Adaptive aggregation in operational modelling of energy system

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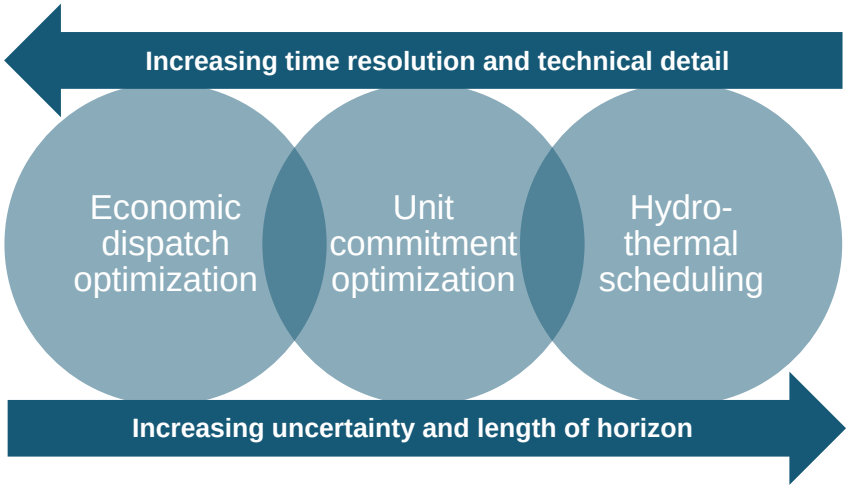
Energy systems operate on different scales and levels of detail

- ***Economic dispatch (ED) optimization:***
  - Very detailed technology representation.
  - Fine time resolution.
- ***Unit commitment (UC) optimization:***
  - Time resolution tied to markets.
  - Horizon needs to allow making rational startup and shutdown decisions.
  - Uncertainty of VRE generation is important!
- ***Hydro-thermal scheduling:***
  - Time resolutions typically > weekly.
  - Horizon needs to allow scheduling multi-year storage!
  - Uncertainty in water inflow is important!

Ideally, everything is considered at the same time.

- Simply extending detailed models to cover for multiple years and adding stochastics results in unreasonable computational complexity.
- ***Can we mitigate this using adaptive aggregation of time steps and power plants?***



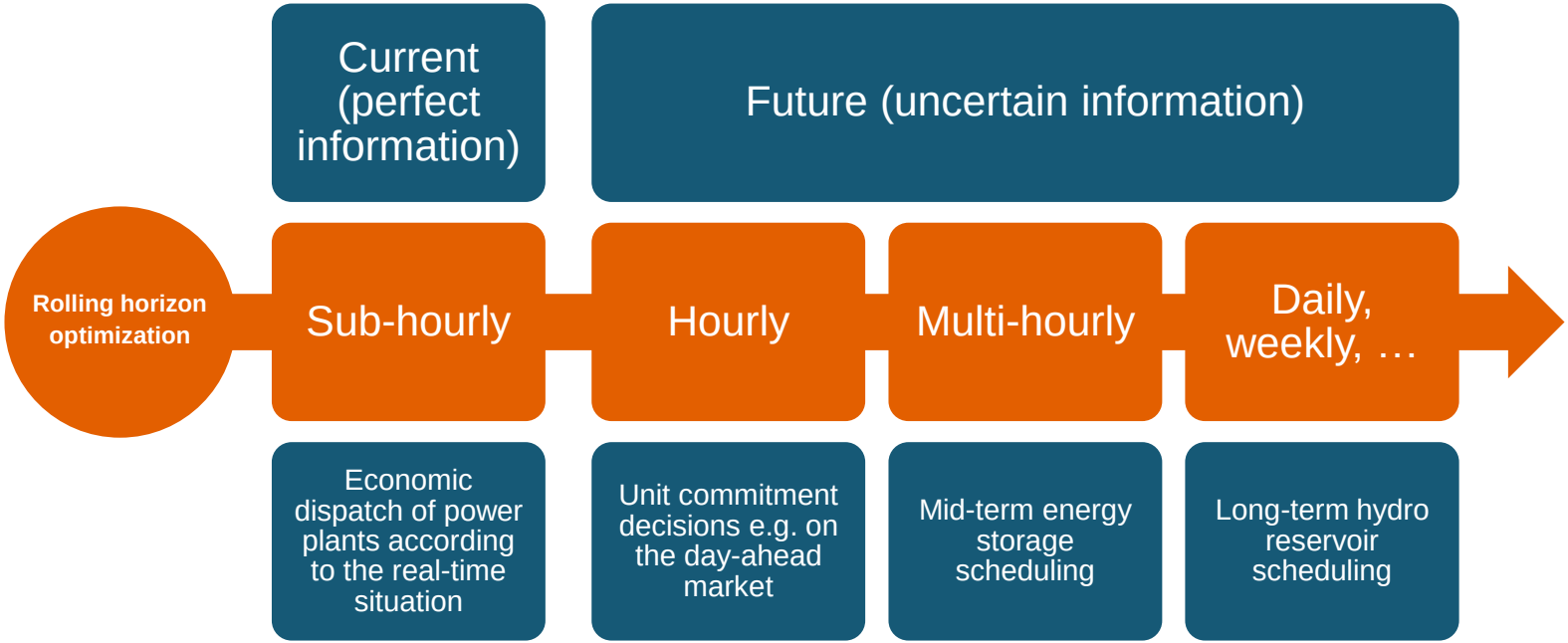
Ideas to contain the problem size:

1. Progressive time step aggregation
2. Variable unit efficiency representation
3. Progressive unit aggregation

*Backbone** for testing these ideas

*Helistö, N., Kiviluoma, J., Ikäheimo, J., Rasku, T., Rinne, E., O'Dwyer, C., … Flynn, D. (2019). Backbone—An Adaptable Energy Systems Modelling Framework. *Energies*, *12*(17), 3388. https://doi.org/10.3390/en12173388

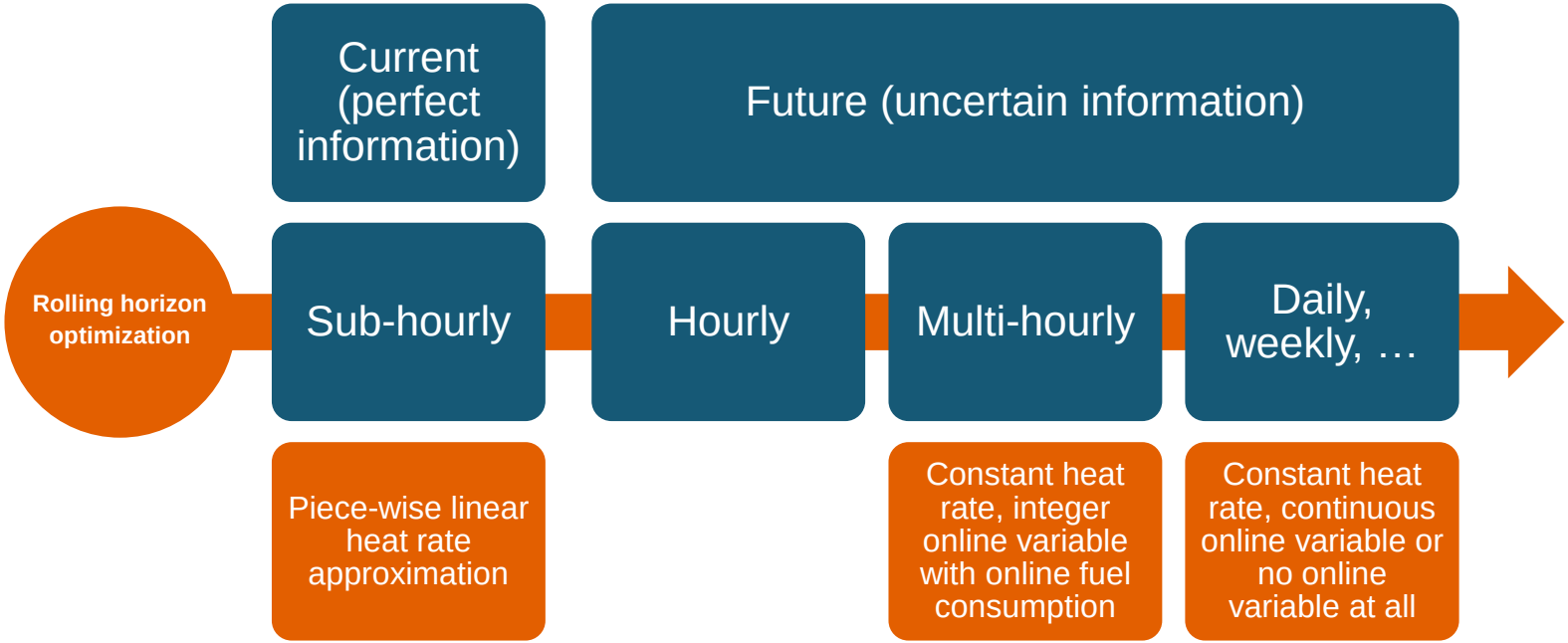
1. Progressive time step aggregation permits mid-to-long term energy storage scheduling



Optimize, save *current* results, roll ahead, repeat

Practical example provided at the end of the presentation.

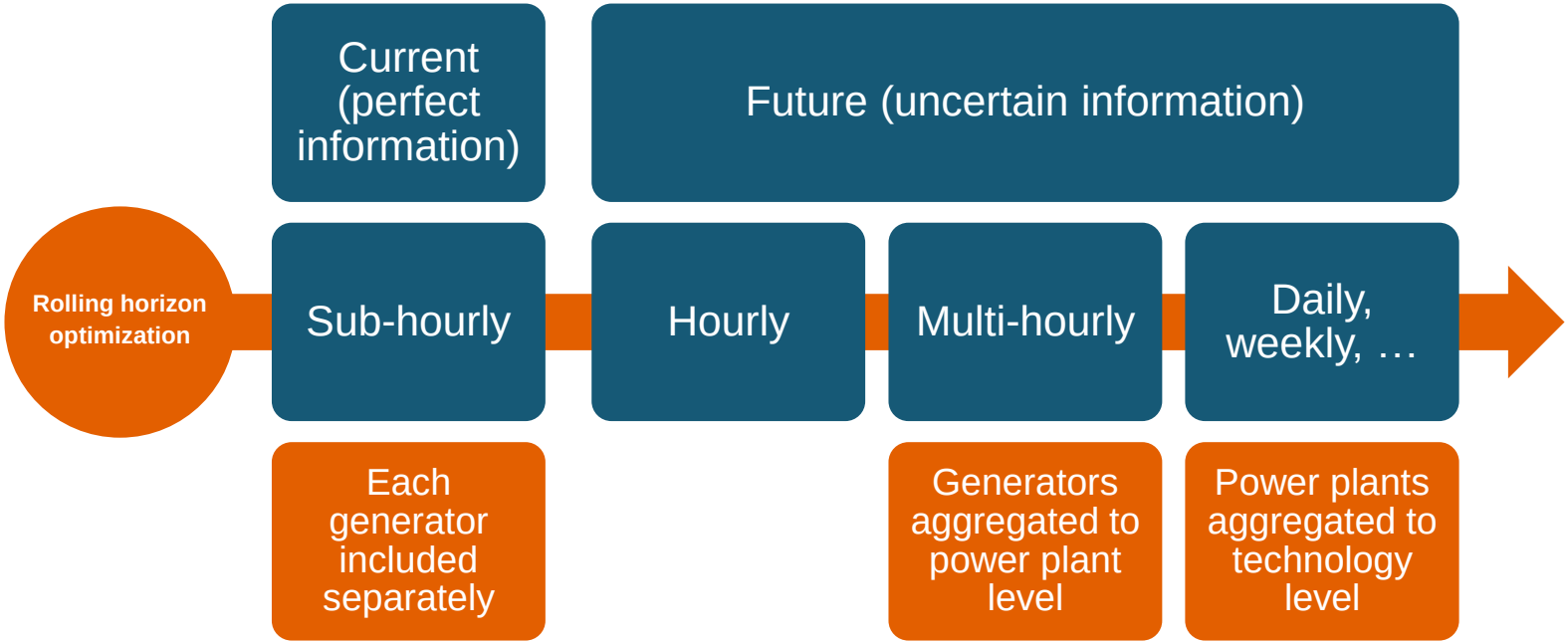
2. Variable unit efficiency representations complement the time step aggregation



Optimize, save *current* results, roll ahead, repeat

Practical example provided at the end of the presentation.

3. Progressive unit aggregation can further reduce the computational complexity

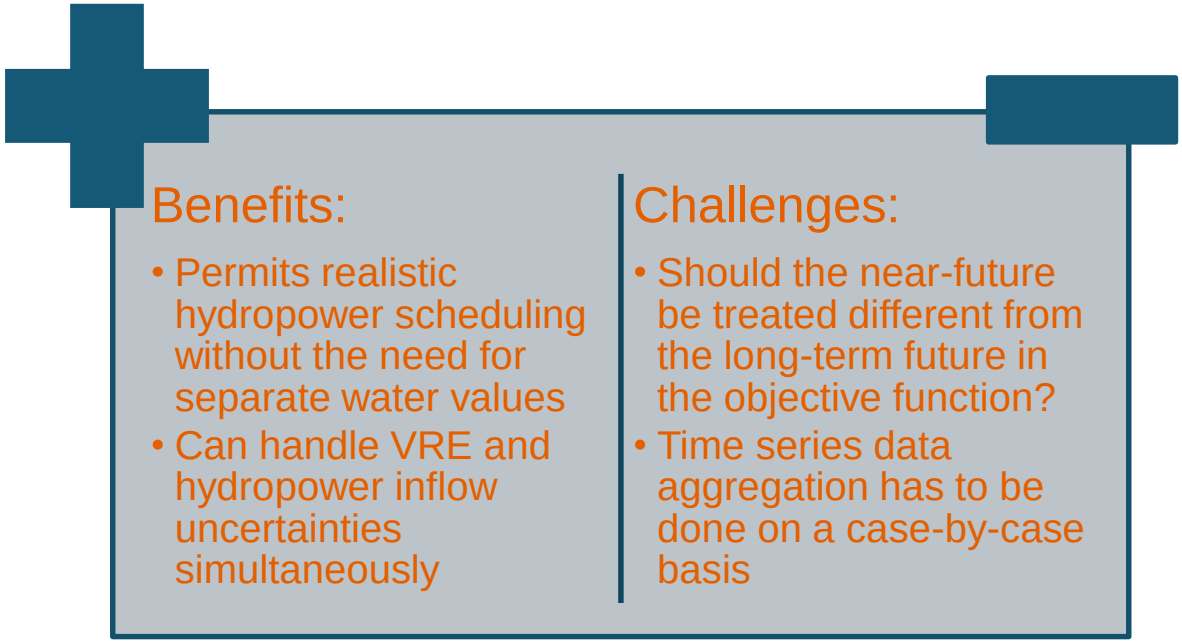


Optimize, save *current* results, roll ahead, repeat

So, do they work?

Experiences and challenges so far…

1. Mostly positive experiences with time step aggregation:



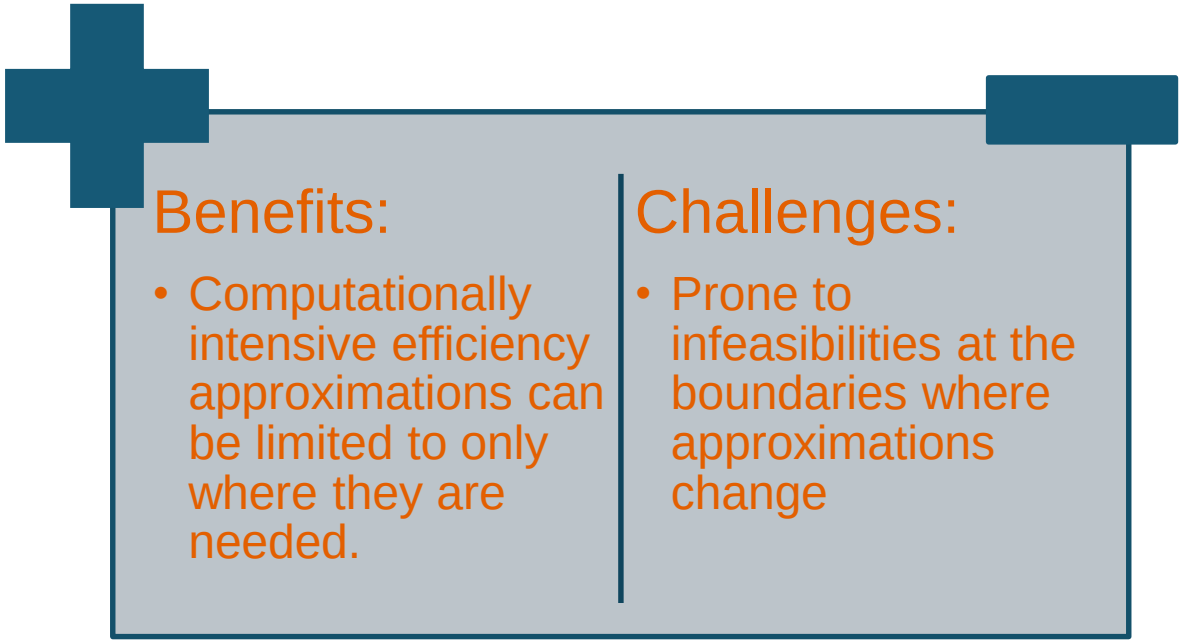
Benefits:

- Permits realistic hydropower scheduling without the need for separate water values
- Can handle VRE and hydropower inflow uncertainties simultaneously

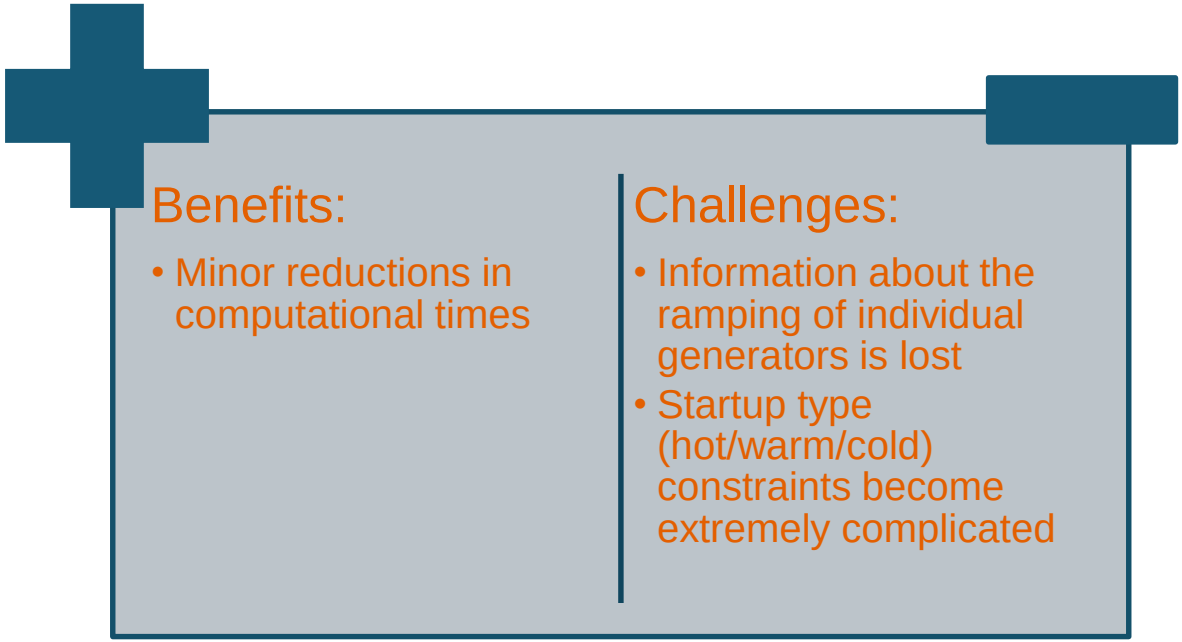
Challenges:

- Should the near-future be treated different from the long-term future in the objective function?
- Time series data aggregation has to be done on a case-by-case basis

2. Varying experiences with variable efficiency representations:



3. Mostly challenging experiences with unit aggregation:



In conclusion:

Time step aggregation works well for combining UC and storage scheduling models

- However, ED can get ”overshadowed”

Variable unit efficiency representation can reduce model size and complexity

- However, approximation boundaries prone to infeasibilities

Unit aggregation seems to cause more trouble than it’s worth

- Ramping and hot/warm/cold startup constraints become a pain

beyond
the obvious

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1. Example of progressive time step aggregation in practise

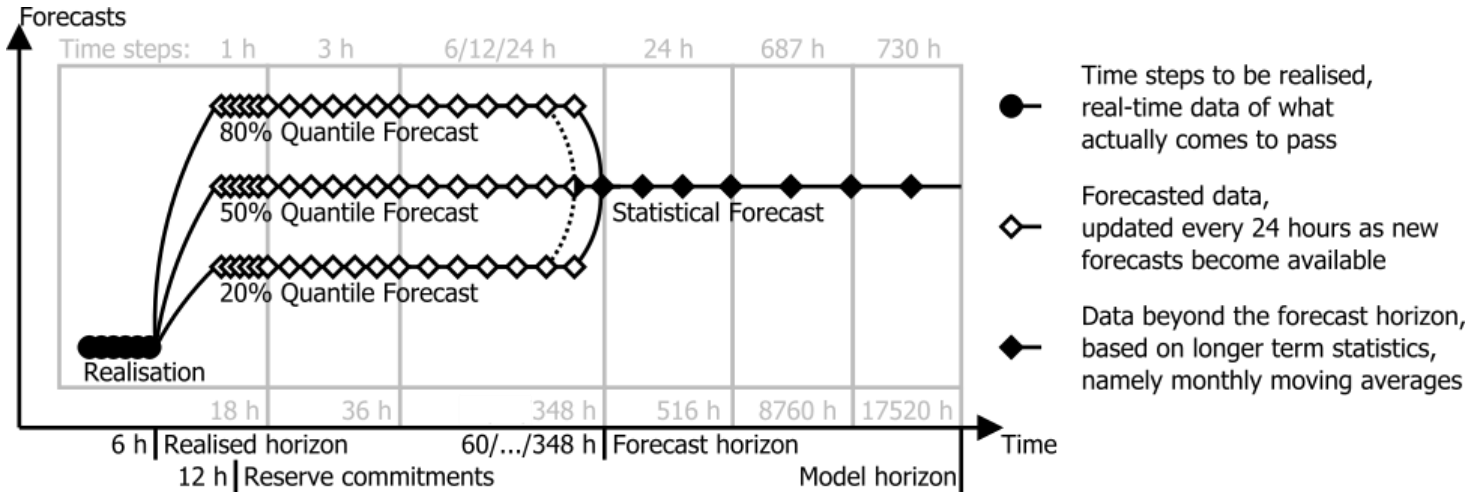
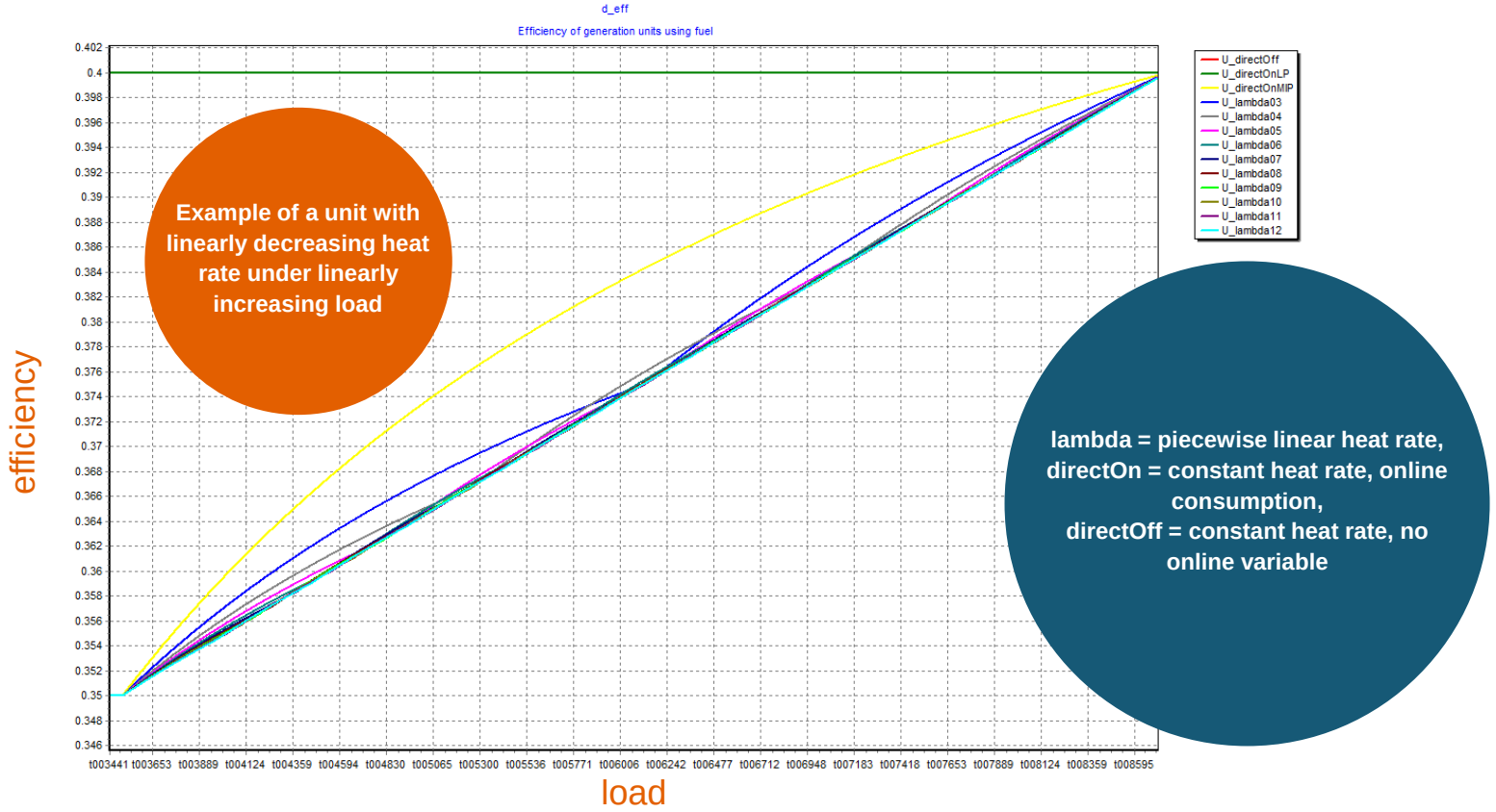


Figure from: Rasku, T., Miettinen, J., Rinne, E., & Kiviluoma, J. (2019). Impact of 15-day energy forecasts on the hydro-thermal scheduling of a future Nordic power system. Manuscript submitted for publication.



Example using Backbone: Helistö, N., Kiviluoma, J., Ikäheimo, J., Rasku, T., Rinne, E., O'Dwyer, C., … Flynn, D. (2019). Backbone—An Adaptable Energy Systems Modelling Framework. *Energies*, *12*(17), 3388. https://doi.org/10.3390/en12173388