Mitigating energy demand emissions

The integrated modelling perspective

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Energy demand

- Energy demand sectors: Buildings, Industry and Transport
- Energy demand sector directly and indirectly contribute to global CO$_2$ emissions
- More focus on energy supply

Global CO$_2$ emissions from Fuel Combustion

- Industry 18%
- Buildings 18%
- Transport 22%
- Electricity and heat
- Other 5%
- Services 3%
- Buildings 9%

(IEA 2016)
Demand sector complexity

**Demand Sectors**
- Many subsectors
- Many technologies
- Different users
- High capital stock turnover
- Less defined decision-making criteria

**In IAMs**
- More detail comes at a costs
- Data intensive
- Uncertain assumptions
- Transparent
- Aggregated trends

Effect: Demand side changes not so well understood
Integrated Assessment Models

• Interaction of human development, earth system and environmental system
• Integration across different issues and disciplines
• Focused on decisions processes (assessment)

→ Sugiyama et al. (2014), Marangoni et al. (2017) show energy intensity projections, important determinant of future carbon emissions
• Assess the role of the **energy demand sectors** in global stringent **mitigation pathways**

• Making use of the newly developed **Shared Socio-Economic scenarios**

• Compare to recent **technology assessment** of the demand sectors for 2030
Methods

- Cross model
- Cross demand sector
- Cross scenario
- Decomposition

- Efficiency
- Electrification
- Fuel content

\[
\text{Direct emissions} = \frac{\text{Energy service demand}}{\text{Population}} \times \left(1 - \frac{\text{Efficiency}}{\text{Fuel content}}\right)
\]

Riahi et al., 2017, van Vuuren et al., 2017, O’Neill et al., 2014
Baseline emissions

![Chart showing emission change relative to 2010 for different sectors and timelines.](chart.png)

- SSP1
- 2030 range
- 2050 range
- 2100 range
- IMAGE
- AIM/CGE
- GCAM
- MESSAGE-GLOBIOM

**Emission change relative to 2010**

**Gt CO2**

**Sectors:** Buildings, Industry, Transport
Baseline - components

Emission change relative to 2010

SSP1

SSP2

SSP3

Buildings Gt CO₂/yr

Population, FE per cap, Electrification, Fuel content

IAM range
IMAGE
AIM/CGE
GCAM
MESSAGE-GLOBIOM

2030
2050
2100
Stringent mitigation

[Graph showing emission change relative to 2010 for SSP1, SSP2, and SSP3 across different sectors: Buildings, Industry, Transport. Each sector is represented by various markers indicating different models and ranges.]
Mitigation - components

Avoided emissions relative to baseline

- SSP1
- SSP2
- SSP3

Graph showing avoided emissions in different scenarios.
Technology Assessment (Gap report)

● UNEP GAP: Technology-oriented study assessing sectoral reduction potentials
● Bottom-up approach
● Per sector for a cut-off cost-level of 100 US$/tCO2e (UNEP, 2017) based on literature review
● Compared to a reference level: energy related emissions based on the WEO current policy scenario (IEA, 2016)
Comparison with bottom up technology assessment for 2030:
  ○ More potential for efficiency!

(UNEP GAP, 2017)

<table>
<thead>
<tr>
<th></th>
<th>Buildings</th>
<th>Industry</th>
<th>Transport</th>
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<tbody>
<tr>
<td>IAM total sector</td>
<td>0.7 (0.3 to 1.0)</td>
<td>2.6 (0.9 to 3.2)</td>
<td>1.7 (0.9 to 2.7)</td>
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<tr>
<td>IAM eff</td>
<td>0.4 (0.0 to 0.7)</td>
<td>1.1 (0.2 to 2.0)</td>
<td>1.3 (0.0 to 2.5)</td>
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<td>IAM electrification</td>
<td>0.0 (-0.1 to 0.0)</td>
<td>0.0 (0.0 to 0.2)</td>
<td>0.0 (0.0 to 0.3)</td>
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<tr>
<td>IAM fuel switch</td>
<td>0.3 (0.2 to 0.4)</td>
<td>1.4 (0.6 to 1.9)</td>
<td>0.3 (0.0 to 0.8)</td>
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<tr>
<td>Technology-oriented assessment</td>
<td>1.6-2.1</td>
<td>2.1-3.3 (incl. CCS 3.3 - 4.6)</td>
<td>4.1 – 5.3</td>
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<tr>
<td>BU eff</td>
<td>1.2 - 1.8</td>
<td>1.6 – 2.8\textsuperscript{40}</td>
<td>3.0 – 4.5</td>
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<td>BU electrification</td>
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<td>0.4 – 0.8</td>
<td>0.4 – 0.6 +</td>
<td>0.6 – 0.8</td>
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<td>0.9 – 1.5 (CCS)</td>
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Conclusions

- Baseline emissions can grow rapidly in industrial and transport sectors
- Key uncertainty is saturation of final energy
- The SSP scenarios show that the growth of the demand sector and the technology development largely affects the sectors mitigation challenge
- Demand side mitigation is dependent on energy efficiency and fuel switching in the short term but fuel switching becomes dominant
- More potential for energy efficiency improvement
- Need to better understand demand side dynamics
Questions?
References


Technology Assessment (baseline)

2030 emissions (Gt CO2eq/yr)

- HFCs: Substitutes for Ozone-Depleting Substances
- Other
- Waste
- Burning of agricultural residues, savanna burning and open burning of forest clearing
- Agriculture
- Energy supply emissions
- Emissions from stationary and mobile combustion
- Deforestation/land use change
- Other
- Buildings
- Transport
- Industry
- Electricity production

Sectors and scenarios compared:
- SSP1
- SSP2
- SSP3
- 2030 Reference BU Sector by Sector

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