Climate Paths and Sector Coupling

MIT - CEEPR Meeting

Berlin, July 2/3, 2018
Climate Paths for Germany

Unique fact base
- All sectors
- Analysis level: individual GHG reduction measures
- Optimized to minimize GHG abatement costs
- Investments, costs, GDP-effects

Broad validation of results
- 68 industry associations and companies
- ~ 200 industry experts
- ~ 40 workshops
- Scientific board
61% greenhouse gas reduction even under a 'current policies' scenario, but a major gap to national reduction target remains.
80% path achievable with existing technologies

**Energy:** 240 GW wind and PV, grid expansion

**Energy:** Gradual replacement of coal with gas

**Buildings:** 50% more insulation/refurbishments (1.7% p.a.)

**Buildings:** Expanded urban district heating

**Buildings:** 14M heat pumps, mainly in 1- to 2-family homes

**Industry:** 90% penetration of efficiency technologies

**Industry:** Concentration of national solid biomass for heat < 500°C

**Transport:** 26M electric vehicles, 2/3 of passenger cars

**Transport:** 4,000 km of freeway equipped with truck overhead lines

**Agriculture:** More efficient use of fertilizer

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PV = photovoltaics
All figures refer to 2050
95% path pushes boundaries of technology and acceptance

340 TWh imports of renewable fuels (PtL, PtG)

Energy: 292 GW wind and PV, grid expansion

Energy: 100% renewable through PtG, gas grid as seasonal storage facility

Buildings: 70% more insulation/refurbishments (1.9% p.a.)

Buildings: 100% emissions-free heat (esp. through 16M heat pumps and district heating)

Industry: 100% renewable heat through biogas/PtG ...

Industry: ... produced with recycled carbon from biomass combustion

33M electric vehicles, 4/5 of passenger cars

Transport: 8,000 km of freeway equipped with truck overhead lines

Agriculture: “Methane pill” for the cattle population

Carbon capture and storage for steel, cement, steam reforming, refineries, and waste incineration

PtL = power-to-liquid, PtG = power-to-gas
All figures refer to 2050
95% target requires zero emissions in most sectors

<table>
<thead>
<tr>
<th>Bubbles: Mt CO₂e</th>
<th>1990 (dark) vs. 2015 (light)</th>
<th>2050 Current Policies</th>
<th>2050 80% climate path</th>
<th>2050 95% climate path</th>
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<tbody>
<tr>
<td>Power sector</td>
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<td>-22 %</td>
<td>-71 %</td>
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<td>Industrial processes</td>
<td>-36 %</td>
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<td>Industrial heat/steam</td>
<td>-32 %</td>
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<td>Transport</td>
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<td>Buildings</td>
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<td>Agriculture, other</td>
<td>-46%</td>
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<td>Σ</td>
<td>1990: 1.251</td>
<td>2015: 902 (-28%)</td>
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Net electricity consumption increases only moderately

Net electricity consumption by application (in TWh)

### Current Policies

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### 80% Climate Path

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Power flexibility 'merit order': PtX needed for long-term storage

1. Expand power grids and interconnections
   Increase amount of generated power that matches given demand; avoid grid related curtailments

2. Flexibilize 'direct' consumers, i.e. Power-to-Heat, heat pumps electric vehicles
   Focus demand on periods with sufficient available renewable power

3. Secure short term storage
   Batteries and pump storages important elements to bridge short-term production and demand peaks

4. Accept curtailments of renewables, which are concentrated on very few hours per year
   Technologies built only around such 'excess power' are not economically viable

5. Secure carbon-neutral long-term storage (and fully decarbonize other sectors)
   Hydrocarbons needed for interseasonal power storage and for decarbonizing 'beyond' electrification

Source: BCG analysis
Fundamental change in energy mix, significant import reduction

Primary energy consumption across all German sectors (TWh)

Remarks: Including international bunker fuels
Source: Prognos; BCG
"Demystification" of German climate paths

<table>
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<tr>
<th>Myth</th>
<th>Study outcome</th>
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<tr>
<td>&quot;Tech breakthrough needed&quot;</td>
<td>More than 80% GHG reduction with current technologies</td>
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<tr>
<td>&quot;All electric society&quot;</td>
<td>Electrification is important for GHG reductions, but power demand hardly increases</td>
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<td>&quot;Hydrogen economy&quot;</td>
<td>Broad use of hydrogen would require further cost depression</td>
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<td>&quot;Large amounts of excess power&quot;</td>
<td>Grid expansion, power trade, and flexibilization limit curtailment need for renewables</td>
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<tr>
<td>&quot;Import dependency&quot;</td>
<td>Energy imports reduced by up to 80%; but: no energy autarky either</td>
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Technology breakthroughs in PV, H₂ or storage would increase option space
80% economically feasible—95% only possible globally

80% Climate Path

Additional investments¹

€1,500B (energy €430B)

Additional cost to the economy¹

€470B (energy €156B)
Avg. €15B annually

GDP effect

At least a breakeven in all scenarios

Major investment effort
Feasible on a macroeconomic level

95% Climate Path

€2,300B (energy €620B)

€960B (energy €196B)
Avg. €30B annually

Breakeven in case of global cooperation

Major social and technological effort
Only feasible with a global consensus

¹. Cumulative for the years 2015 to 2050; including investments and additional costs of the reference; Capital costs calculated with a macroeconomic interest rate of 2%, imports at border-crossing prices
Summary

**No new technologies needed**

- G20 nations could close *at least two thirds of the gap* between current-policies emissions and their 2°C contributions with proven technologies
- Also for the remaining gap solutions exist today

**Systemic, economically optimized approaches required**

- All countries should install *systemic economic optimization* as guiding principle.
- Many countries can take *significant unilateral action* without suffering an early-mover disadvantage
- *All could benefit economically* from moving closer to its 2°C emission target

**Time to move**

- Policymakers should take a systemic view across sectors and develop national mitigation agendas that maximize economic gain
- Companies need to prepare for a world with accelerated growth in carbon-neutral technologies and declining fossil fuel consumption