Decarbonization bottlenecks and short-term policy entry points towards achieving the Paris climate goals

Gunnar Luderer, Elmar Kriegler, Christoph Bertram and many co-authors

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June 6th, 2019
The case for well-below 2°C stabilization

Schellnhuber et al. (2016)
The case for well-below 2°C stabilization

Schellnhuber et al. (2016)
Very small remaining CO₂ budget for Paris targets

Global warming is roughly proportional to cumulative emissions

- There is a finite residual CO₂-budget
- Emissions have to be reduced to near-zero in the long-term

IPCC AR5 SYR (2014)

Table 2.2.

IPCC SR1.5 (2018)
Post-Paris mitigation scenarios

- **Reference:**
  Continuation of pre-Paris policies

- **NDCs:**
  Implementation of NDCs, extrapolation of effort beyond 2030

- **well below 2°C:**
  2016-2100 CO₂ emissions limited to 800 GtCO₂

- **1.5°C:**
  2016-2100 CO₂ emissions limited to 200 GtCO₂

Post-Paris mitigation scenarios

Based on
Implications for energy systems

Dr. Gunnar Luderer
Energy Systems Group

Based on Luderer et al. (2018), Nature Clim. Change
Sectoral breakdown of cumulative emissions

Based on Luderer et al. (2018), *Nature Clim. Change*
1.5°C Scenarios (average of models)

- Remaining fossil emissions of 1000 Gt CO₂, even with immediate and comprehensive climate action
- Major emissions from transport and industry
- Negative emissions required for 1.5°C limit

Feasibility of Paris targets and scale of carbon dioxide removal (CDR) ultimately determined by residual fossil emissions
Clean power is not enough!

- Power sector is the most important early entry point for decarbonization
- Most of the incremental effort for 1.5°C over 2°C comes from demand side

How can demand-side emissions be limited?

Decomposition of CO2 Emissions

- Total demand side emissions [Gt CO2]
- Final energy consumption [EJ]
- Non-electric energy demand [%]
- CO2-intensity of fuels [kg/GJ]

Abatement strategies:
- Energy efficiency & demand reduction
- Reduction of fuel use (Electrification)
- Decarbonization of fuels (Biomass, H2, industry CCS, synthetic fuels)

2050

Models
- max
- 84th
- median
- 16th
- min

Scenario
- Med-2C
- WB-2C
- 1.5C-2100

Reference
- 84th
- median
- 16th

Delay of strengthening action...

...likely to push 1.5°C out of reach:
4 of 7 models infeasible
Delay of strengthening action...

Post-2030 CO₂ prices as in immediate action scenarios
Impact of not strengthening before 2030

- 80 GtCO2 of excess emissions in NDCs until 2030
Impact of not strengthening before 2030

- 80 GtCO2 of excess emissions in INDCs until 2030
- Growing to 250 GtCO2 until 2050 due to carbon lock-in
Impact of not strengthening before 2030

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Entry points to bridging emissions gap

"Good Practice" and "Net Zero" Policy packages include

- Renewable energy quotas
- Restrictions on new coal and gas power plants w/o CCS
- Energy efficiency improvements in industry and buildings
- Upscaling of industry CCS
- Fuel efficiency improvements in road transport and aviation
- Increase of electric vehicle share
- Eliminating deforestation and 10 mio ha/yr afforestation
- Moderate carbon pricing

Krielger, Bertram et al. (2018), *Env. Res. Letters*
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Krielger, Bertram et al. (2018), *Env. Res. Letters*
## Barriers to political feasibility

<table>
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<tr>
<th>Speed</th>
<th>Adjustment costs, Evolution of legal and institutional frameworks</th>
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<td>CO₂ reduction rate</td>
<td>Maximum gross CO₂ emissions reduction rate per decade</td>
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<td>„Land for CDR“ increase</td>
<td>Maximum increase of land for afforestation and bioenergy crops per decade</td>
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<th>Disruptiveness</th>
<th>Short term economic effects, costs for specific interest groups</th>
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<td>CO₂ trend break</td>
<td>Maximum change in gross CO₂ emissions reduction rate between decades</td>
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<td>Stranded coal assets</td>
<td>Maximum idle capacity of coal power plants in a given year</td>
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<th>Scale</th>
<th>Sustainability concerns, Risk perception, Public Attitudes</th>
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<td>Cumulative CCS use</td>
<td>Cumulative CCS deployment over 21st century</td>
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<tr>
<td>Net Negative CO₂</td>
<td>Cumulative net negative CO₂ emissions over 21st century</td>
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<tr>
<td>Land for CDR</td>
<td>Maximum global area for afforestation and bioenergy crops</td>
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<th>Efficiency</th>
<th>Macro-economic costs of mitigation</th>
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<tr>
<td>Consumption loss</td>
<td>Net present value consumption loss 2020-2100 in % of baseline consumption</td>
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<th>Price changes</th>
<th>Changes to household consumption, with potential higher impacts on the poor (Distributional impacts)</th>
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<td>CO₂ price increase</td>
<td>Maximum increase of carbon price per decade</td>
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<tr>
<td>Food price increase</td>
<td>Maximum annual average increase of food price index per decade</td>
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</tbody>
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Krielger, Bertram et al. (2018), *Env. Res. Letters*
Conclusions

- Paris targets require near-zero emissions energy system by 2050 (1.5°C), or shortly thereafter (well below 2°C)
- Carbon-free electricity is a key entry point, but not enough
- Demand sectors:
  - Energy efficiency improvements (e.g., buildings heat)
  - Electrification (electric cars, freight, industry)
  - Sustainable biomass & Synthetic fuels (e.g., “power-to-gas”)
  - CCS for industrial processes
- Delaying drastically reduces medium-to-long term reduction potentials, due to carbon lock-ins and lock-out of low-carbon technology
- Diverse policy portfolios are required to bridge to ambitious, comprehensive pricing of all greenhouse gases
Thank you!

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PEP1.5 Project

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Bertram, Luderer, Popp, Humpenöder, Minx, Lamb, Stevanovic, Giannousakis, Kriegler.
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*Environmental Research Letters*, 2018..


Vrontisi, Luderer, Saveyn, Keramidas, Aleluia, Baumstark, Bertram, et al.