Capacity-dependent tariffs as an incentive for a grid-benefiting storage operation in private households

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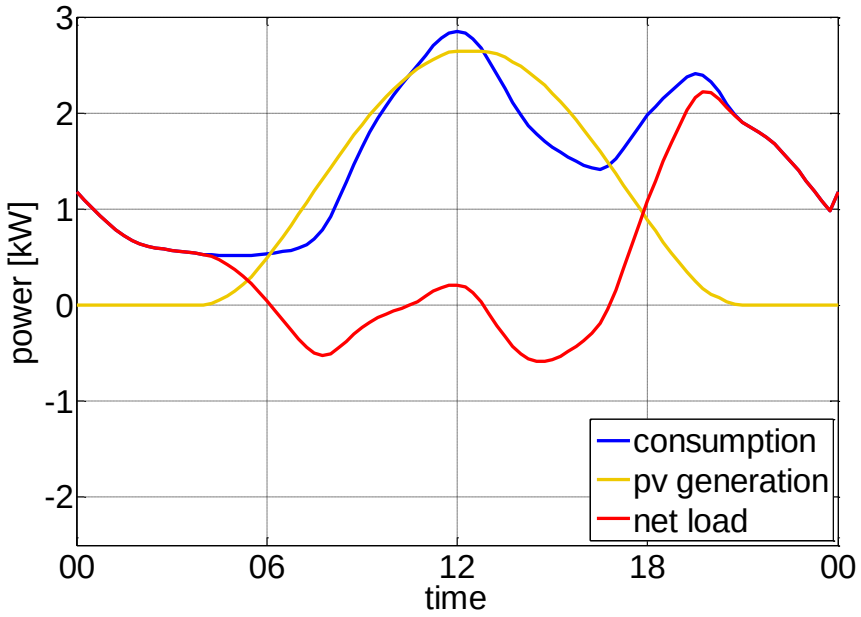
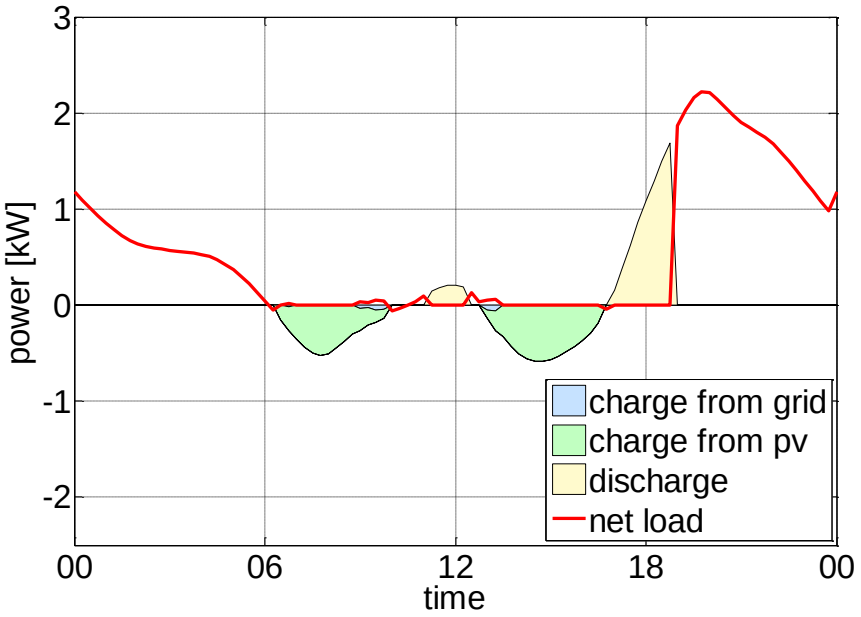
What are we going to learn today?

What could make accumulators in private households serve the overall system?

Picture: Kigoo Images / pixelio.de

Optimization of self-sufficiency does not serve the overall system





- Load (standard profile), PV generation and net load of a private household

- Storage to maximize self consumption
- Net load with high gradients and peaks

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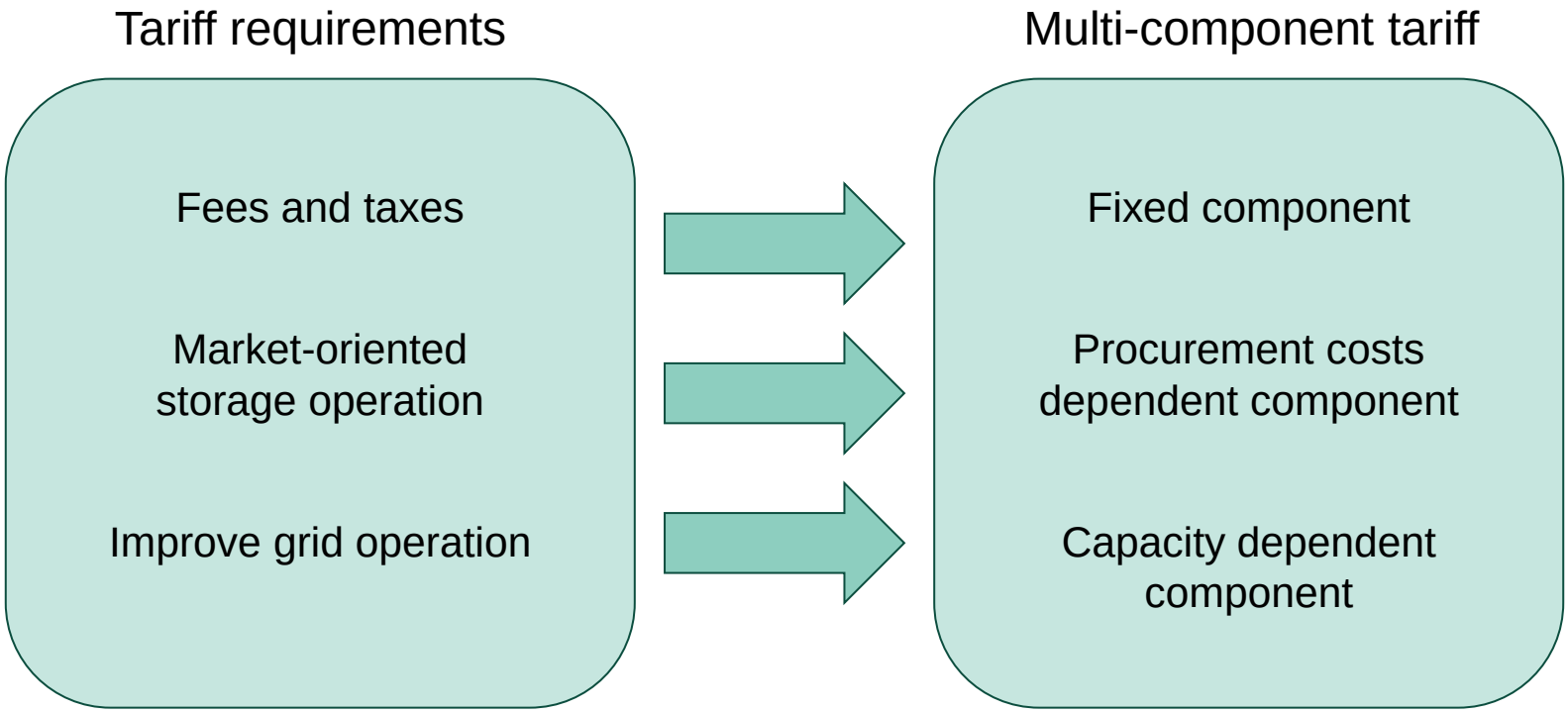
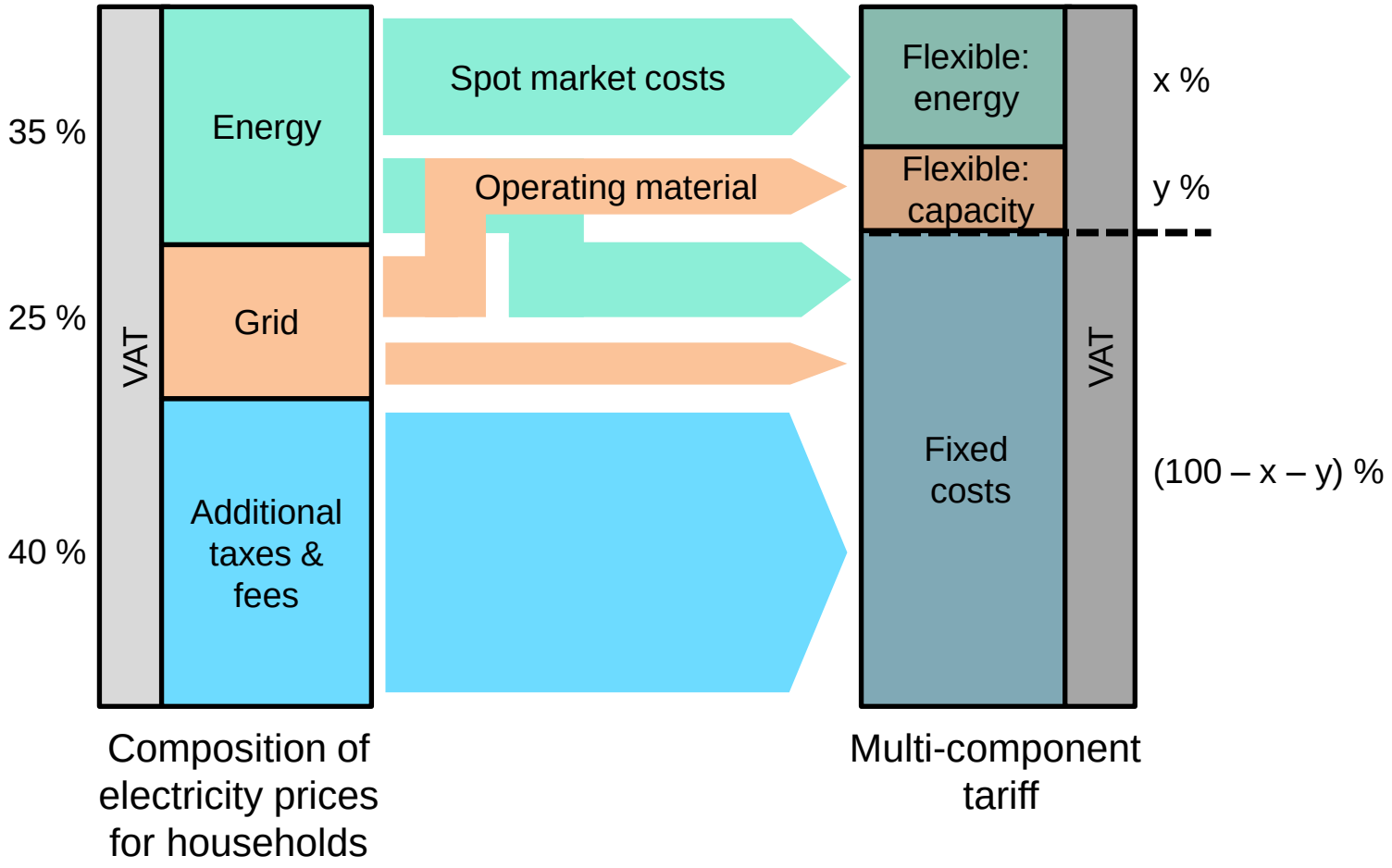
Approach for an intelligent energy management



Combining fixed and variable tariff components

Possibilities for flexible components in retail electricity tariffs



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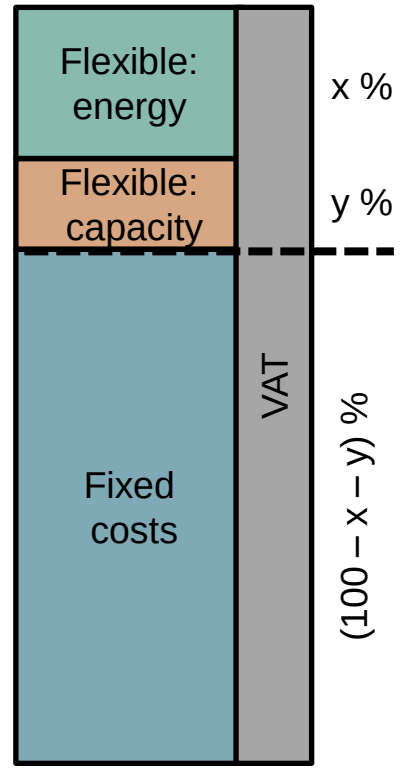
Study of four tariffs with different levels of flexibility

Retail electricity tariff	Flexible energy component	Flexible capacity component	Fixed costs component
Reference	0 %	0 %	100 %
Real time pricing (RTP)	x = 21 %	0 %	79 %
Capacity	0 %	y = 10 %	90 %
Capacity + RTP	x = 21 %	y = 10 %	69 %



Multi-component tariff

Cost minimization for multi-component tariffs

$$\min \sum_{T} c_{total}$$

$$c_{total} = 1.19 \cdot \left(c_{energy} + c_{capacity} + c_{fix} \right) - rev_{PV}$$

$$c_{energy} = P^{+} \cdot c_{spot}$$

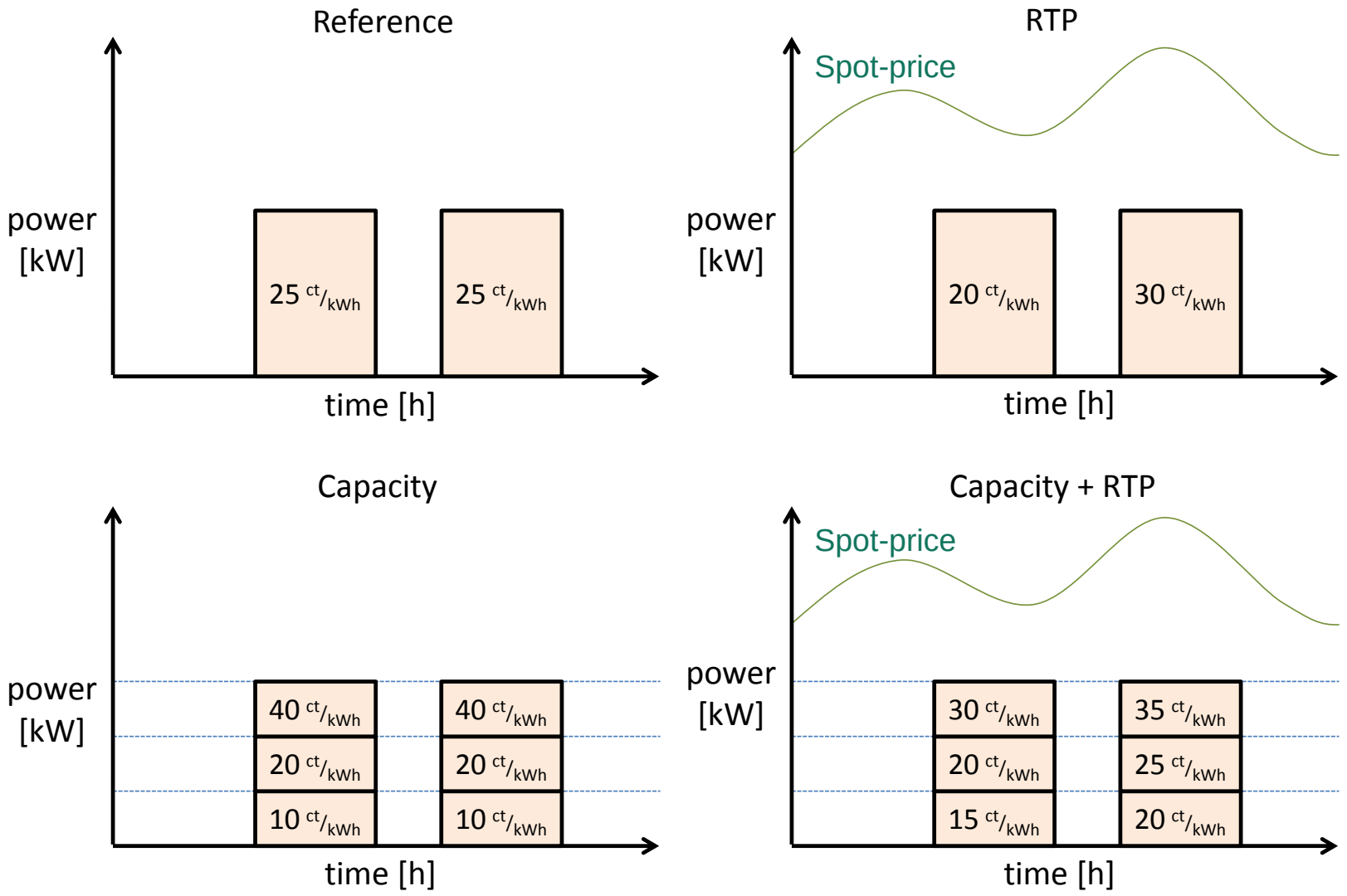
$$c_{capacity} = c(y) \cdot P^{2}$$

$$c_{fix} = P^{+} \cdot (1 - x - y) \cdot 24.14 \frac{Cent}{kWh}$$

$$rev_{PV} = \begin{cases} P^{-} \cdot 15.35 \frac{Cent}{kWh}, & P^{-} \leq 0.6 \cdot P_{PV} \\ 0, otherwise \end{cases}$$

- **Energy component:** EPEX spot price for purchasing energy, fixed compensation for grid feed-in
- **Capacity component:** Increases disproportionately high to net capacity (quadratically), both for purchasing and selling energy

Visualization of the costs of the different tariffs



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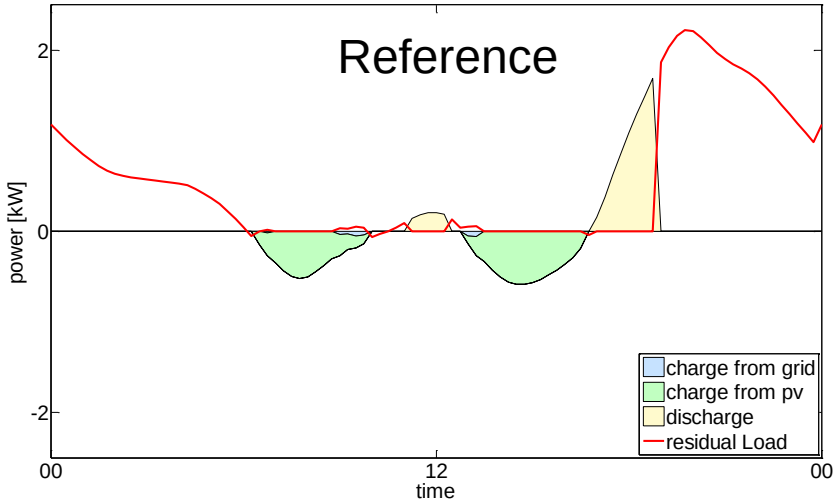
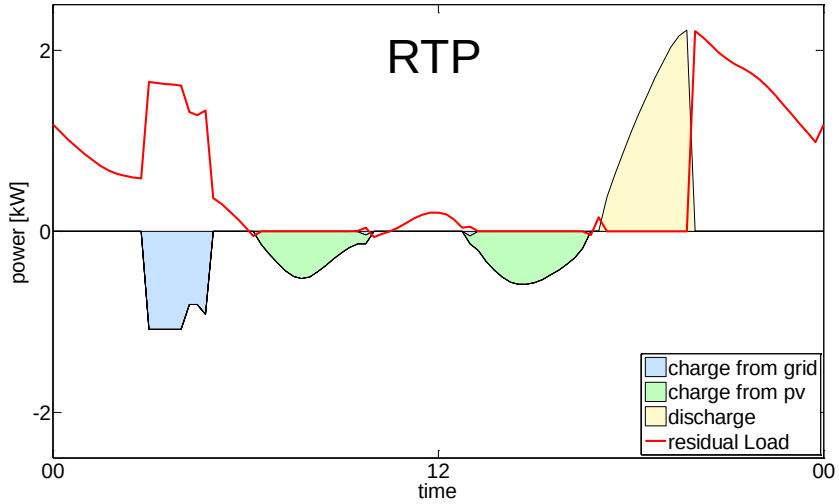
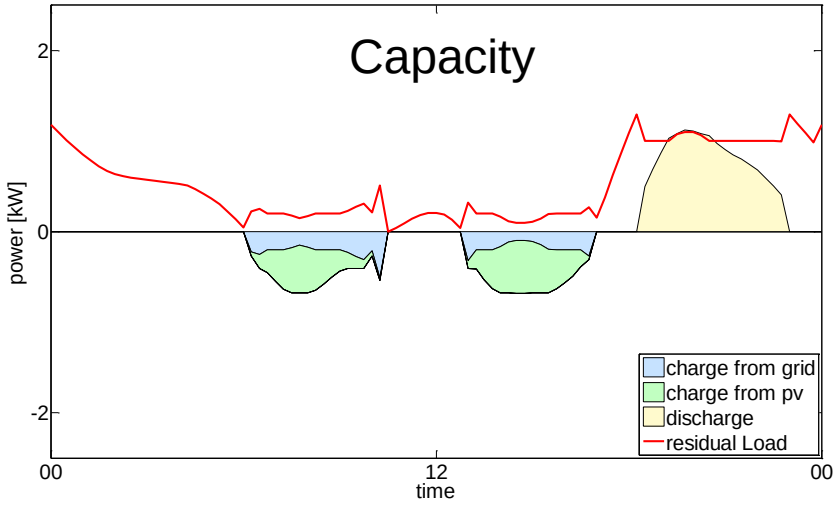
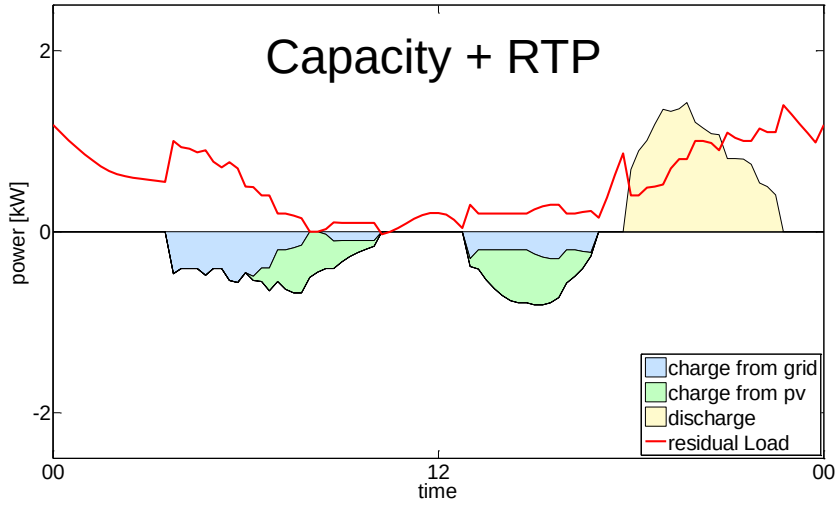
Energy management for a household (standard profile)









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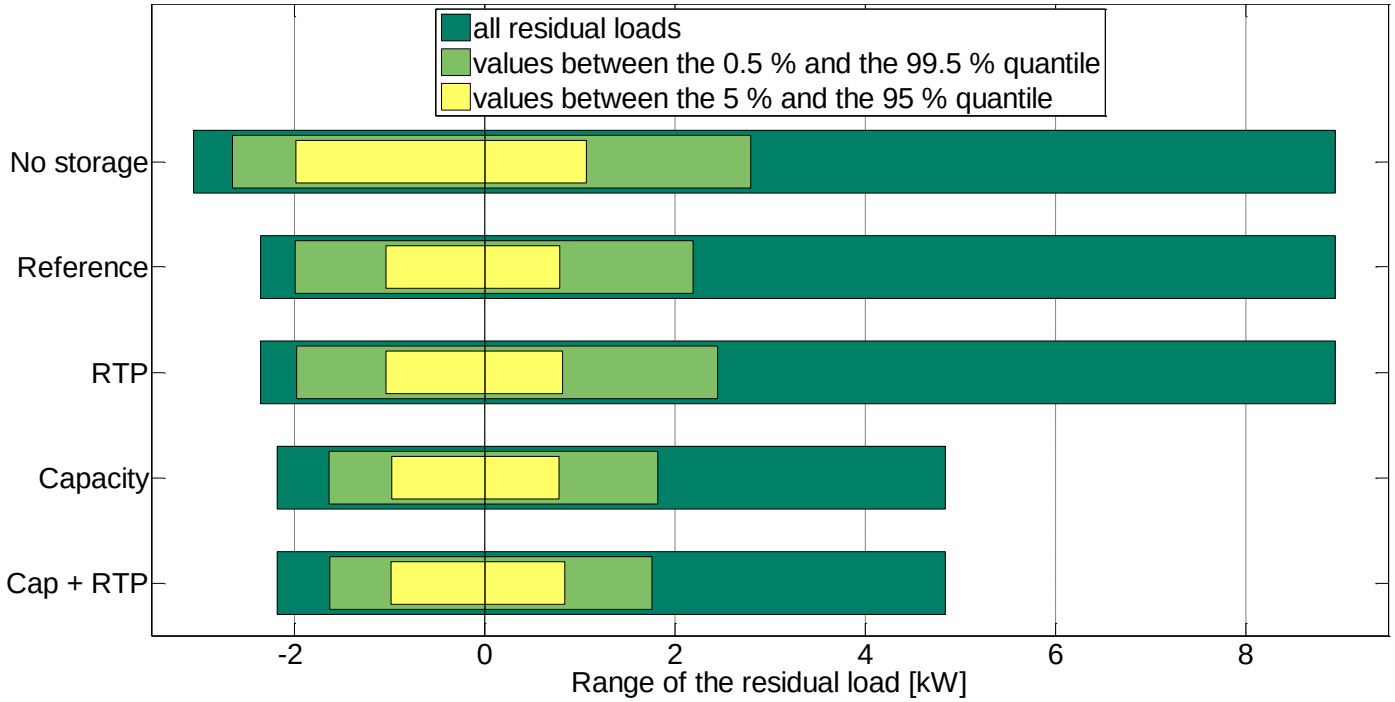
Test household: databases

- Measured load data with E_{con} = 4350 kWh/a, time resolution: 15 minutes
- Simulated photovoltaic generation with $E_{gen} = E_{con}$, P_{PV} = 4.1 kW
- Battery system with a usable storage capacity of $C = 2 \cdot P_{PV}$ = 8.2 kWh
- Rectifier and inverter with $P = P_{PV}$ = 4.1 kW (efficiency curves are considered)

Influence of tariffs on net load



- Accumulator reduces maximum feed-in for all energy tariffs. Reduction is higher when tariff has a flexible capacity component
- Maximum grid withdrawal can be reduced significantly by capacity component

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Financial effects of retail electricity tariffs

	Household: electricity costs [Cent/kWh]	**Supplier:** contribution margin [Cent/kWh]	**Network operator:** revenues [Cent/kWh]
No storage	28.7	3.5	5.7
Reference	28.7	3.9	5.7
RTP	27.6	3.5	5.7
Capacity	27.4	3.9	4.7
Capacity + RTP	26.5	3.5	4.7

contribution margin = revenues – procurement costs

Conclusions and outlook

- Both real time pricing tariffs and capacity tariffs have various weaknesses
- A combined tariff with both components can reduce peak loads, smooth gradients and lower energy procurement costs
- The economic efficiency has to be demonstrated for a larger system
- Refinancing of higher technological efforts have to be ensured

Thank you for your attention!

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