Addressing variable renewables in long-term energy planning (AVRIL)

Strommarktetreffen
Jan 30, 2015, Berlin
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IRENA was founded in 2009 with the mandate of
Supporting sustainable deployment of renewables worldwide
IRENA member states request support for energy planning with variable renewables

Energy planning officials:
“Let’s quickly deploy variable renewables (VRE)”
“Adopting ambitious long-term VRE targets is worthwhile”

System operators:
“VRE endanger the power system’s reliability”
„There is an upper limit of X% VRE“

1. Guideline for how to introduce variable renewables in the short term.
2. Guideline for long-term energy planning with variable renewables.
Guideline for long-term energy planning with variable renewables: key questions

1. Why long-term energy planning?
2. Which VRE system impacts are relevant to long-term planning?
3. Which planning tools are currently used? What do they miss?
4. What are modeling approaches that account for these impacts?
Why does a cost-efficient and reliable power system require long-term energy planning?

1. No markets in many countries (in particular non-OECD) → central planner (e.g. state-owned utility)

2. Market based systems: planning needed for policy targets/instruments, transmission grid expansion, private investment decisions

3. Long building times and lifespan of energy infrastructure

4. Inadequate generation & transmission cause „costs of mismatch“ and might endanger system reliability

5. VRE increase the need for long-term planning
   - Transformation & More interaction of system components
     → „costs of mismatch“ increase and addional challenges to reliability
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Which VRE system impacts are relevant to long-term planning?

<table>
<thead>
<tr>
<th>VRE properties</th>
<th>System impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Variability</td>
<td>1. Small capacity credit, reduced utilization of dispatchable plants, increased flexibility requirements</td>
</tr>
<tr>
<td>2. Uncertainty</td>
<td>2. Higher forecast errors → additional operating reserves</td>
</tr>
<tr>
<td>3. Spatial variability</td>
<td>3. Grid congestion, additional transmission grid investments</td>
</tr>
<tr>
<td>5. Distributed generation</td>
<td>(5. Voltage stability, additional distribution grid investments, advanced power devices)</td>
</tr>
</tbody>
</table>

- 2nd order impact: curtailment
- There are more mitigation measures
- more relevant impacts?
What temporal resolution is required to directly address impacts in models?

- Reduced utilization of dispatchable plants
- Small capacity credit
- Grid congestion/extension
- Increased flexibility requirements
- Additional operating reserves

Stability studies

- Frequency stability
- Voltage stability

1s 1min 1hour 1month 1year

Challenge: Combining these short-term scales with long-term time horizon of capacity expansion models
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Capacity expansion models used for planning in non-OECD countries: e.g. MESSAGE, Balmorel, OSeMOSYS, TIMES, WASP, HOMER
…or no model at all
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### What are modeling approaches that account for these impacts?

<table>
<thead>
<tr>
<th>Approach</th>
<th>Merits</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Directly increasing the temporal resolution</td>
<td>• One optimization framework.</td>
<td>Numerically demanding or not possible</td>
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<tr>
<td></td>
<td>• Straight forward implementation</td>
<td></td>
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<tr>
<td></td>
<td>• Could cover all VRE impacts</td>
<td></td>
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<tr>
<td>2. Representative time slices (adhoc/clustering)</td>
<td>• Numerically less demanding.</td>
<td>• What is a good choice?</td>
</tr>
<tr>
<td></td>
<td>• Captures most VRE impacts.</td>
<td>• Temporal order partly lost.</td>
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<tr>
<td></td>
<td></td>
<td>• High number necessary to capture wind variability?</td>
</tr>
<tr>
<td>3. Residual load duration curves</td>
<td>• Numerically much less demanding.</td>
<td>• Temporal order lost.</td>
</tr>
<tr>
<td></td>
<td>• Captures most important impacts (capacity credit, utilisation)</td>
<td>• Copper plate assumption → no transmission</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Linear implementation?</td>
</tr>
<tr>
<td>4. Characteristic days/weeks</td>
<td>• Numerically less demanding.</td>
<td>• How to find a representative choice?</td>
</tr>
<tr>
<td></td>
<td>• Very high detail possible → capturing all VRE impacts</td>
<td></td>
</tr>
<tr>
<td>5. Link with a highly resolved model</td>
<td>• Numerically less demanding?</td>
<td>• Separated optimization → Complex iteration to converge?</td>
</tr>
<tr>
<td></td>
<td>• High detail possible → capturing all VRE impacts</td>
<td>• Harmonize model scope and parameter</td>
</tr>
<tr>
<td>6. Parameterizations (e.g. flexibility constraint)</td>
<td>• Numerically less demanding.</td>
<td>• How to find parameterization that is robust over many scenarios?</td>
</tr>
<tr>
<td></td>
<td>• Intuitive and easy to implement</td>
<td>• How to account for interactions?</td>
</tr>
</tbody>
</table>
Danke für die Aufmerksamkeit und das Feedback!