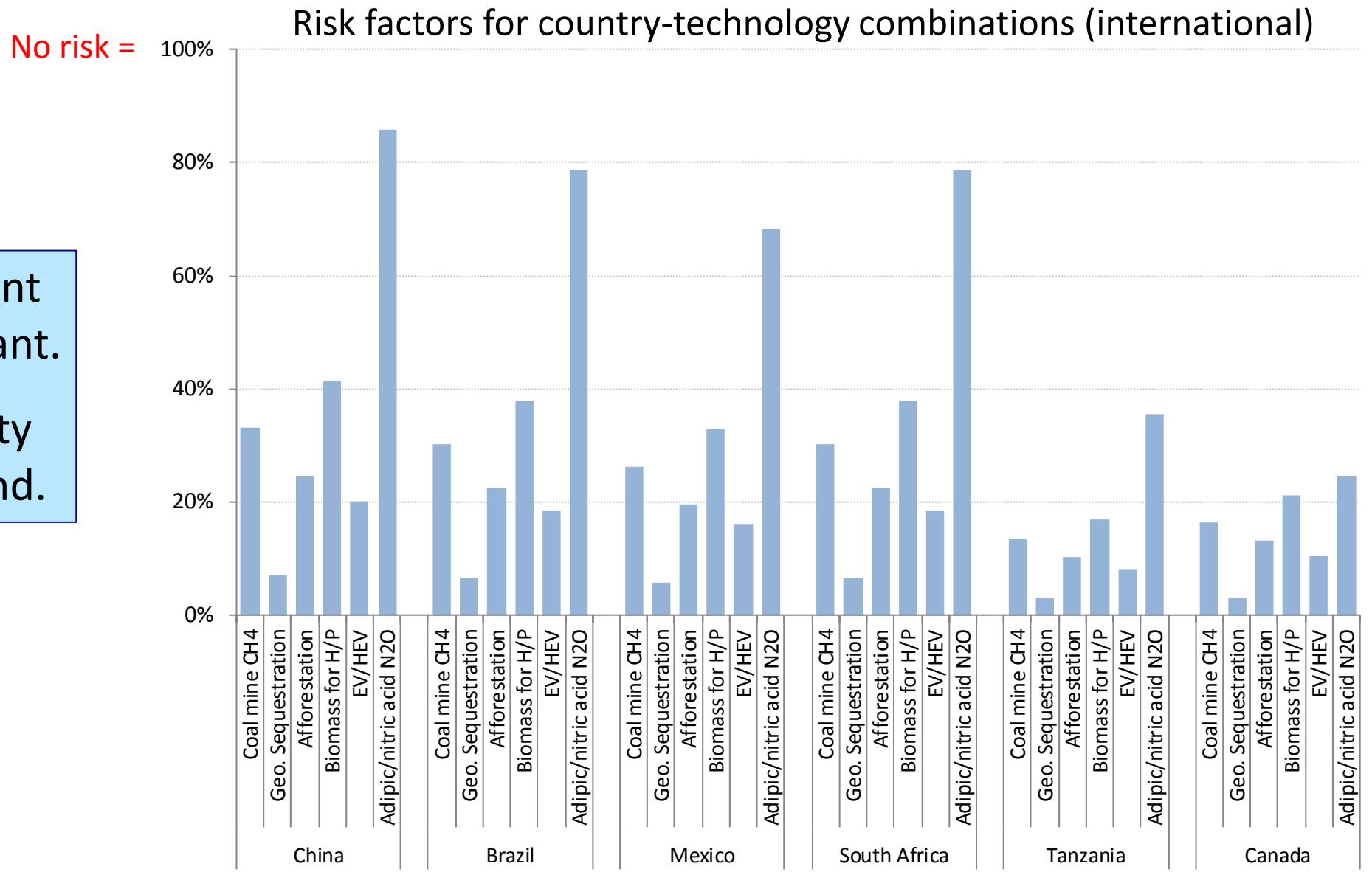


Rose et al. (forthcoming)

Electrification and Investment Risks

Relative investment risk will be important.

Risks for electricity supply and demand.



Rose et al. (forthcoming)

Concluding Thoughts

- Limiting global warming to 2˚C implies stringent emissions constraints for developing and developed countries
- Potentially large cost-effective role for electrification in developing country decarbonization
- Potential synergies with development goals (decarbonization & electricity growth)
- Electrification's decarbonization contribution, and the societal cost, will be defined by policy, technology (energy supply and demand), and institutions (and more)
- Valuing economy-wide emissions important for realizing cost-effective decarbonization electrification

Thank you!

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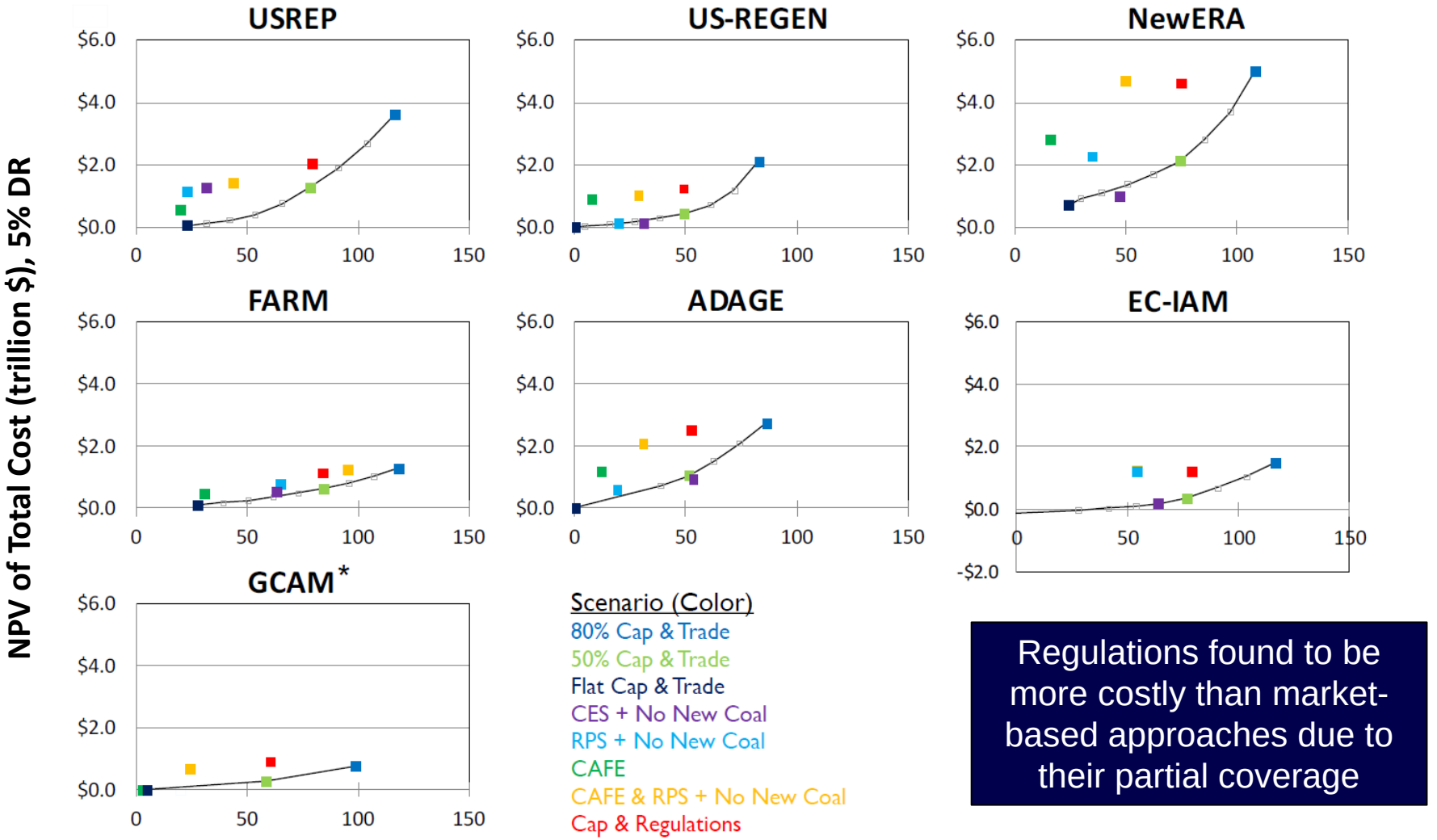
Resources

- Calvin, K., S. Rose, M. Wise, H. McJeon, L. Clarke, J. Edmonds, 2015. Global climate, energy, and economic implications of international energy offsets programs. *Climatic Change* 133(4): 583–596.

- Rose, S.K., R. Beach, K. Calvin, B. McCarl, J. Petrusa, B. Sohngen, R. Youngman, A. Diamant, F. de la Chesnaye, J. Edmonds, R. Rosenzweig, M. Wise, forthcoming. *Market Realities for Global Mitigation Supplies: Accounting for Risks and Incentives*. EPRI Report #1025510.

- Rose, S.K., R. Richels, G. Blanford, T. Rutherford, 2017. The Paris Agreement and Next Steps in Limiting Global Warming. *Climatic Change* 142(1), 255-270. [Discussion Paper – EPRI Report #3002007427, http://epri.co/3002007427]

Cost Comparisons of Different U.S. Climate Policy Architectures



Weyant et al. (2014)