Start-up and Shut-down Capabilities in an Energy System Optimization Model with Flexible Temporal Resolution

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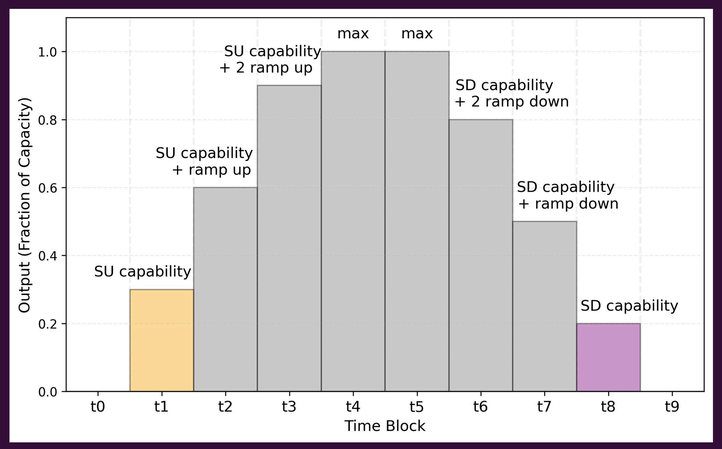
1. Background

- Generation Expansion Planning (GEP) problem: deriving an optimal investment plan for installing new generators.
- Unit Commitment (UC) problem: deriving an optimal operation plan for generators.
- Flexible temporal resolution: time periods used in the model can be defined in different level of detail for each variable/constraint.

1	2	3	4	5	6	7	8
1:3			4	5	6:7		8

Examples of resolutions: hourly (top) and fully flexible (bottom).

- Start-up (SU) capability: how much a generator can produce when it is turning on.
- Shut-down (SD) capability: how much a generator can produce before it is turned off.



Example of an asset turning on at SU capacity, ramping up, producing at maximum capacity, ramping down, and shutting down when at SD capacity.

2. Research question

How do the start-up and shut-down capabilites affect the computation time and the optimal solution of Tulipa under differing **flexible** temporal resolutions, as compared to **hourly** resolution?

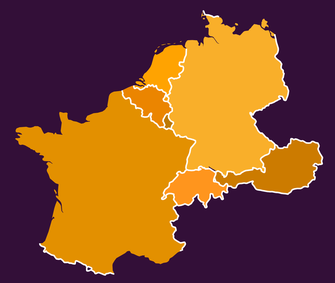
Tulipa - a MILP model to solve GEP, includes UC constraints and fully flexible temporal resolution.

3. Methodology

Tulipa was extended by adding SU/SD variables and SU/SD capability constraints, which were formulated to work with fully flexible temporal resolution.

The effect of adding SU/SD capabilities was assessed in a greenfield case study.

The case study consisted of these 7 European countries.



A model including SU/SD capabilities was compared to one excluding these capabilities, and 8 different temporal resolutions were used:

Capabilities: { excluded, included } × *Resolutions*: { hourly, multiples, flexible } → *Results*: { objective function, model variables, computation time }

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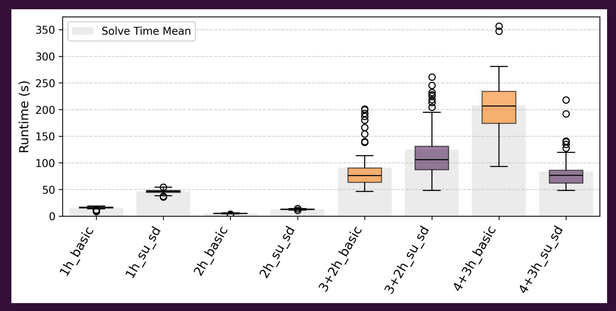
Supervisor: Maaike Elgersma

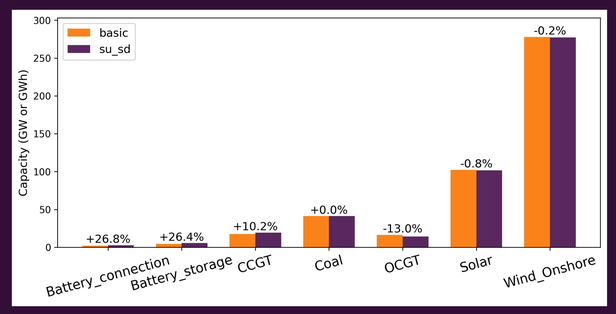
4. Experiment **results**

Scenario	basic	su_sd
1h	63,029,875	63,052,376
3+2h	62,905,930	62,967,213
2h	62,822,680	62,866,889
3h	62,517,080	62,619,569

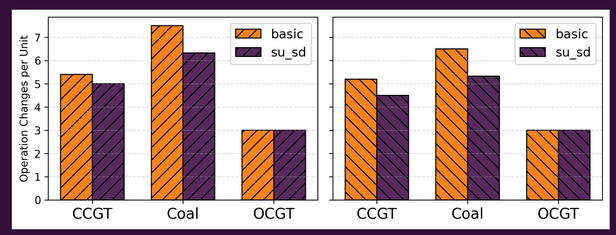
Larger objective function value when including SU/SD capabilities and for higher resolutions.



Solving and creation times mostly become longer. For fully flexible resolutions, runtime is unusually long.



Investments stay similar, but with SU/SD capabilities there are slightly more batteries and CCGTs, slightly less OCGTs.



Units start-up (left) and shut-down (right) slightly less often.