Start-up & Shut-down Trajectory Constraints in Tulipa

Author: Yurian Lagrand E-mail: Y.G.Lagrand@student.tudelft.nl Supervisor: Maaike Elgersma Responsible Professor: German Morales-España

1. Background

Generation Expansion Planning (GEP) is determining the optimal addition of new energy generation/storage capacity for some energy system.

(Clustered) Unit Commitment ((C)UC) is determining operational specifics of energy generators/storages. This includes their uptime/downtime scheduling, but also modulation. The clustered variant is grouping together all technologies of 1 type in 1 variable, rather than 1 variable per technology.

Fully-Flexible Temporal Resolution allows different technologies to have different resolutions for which their CUC is computed. The resolutions do not have to be uniform. This allows to reduce detail for technologies that are less relevant at certain times (e.g., solar panels at night).

Start-up/Shut-down (su/sd) Trajectories describe energy output behaviour of large/complex generators when starting up or shutting down. Figure 1 shows example trajectories.

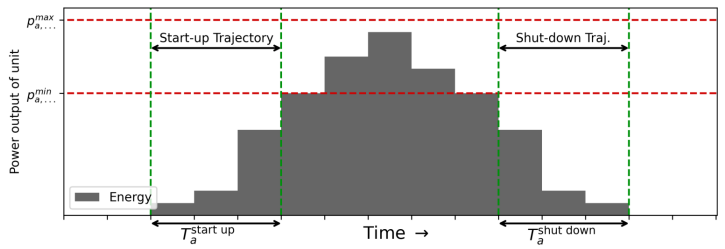

Figure 1: Example of start-up/shut-down trajectories

2. Research Question

How does adding **start-up/shut-down trajectory** constraints affect the computation **time** and the optimal **solution** of Tulipa, in terms of **objective function** and **variable values**, compared to not having them?

3. Methodology

Since trajectory constraints require minimal down-time constraints to be valid, 3 cases are compared:

1. Existing model
2. Extended with min. down-time
3. Extended with su/sd trajectories

There cases are each tested at hourly, and several other resolutions, and include fully-flexible temporal resolutions.

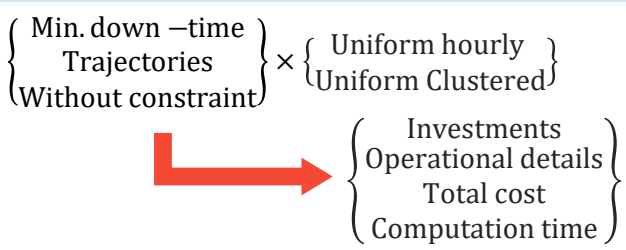

Figure 2: Test cases and resulting metrics

4. Conclusions

The inclusion of trajectory constraints compared to inclusion of minimal down-time constraints:

1. significantly **increases** the computation **time** of the model
2. only **slightly affects** the **investments** of the model
3. does **not** significantly **affect** the **objective function**

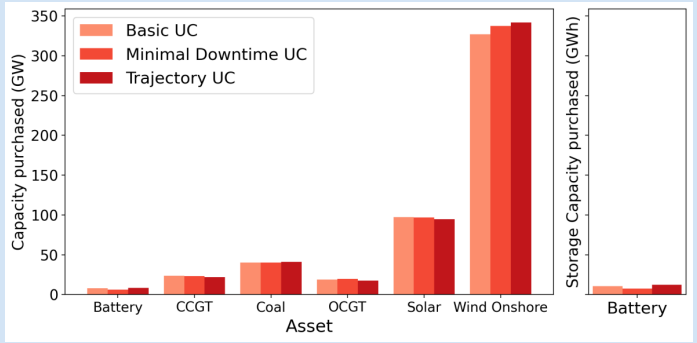

Figure 3: Investments made for different cases

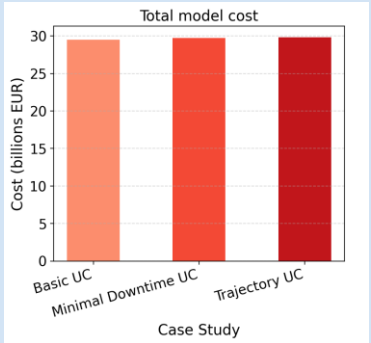

Figure 4: Objective function for different cases

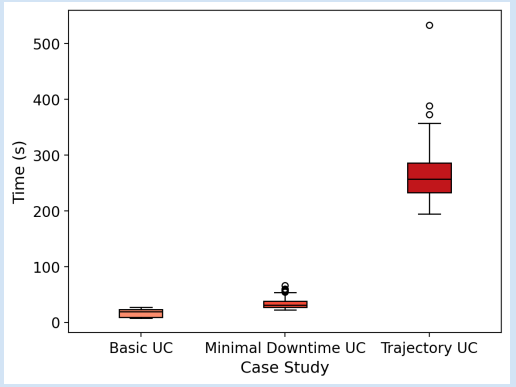

Figure 5: Solve time for different cases

5. Future work

All experiments were run as greenfield experiments, meaning the scenario started without any initial technologies. The inclusion of initial technologies could change the outcomes.

TU Delft Delft University of Technology