Modelling gas transport capacity investments with limited knowledge on future markets

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Overview

1. Energy Systems Modelling
   - The MUSE model

2. Gas transport

3. Hypothetical scenarios on future gas trade

4. Concluding remarks
The MUSE model

MUSE: The Modular Universal energy system Simulation Environment

- Aims
  - modelling transitions to more sustainable energy systems with a focus on gas
  - transparency of modelling framework and results (future release as open access)

- Applications:
  - understanding the role of gas in a low carbon energy system
  - R&D prioritisation of value and role of technologies
  - Strategy development against a variety of scenarios
  - Climate Change Mitigation pathways assessment
The MUSE model

All sectors: PEC (SEC, ESC) Primary (Secondary, Service) Energy Commodities
Long-term horizon with timeslicing
Global scope
A transport model of interregional gas flows

- uses nodes as NG/LNG sources or demand centres
- uses arcs to connect nodes (if pipelines or liquefaction/regasification plants exist)
- defines global supply curve on net present cost
- decides on capacity addition, retirement, spot market share and contract framework (i.e. 5 or 20 years)
A cost merit order approach to global supply curves

- energy commodity balance
- capacity update including addition and retirement
- contract duration
- capacity/activity/trade growth limits
Problem statement

Given

- exogenous demand profile
- unit cost, energy consumption, carbon intensity, technical and economic life, initial stock of technologies (i.e. NG liquefaction, LNG regasification, pipelines)

Determine

- new investment and retirement of NG transport assets
- asset types and operations
- contract framework as well as spot market share
- total cost and breakdown

on a regional and temporal basis (annual with seasonal timeslices)
Exogenous 450 ppm demand projection up to 2070
Spatial aggregation
Modelling uncertainty in demand

Investment decisions taken in planning horizon
Future demand ascertained in foresight horizon
Flat demand between foresight and planning horizon
Sequential planning with flexibility (B): cost deviation from reference
Two examples of sequential planning

2-step (scenario C) and 3-step planning (scenario D)

- scenario C: overall global cost does not vary from reference
- scenario D: global cost goes up 5% from baseline as project lifetime becomes relevant to the planning horizon duration

Figure: China demand profile
Relevant changes from reference scenario

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Liquefaction</th>
<th>Regasification</th>
<th>Pipelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>1.31</td>
<td>1.19</td>
<td>0.92</td>
</tr>
<tr>
<td>C</td>
<td>1.38</td>
<td>1.24</td>
<td>0.94</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>1.71</td>
<td>0.86</td>
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</tbody>
</table>

Table: Variation of total capacity across scenarios

<table>
<thead>
<tr>
<th>Share A</th>
<th>Share B</th>
<th>Share C</th>
<th>Share D</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 %</td>
<td>13 %</td>
<td>14 %</td>
<td>24 %</td>
</tr>
</tbody>
</table>

Table: Variation of LNG spot market share across scenarios
Highlights

- Gas transport model to represent interregional gas flows in long-term
- Runs as standalone model or as a module in MUSE
- Uses bottom-up approach to determine capacity and activity in gas transport chain
- It includes features of contract duration and take-or-pay tariffs
- Is completely configurable in the level of foresight for investment decisions
Thanks for your attention