CHALMERS

A greedy algorithm for the unforecasted energy dispatch problem with storage in Smart Grids

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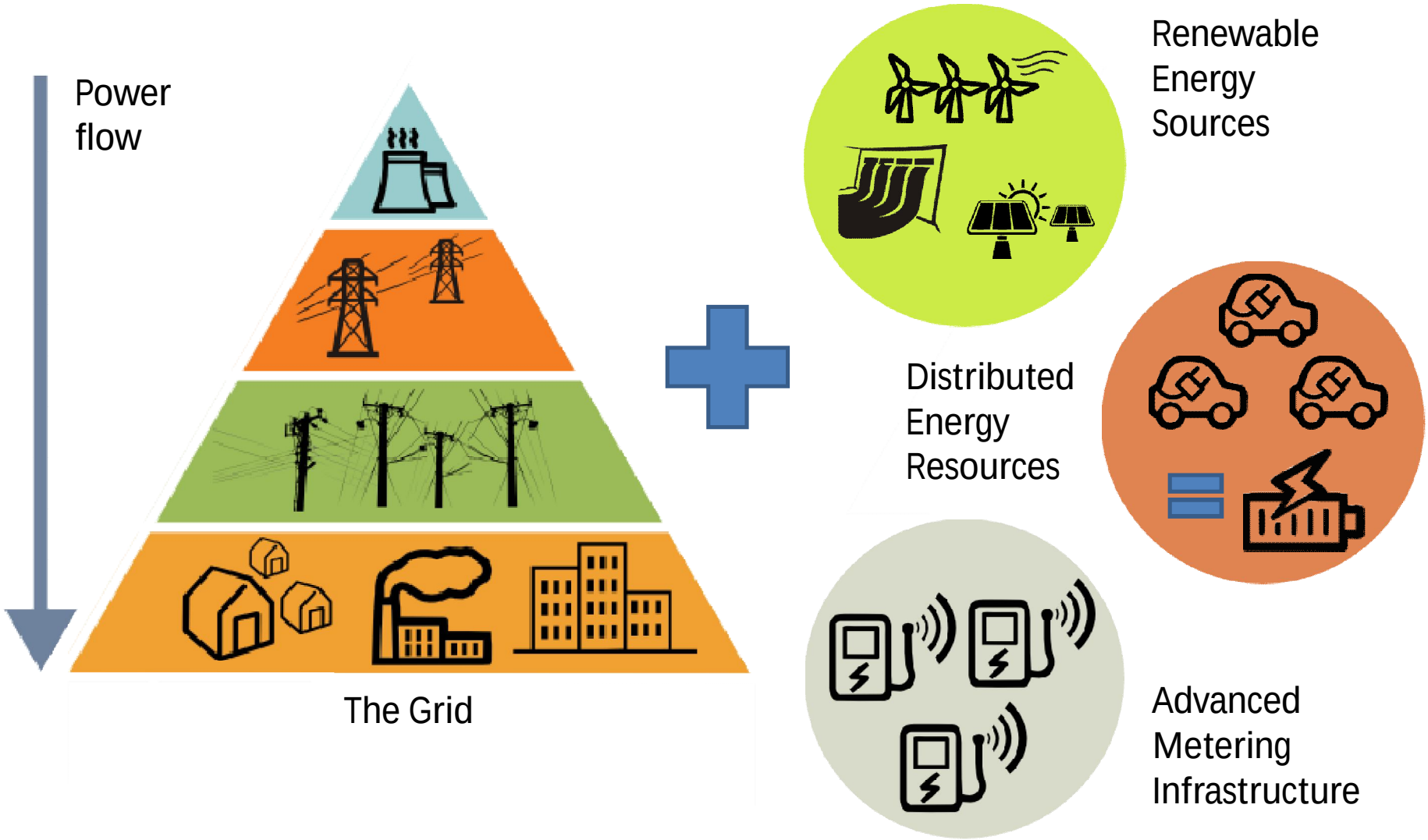
Overview

- What is a Smart Grid
- Opportunities & challenges
- Balancing demand and supply
- *Online load balancing with storage*
  - Definitions
  - Modeling
  - Greedy algorithm
  - Experiments
- What's next?

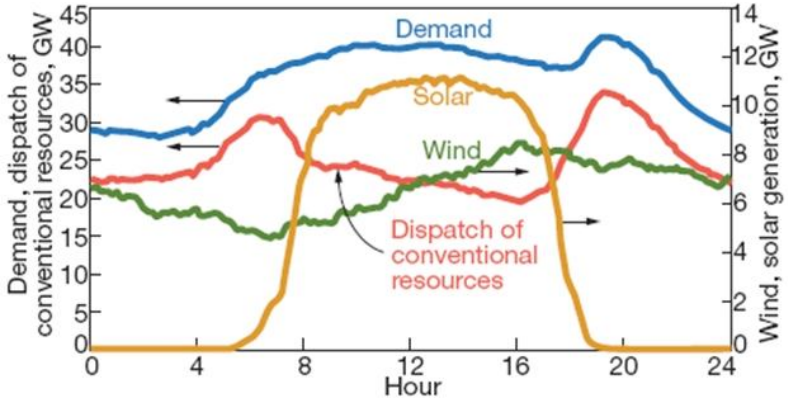
What is a Smart Grid



The challenge

Variability in power generation:

The Grid at its limit…



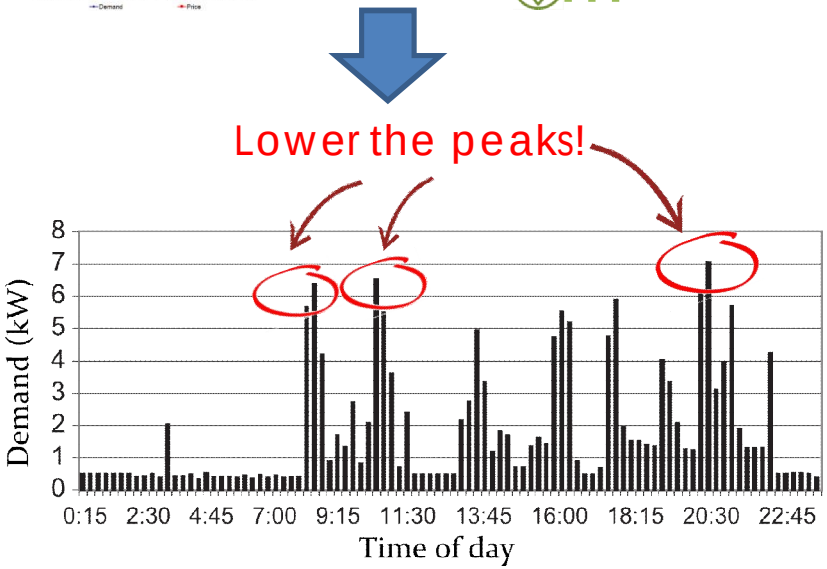
Source: California Independent System Operator

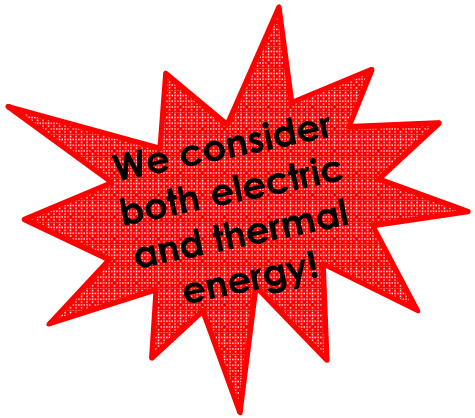
Opportunities & challenges:

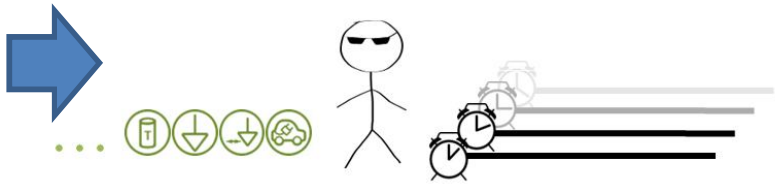
Storage but also efficient storage utilization and intermittent energy demand

→ Demand must connect with supply

The solution:
Online load balancing with storage







Definitions

Definition 1 (Unforecasted energy dispatch problem with storage). *Given a distribution system subgrid, we call* unforecasted energy dispatch problem with storage *the problem of dispatching generated electrical and thermal energy to end consumers without using forecasts and by taking into account any storage capabilities present, while trying to minimize peak energy consumption within a given time interval.*

Definition 2 (Online load demand balancing problem with storage). *Let $M_i, i = 0 \ldots n-1$ be a set of machines where variable load credit (i.e. storage) can accumulate and $t_0, \ldots, t_j, \ldots$ be an input task sequence of two task types, simple and storage, with the following properties: each task t_i of both types has load w_j and restrictions on the allowable machines it can run on, while storage tasks additionally create on all machines load credit equal or less to their load w_j (with the possibility of 0 on some but not all machines[3]). We define the* online load demand balancing problem with storage *as the problem of assigning the tasks to the machines while minimizing the maximum load on the machines.*

- Types of tasks
  - Elastic/inelastic, electrical/thermal, storage/simple
- Simplifications and assumptions
  - No distinction of local/global storage
  - Diurnal pattern, hourly slots

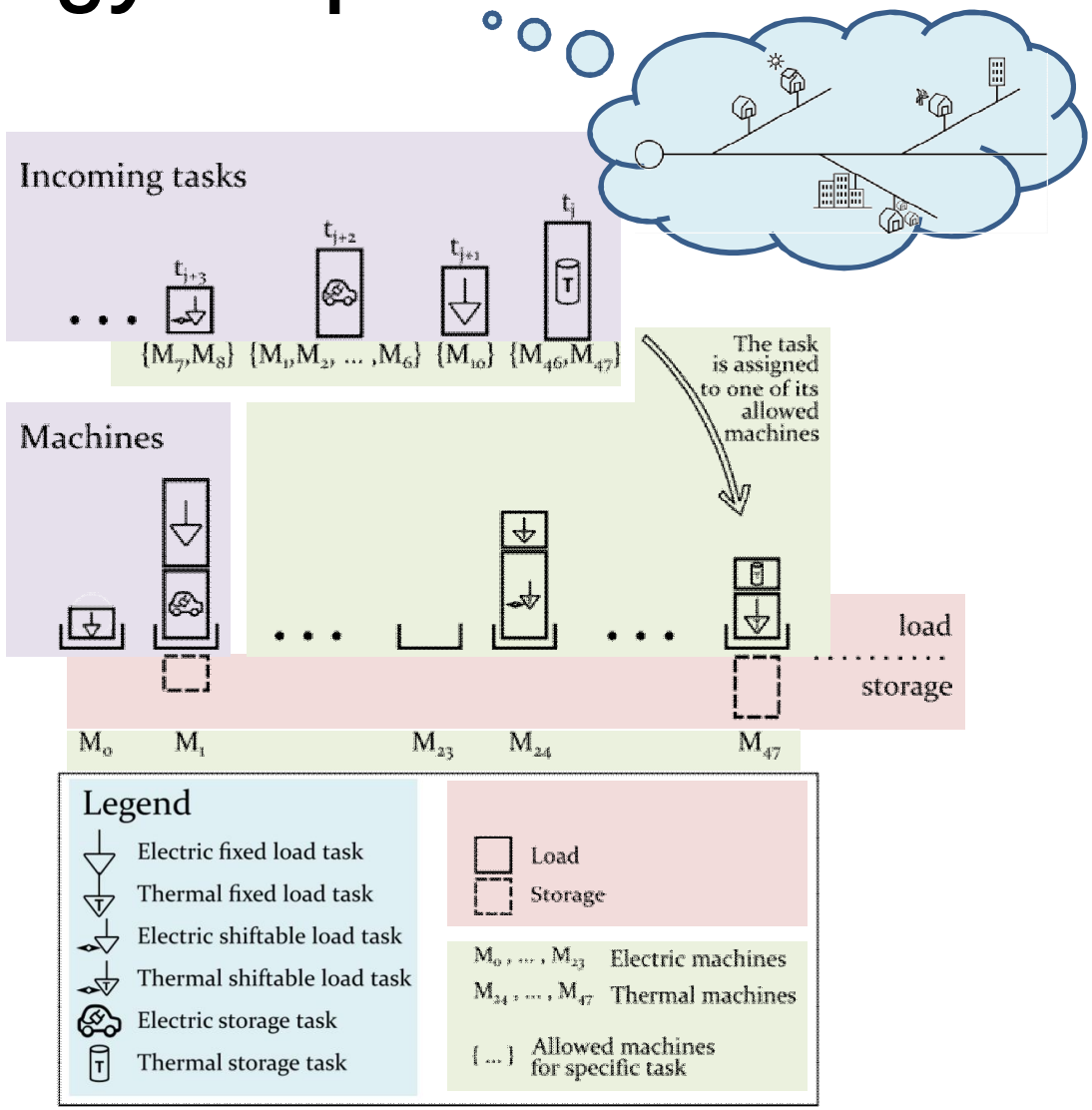
Modeling energy dispatch

Identifying task types

Scheduling tasks to machines

Eliminate time parameter (for flexible tasks)

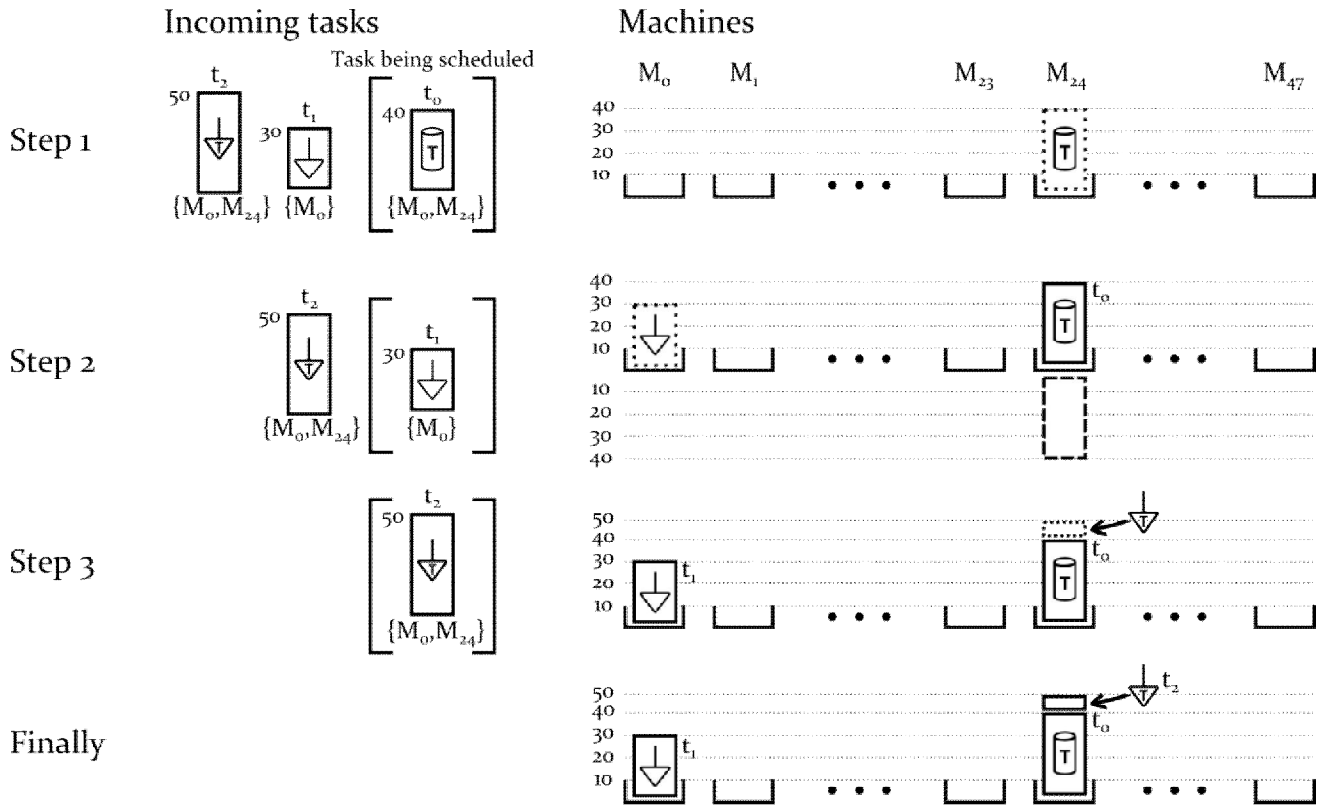
Incorporate storage



Demand assignment algorithm

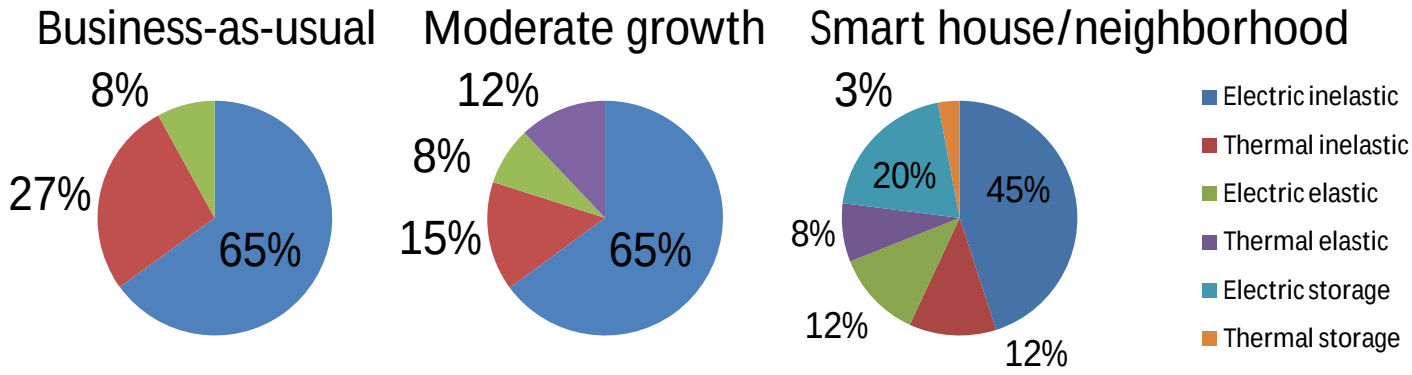
Simple: Assign incoming task to machine with min load-storage difference

Efficient: Within $\lceil \log n \rceil + 1$ of the OPT



Experimental setup

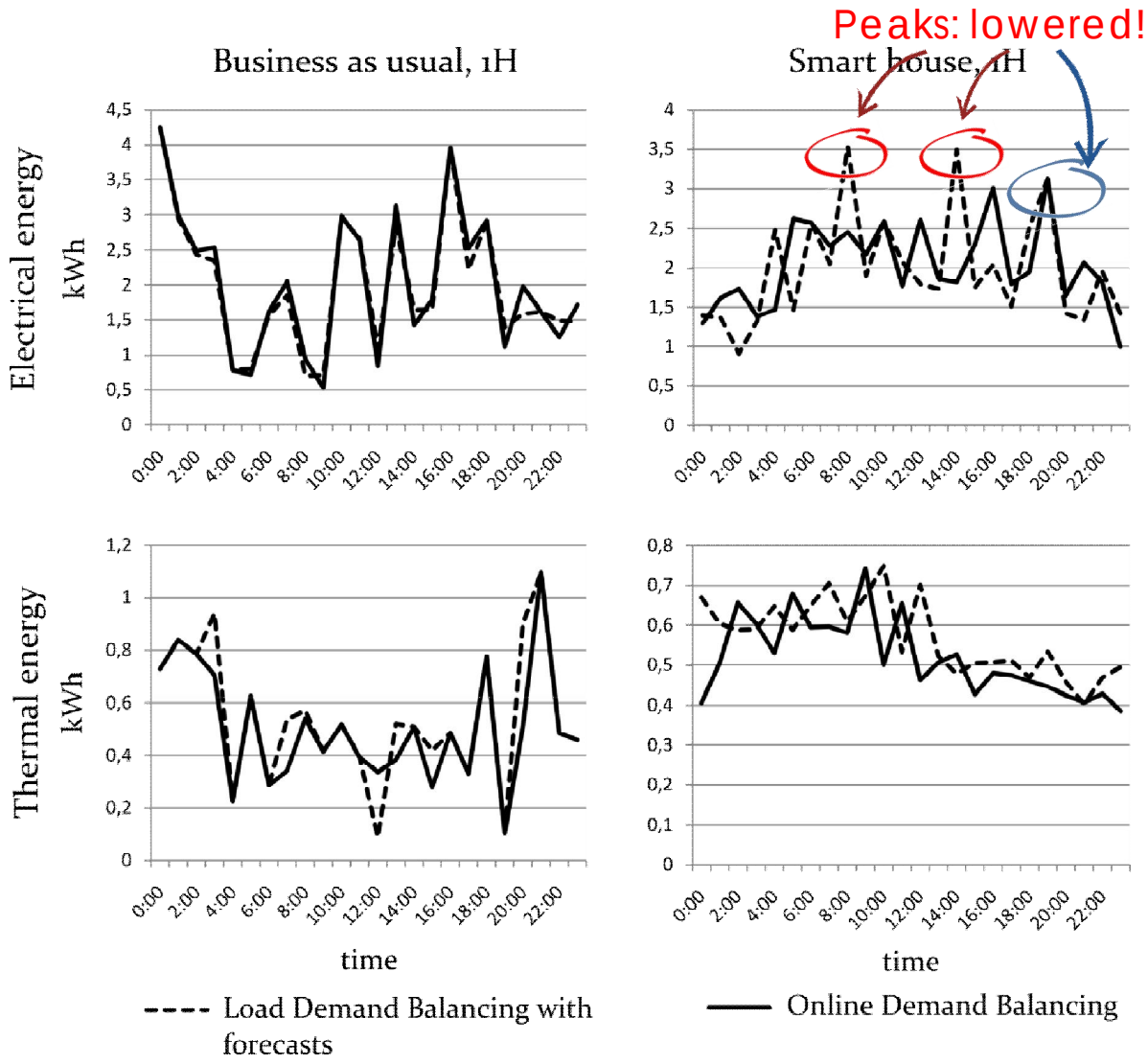
- Two axis
  1) Demand mix



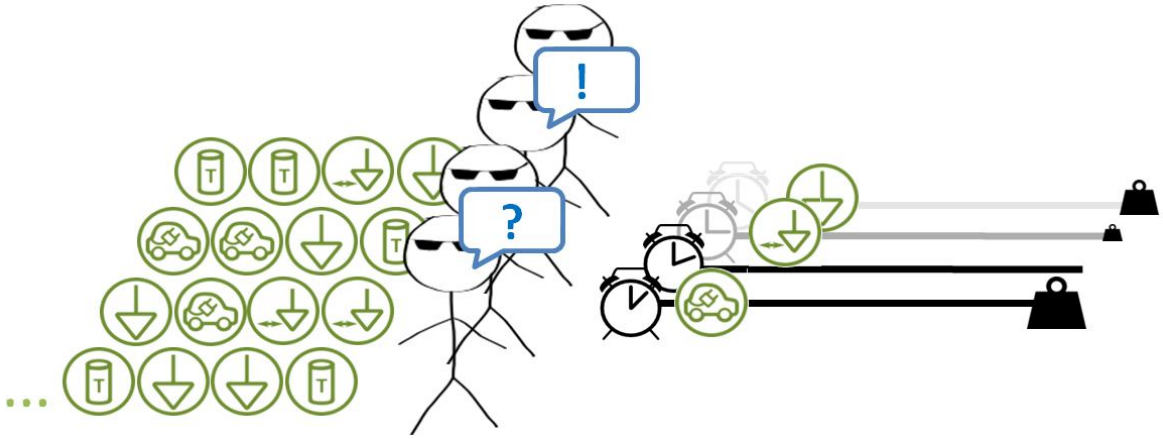
  2) Number and type of households

- Comparison
  - **Longest Processing Time (LPT):** *sorts tasks by decreasing processing time and then assigns each task to the machine that has the least load (breaking ties arbitrarily)*

Experimental results



What’s next?



- Mixed algorithms
  - Communication with global optimizer
  - Allow budget for scheduling over forecasted
  - Call optimizer when over budget
- Strategic games
- New modeling extensions/applications

Summary

- Renewable and distributed energy sources
  - Opportunities & challenges
- Balancing demand and supply is needed!
- *Online load balancing with storage*
  - Energy dispatch: assignment/matching problem with guarantees
  - Transformation of time and unforecastability: resource allocation
  - High quality solution: analytical results and experiments based on real data
- Next: cooperation, strategies, extensions

Thanks!

Questions/comments/ideas?