Modeling magnetic confinement fusion power plants in future energy systems

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### Background
- **Problem**: Global rise of electricity and energy demand, energy dependency
- **Solution contributor**? Controlled nuclear fusion as local energy source
- **Long-term potential of nuclear fusion in energy systems**? Examination of optimal future pathways

### Operational Characterization of 1 GW\textsubscript{e} Fusion Power Plants

<table>
<thead>
<tr>
<th>Component</th>
<th>Power (MW)</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power loss during production</td>
<td>$Q_{\text{prod}}$</td>
<td>500 MW</td>
</tr>
<tr>
<td>Total losses during production</td>
<td>$Q_{\text{loss}}$</td>
<td>500 MW</td>
</tr>
<tr>
<td>Thermal energy production of the fusion reactor</td>
<td>$Q_{\text{therm}}$</td>
<td>300 MW</td>
</tr>
</tbody>
</table>

**Figure 1**: Power requirements of identified operating states \cite{1}

### Fusion Power Plant Modeling in Energy Systems

- **Linear optimization model for expansion and operational planning**
- **Model language**: Python (+ Pyomo)

**Figure 2**: Integration of fusion power plants in energy systems

### Operational Planning in the ASEAN Region

- **ASEAN region in year 2050**
- **10 model nodes**
- **Temporal resolution**: 1h
- **Expansion of installed capacities** part of optimization
- **Optimization method**: Linear
- **Investigation objective**: Expansion planning of fusion in a region with high population and demand density as well as new technological developments

**Figure 5**: Installed capacity (left) and electricity generation (right) in ASEAN region 2050

### Conclusion
- Three operational states of fusion power plants are modeled in energy systems based on their operational characteristic. Stellarator and tokamak types are distinguished.
- First results regarding the modeling of the European energy system indicate that fusion will be used in Europe under the assumption that investments in fusion power plants have been taken and that they are part of the energy system.
- Fusion power could be a suitable extension of energy systems in regions with high population and demand density and new technological developments, like ASEAN region.

### References


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**Figure 3**: Fusion in the energy system optimization framework urbs and evrys

**Figure 4**: Installed capacity (left) and electricity generation (right) in Europe 2050