Global Climate Goals and Developing Country Electrification

Steven Rose

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Potential Regional Emissions Constraints

- Baseline
- NDC only
- NDC +
- NDC ++
- Level 1
- Level 2
- Level 3

Even leveling off non-trivial

Rose et al. (2017)
Global Emissions & Temperature Implications

Global Emissions

Peaking global emissions requires more than NDCs, and more than developed countries

Baseline

US/EU/OG20/China

NDC only

NDC +

NDC ++

Adding India & OD

NDC ++ w/ Level 1

NDC ++ w/ Level 2

NDC ++ w/ Level 3

Global Temperature

• Reduction in warming risk for all policy pathways
• For a chance at < 2°C, significant mid-century abatement needed

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

Rose et al. (2017)
Global Emissions & Temperature Implications

Global Emissions

- Baseline
- US/EU/OG20/China
  - NDC only
  - NDC +
  - NDC ++
- Adding India & OD
  - NDC ++ w/ Level 1
  - NDC ++ w/ Level 2
  - NDC ++ w/ Level 3

For pursuing a medium likelihood of < 2°C, precipitous drop in global emissions post-2030

Global Temperature

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

Rose et al. (2017)

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Potential Regional Emissions Constraints

- Baseline
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Billion tonnes CO$_2$e/year

2000 2020 2040 2060 2100
USA  EU  Other G20  China  India  Other Developing

Rose et al. (2017)
Potential Regional Emissions Constraints

For a medium likelihood of < 2°C, dramatic immediate regional and mid-century emissions reductions

[Graph showing potential regional emissions constraints for different regions and scenarios]
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)
### 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

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Reductions in discounted average per capita consumption through 2100 (%)</th>
<th>Global welfare loss (%)</th>
<th>Max °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USA</td>
<td>EU</td>
<td>Other G20</td>
</tr>
<tr>
<td>S2: NDC only</td>
<td>Base</td>
<td>0.2%</td>
<td>0.3%</td>
</tr>
<tr>
<td>S3: NDC +</td>
<td>Base</td>
<td>0.3%</td>
<td>0.4%</td>
</tr>
<tr>
<td>S4: NDC ++</td>
<td>Base</td>
<td>0.5%</td>
<td>0.7%</td>
</tr>
<tr>
<td>S5: NDC ++</td>
<td>Level 1</td>
<td>0.5%</td>
<td>0.7%</td>
</tr>
<tr>
<td>S6: NDC ++</td>
<td>Level 2</td>
<td>0.5%</td>
<td>0.7%</td>
</tr>
<tr>
<td>S7: NDC ++</td>
<td>Level 3</td>
<td>0.5%</td>
<td>0.8%</td>
</tr>
<tr>
<td>S8: 2 °C post-2030</td>
<td>2.1%</td>
<td>2.2%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>

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)

Without CCS, lower electricity consumption & dependence.
(Also, no solution for most stringent policy)
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/tCO₂eq

Subsidy increasing electricity, but…

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

…increasing fossil and low-carbon generation

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)

**SECTORS / ACTIVITIES**
- Transportation
  - Cars and Light Trucks
  - 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
- Buildings
  - Space Cooling
  - Space Heating
  - Water Heating
  - Clothes Dryers
  - Cooking
  - Lighting
  - Other Appliances
  - Electronics
  - Ventilation
  - Other Building
- Industry
  - Agriculture
  - Construction
  - Mining (non-energy)
  - Non-Building Commercial
  - Water Services
  - Bulk Chemicals
  - Iron and Steel
  - Paper/Pulp/Wood
  - Food
  - Cement
  - Other Manufacturing
  - Refining
  - Upstream Energy Extraction

**END-USES**
- ICEV
- PHEV
- EV
- FCV
- Autonomous Vehicles
- Central A/C
- Window A/C
- Air-Source Heat Pump
- Ground-Source Heat Pump
- Electric Furnace/Resistance
- Gas Furnace
- Oil/LPG Furnace
- Wood Furnace/Stove

**TECHNOLOGIES**
- Boilers
- Co-gen Boilers
- Process Heat
- Motor Drive
- Feedstocks
- Facilities
- Off-Road Transport
Electrification and Investment Risks

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

For EV/HEV

- Country
- Technology
- Overall

For T&D Grid Expansion

- Country
- Technology
- Overall

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


Cost Comparisons of Different U.S. Climate Policy Architectures

Regulations found to be more costly than market-based approaches due to their partial coverage.

Weyant et al. (2014)

Cumulative Emissions Reductions (GtCO₂)

Scenario (Color):
- 80% Cap & Trade
- 50% Cap & Trade
- Flat Cap & Trade
- CES + No New Coal
- RPS + No New Coal
- CAFE
- CAFE & RPS + No New Coal
- Cap & Regulations