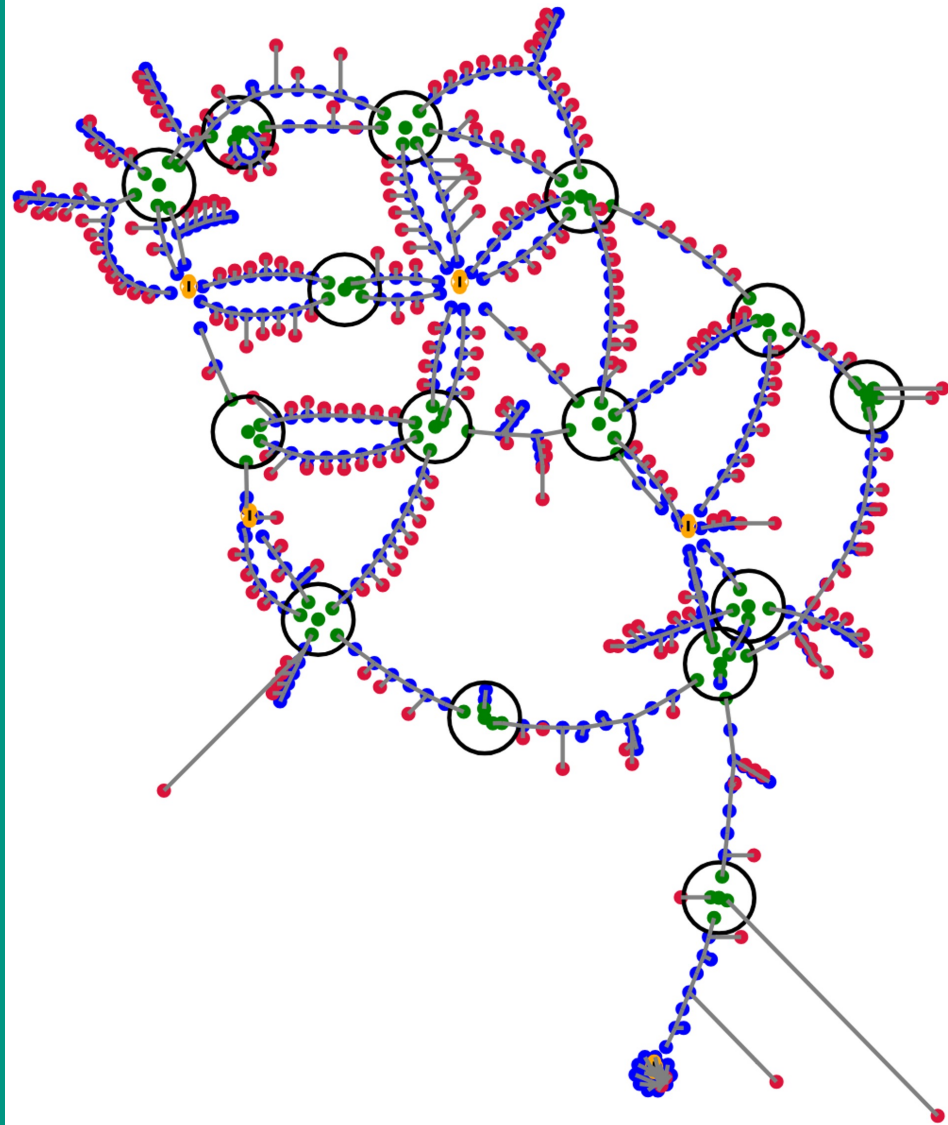


Starting Points Towards new Grid Operation Concepts

Reality check yet
promising outlook



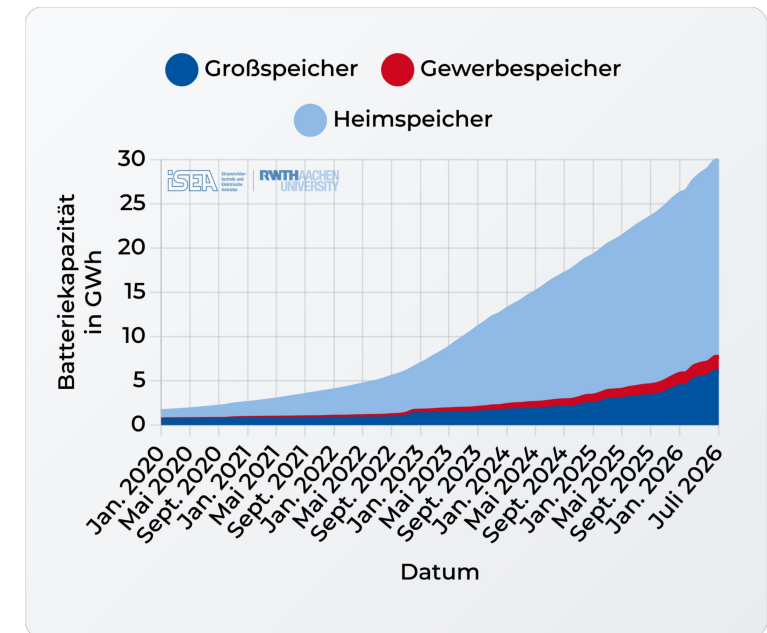
Greenfield versus status quo

- Disruptive ideas come from “greenfield thinking”
 - Example “Energy Packet Grid^[1-3]”
- Actors on the operator side like guarantees and little change
 - “Easy” things (EnWG §14a or iMSys) are slow in adoption
- Money reigns the grid
 - Some consideration of “what does it cost” necessary
 - If it makes money (in the current system) – adoption can be fast...



What now, given our societal obligations?

- Work both technical fronts
- Build trust and evidence to eventually influence regulators and operators



<https://battery-charts.de/de/battery-charts-de/#speicherkapa>

[1] Monti, A. et al. (2017). Towards a real digital power system: An energy packet approach. In 2017 IEEE Conference on Energy Internet and Energy System Integration (EI2)

[2] De Din, E. et al. (2018). A new solution for the energy packet-based dispatching using power/signal dual modulation. In Proceedings of the Ninth International Conference on Future Energy Systems (pp. 361-365).

[3] Wiegel, F. et al. (2021). A Novel Receiver Design for Energy Packet-Based Dispatching. Energy Technology, 9(2), 2000937.

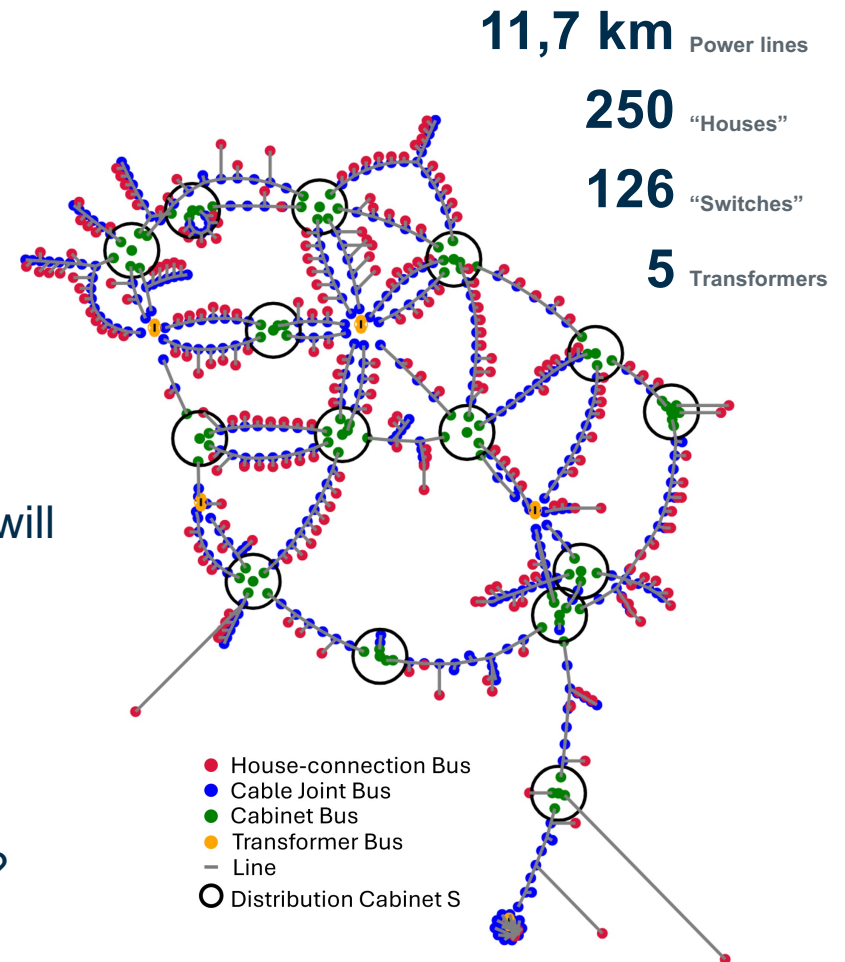
Starting point: Existing Grid

Limited integration capacity

- Actual grid, geographically correct, anonymized plot
- Typical suburb, parallel strands in streets
 - Operated in radial configuration
- Peak-Line-Loading puts limits to “all-electric-vision”
 - Increase “capacity” / reduce peak loading
- Assumption: System to “steer the power” between A & B at will
→ Exploit asymmetries in line loading

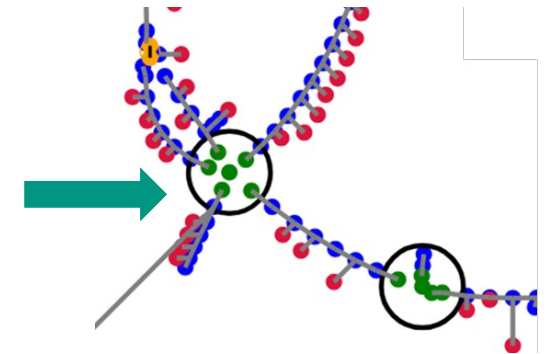
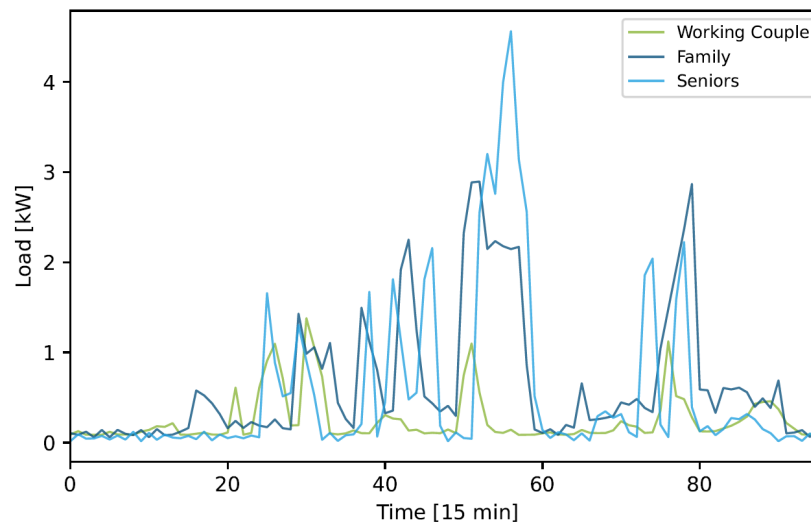


- Questions:
 - Where to place it? → What are the dependencies?
 - How to operate it?
 - How much to gain?



Study Design^[4]

- Limit our “access” to cable distribution cabinets
- Load profiles only → isolate impact of consumption patterns
- Inclusion of load profiles with multiple levels of detail
 - H0 “for all” vs. individual household
 - Individual profiles from agent based generation – activity driven



[4] J.-N. Schmidt et al. “Impact of Load Profiles on Optimal Meshing Point Selection in Distribution Grids”, Accepted at IEEE PES ISGT Europe 2026, Budapest, Hungary

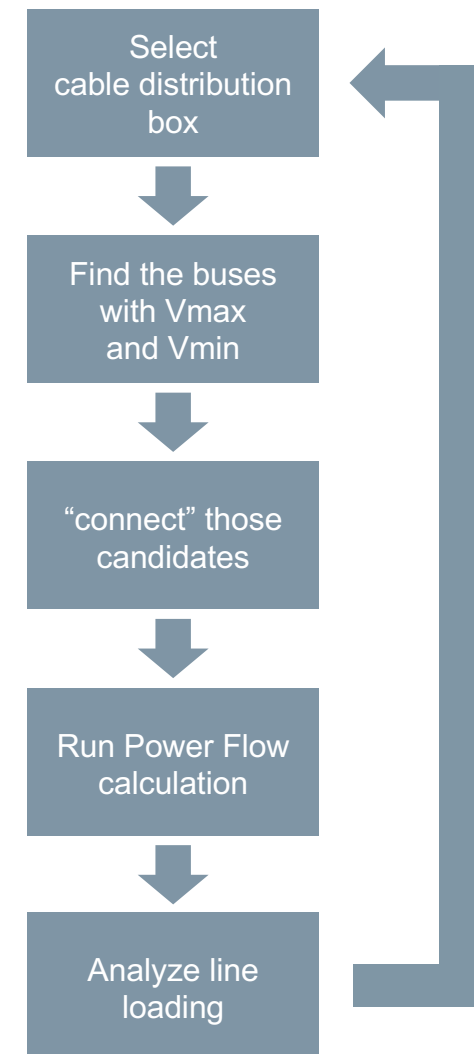
Placement Method

Basic Algorithm

- Iteration of the time-steps of the load profile (15 min)
- For each cable distribution cabinet: Identify two connections with the greatest voltage difference
- Run a Power Flow Analysis
- Record / Identify Peak Line Loading across the grid.
 - Best connection for each time step

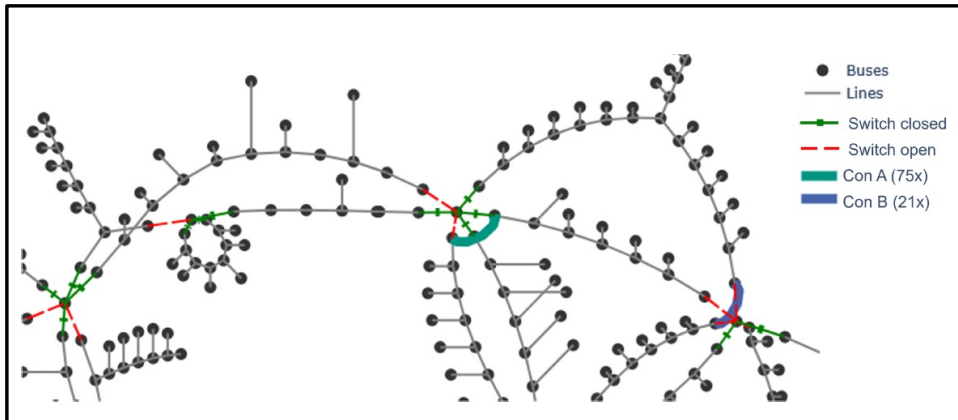
Optimization Goal:
Reduce the load on the most heavily loaded line

→ Proxy for increasing grid capacity under realistic operation conditions – thermal limits and voltage band violation

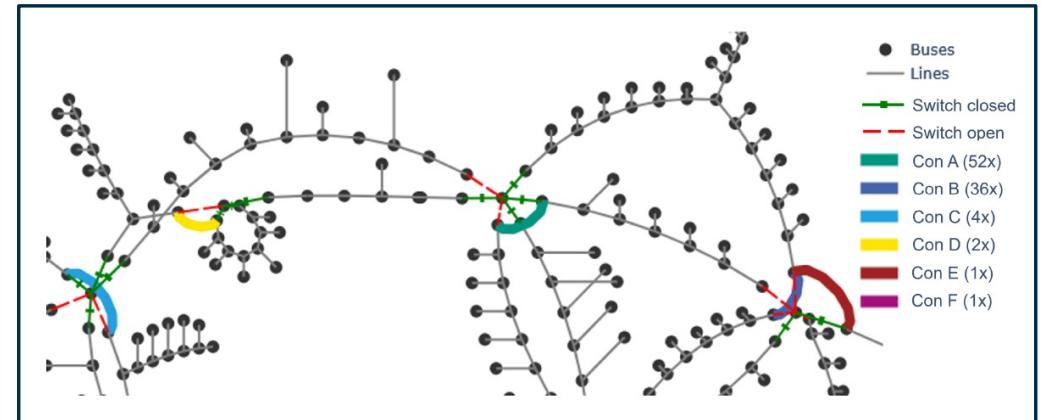


Key Observations 1

- A few connections dominate (2 for H0, 6 for individual)
- Dominating connection are the same for H0 and individual
- Almost all connections are in the same part of the grid → historic changes in grid planning?
- Profiles impact the “variety” of optimal connections



H0



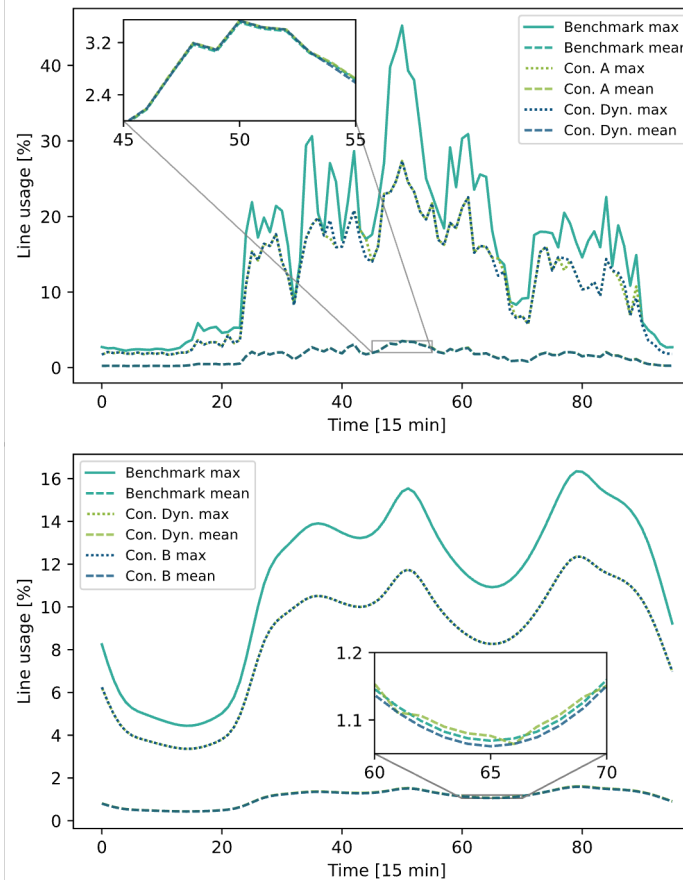
individual

Key Observations 2

What to gain?

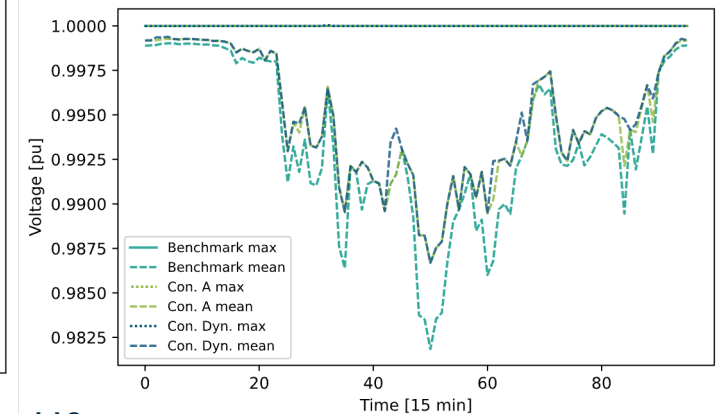
- Substantial line loading reductions achievable
47% → 28%
- One connection achieves the majority of the reduction
- “peak loading” only visible with individual profiles → H0 unsuitable for peak estimation
- Popular loss metric of “average line loading” not useful in this context
- Loading reduction from meshing only: What to gain from PECs?

Line Loading

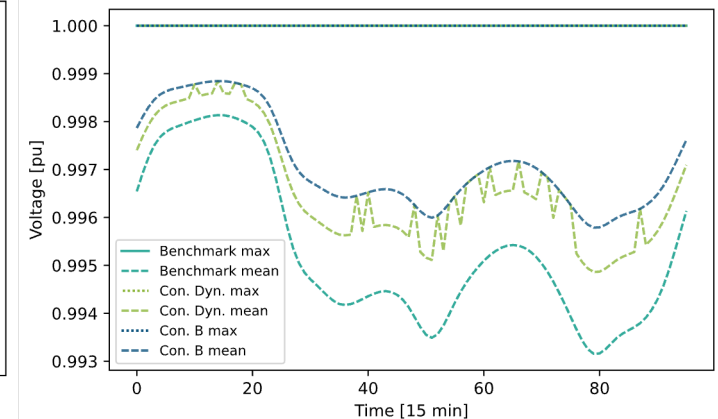


Voltage Extrema

Individual



H0



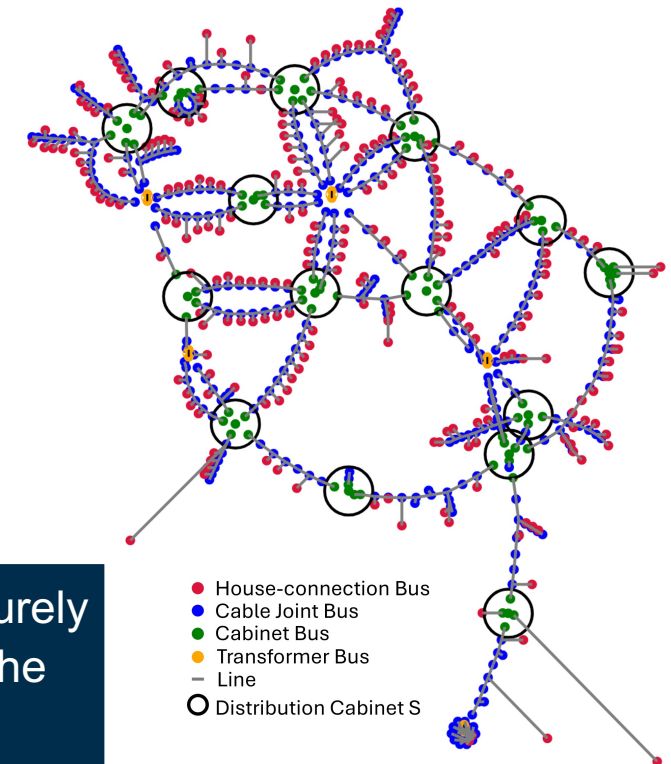
Takeaways

- Even limited “access” via distribution cabinets achieves significant peak loading reductions
 - Accessible, existing infrastructure, no excavation work
- Load profile detail impacts the selection of optimal meshing point
- Meshing is the main leverage of the PEC “connections”
 - Optimally placed “static” connections are nearly as good as dynamic placement

Optimal meshing in LV networks is not purely a topological problem - it depends on the profile and time resolution.

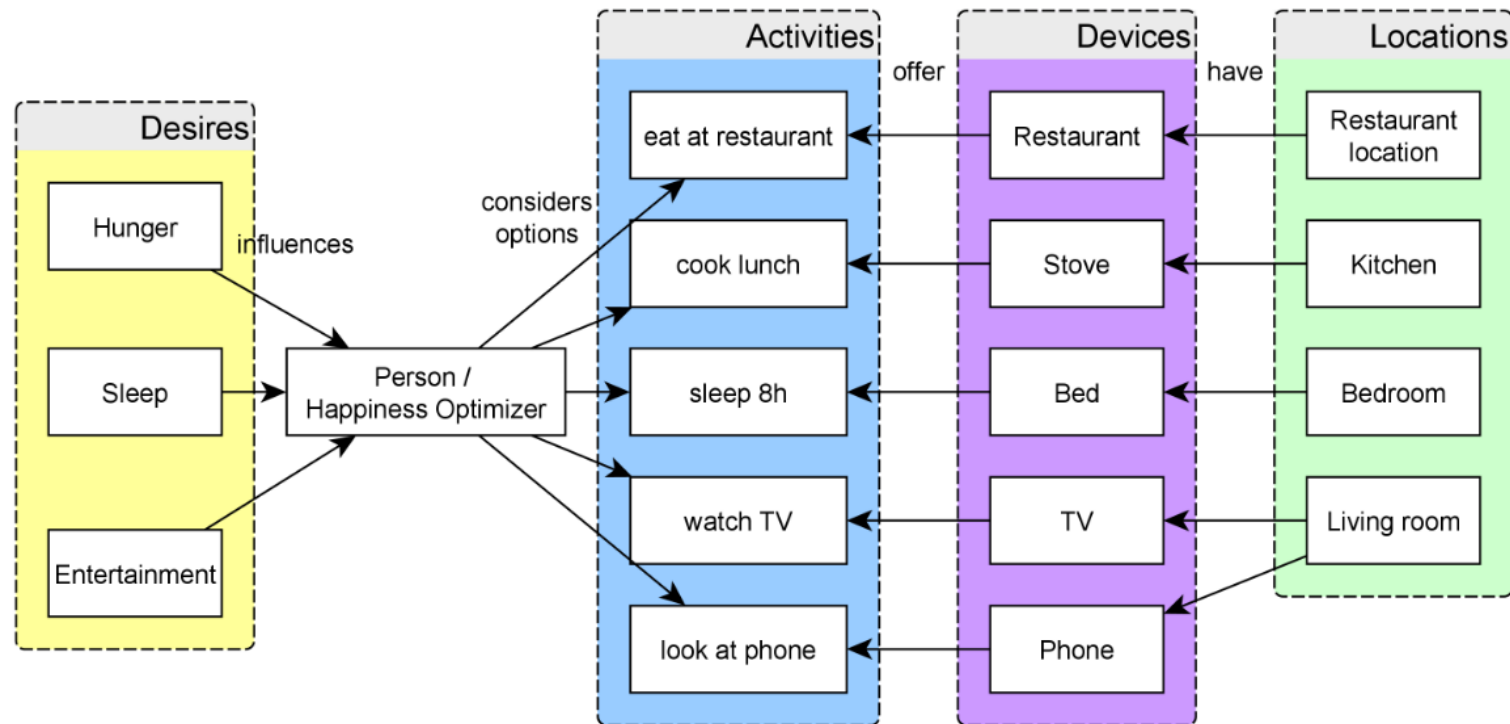
Some say: Peaks remain – just “lower down”!

Next: Replace spatial “smearing” of H0 with temporal “smearing” using coordinated batteries... (which goes well with the development we are already seeing)





Agent-Based Behavior Simulation for Generating Residential Load Profiles



Pflugradt et al., (2022). LoadProfileGenerator: An Agent-Based Behavior Simulation for Generating Residential Load Profiles. Journal of Open Source Software, 7(71), 3574, <https://doi.org/10.21105/joss.03574>