School of
Management and Law

Design and Impact of Capacity Charges

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Einleitung: Dynamische Stromtarife kommen

Günstigere Stromrechnungen wegen dynamischer Preise
Aus **Rendez-vous** vom 29.08.2025
BILD: KEYSTONE/GIAN EHRENZELLER

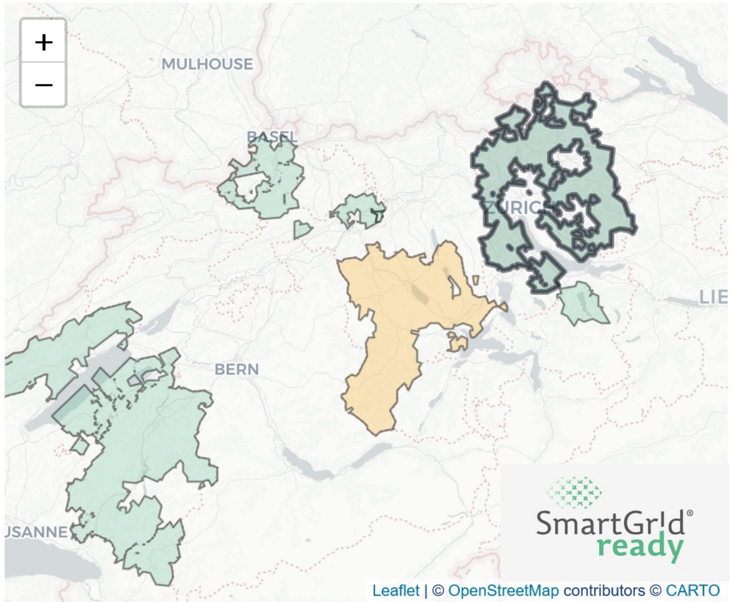
News › Wirtschaft ›

Stromtarife für 2025

Dynamische Stromtarife kommen – das müssen Sie wissen

Dynamische Stromtarife lassen hoffen. Doch nur wer seinen Verbrauch auch optimieren kann, dürfte letztlich sparen.

Freitag, 29.08.2025, 14:05 Uhr



Einleitung: Projekte und Weiterbildungen am ZHAW-CEE

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Weiterbildungen am CEE:

Dynamische Tarife und Pilotprojekte:

EKZ groupe e swisspower

ewl EW HÖFE regio energie solothurn IWB energie thun STADTWERK WINTERTHUR

Einleitung: Dynamische Stromtarife können Rebound Peaks bewirken

Past paper: problem of rebound peaks

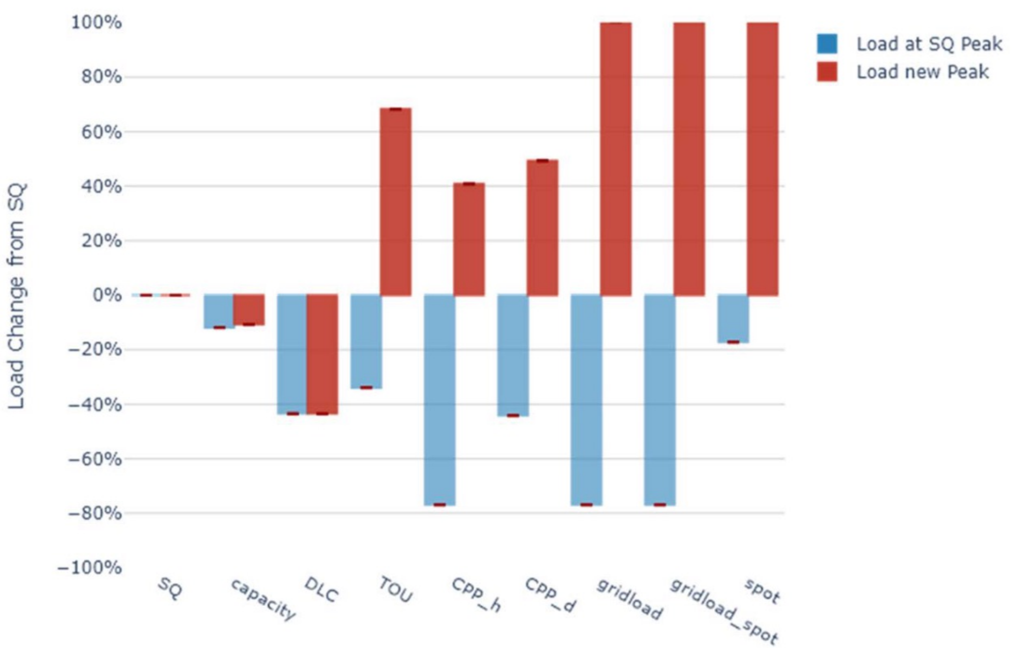
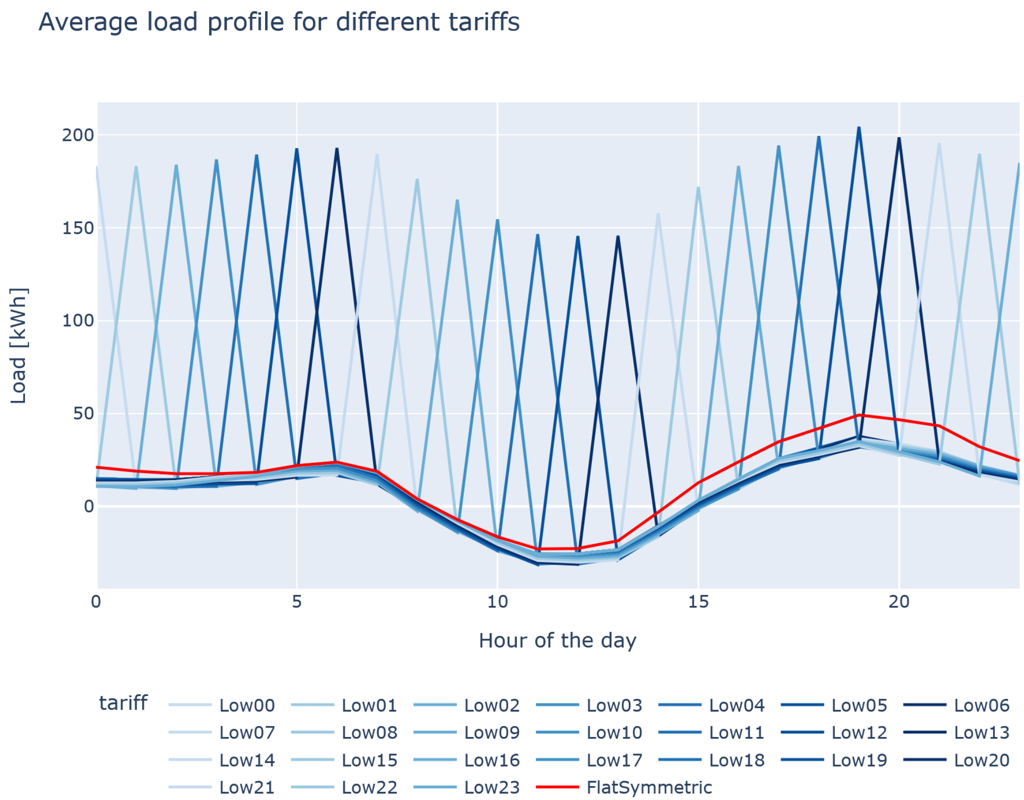


Figure 10. Change of system peak load compared to the SQ scenario in 2050



Rebound peaks are caused by ex-ante tariffs

Current paper: focus of today

Design and Impact of Capacity Charges

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Abstract

As a result of sector coupling, a growing amount of flexible loads will be connected at the distribution grid level. Dynamic per-kWh prices for end customers can unlock this flexibility and help to absorb increasing shares of variable renewable electricity production. However, dynamic prices fixed at the day-ahead stage may lead to the occurrence of new peaks (rebound peaks). While rebound peaks do not cause a problem when the share of flexible loads is small, they could increase in size when the share of automatically controlled flexible loads increases. Capacity charges per-kW can avoid the occurrence of rebound peaks, even in a setting where many flexible loads automatically react to the tariff signal. However, capacity charges may also cause unintended consequences, because individual consumption peaks often occur during times with low grid-load. Within this paper, we explore which combination of dynamic per-kWh charges and per-kW capacity charges is best suited to mitigate unintended consequences of both charging approaches in a way that minimizes system cost.

Keywords: Capacity charges, Dynamic electricity tariffs, Demand-side management, Rebound peaks, Grid flexibility, Energy management systems

Overview

1. Model, Input and Scenarios
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Model and Input: Calculation steps

Step1
- **Calibrate Tariffs:**
  All scenarios recover same cost in case of reference load profile.

Step2
- **Dispatch Loads:**
  Each customer shifts its flexible to minimize its own annual bill.

Step3
- **Evaluate Results:**
  Calculate grid peakload, grid-cost, energy-cost and total-cost.

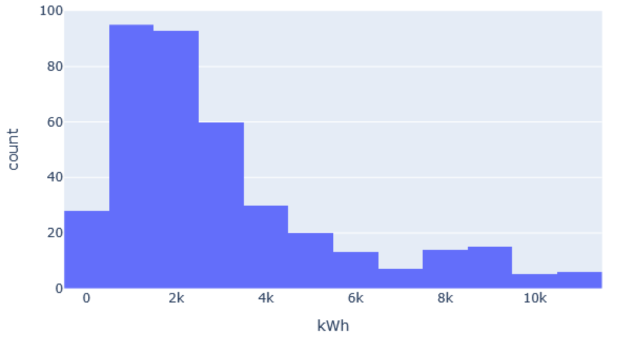
Model and Input: Household Types

Table 1: Number and share of household types included in the simulations

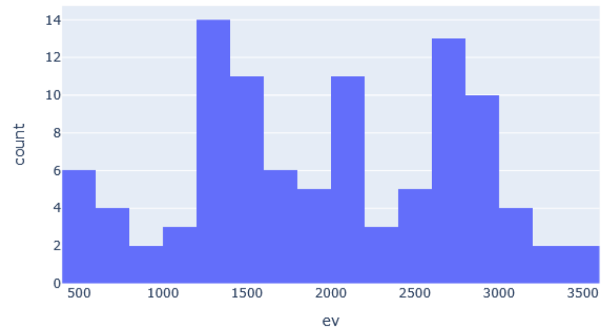
Type	Count	Share	EV	HP	PV	BT
type1	66	22%	no	no	no	no
type3	29	10%	yes	no	no	no
type5	4	1%	yes	yes	no	no
type7	1	0%	yes	no	yes	no
type9	60	20%	yes	yes	yes	no
type12	140	47%	yes	yes	yes	yes

Model and Input: Distribution of Annual Loads

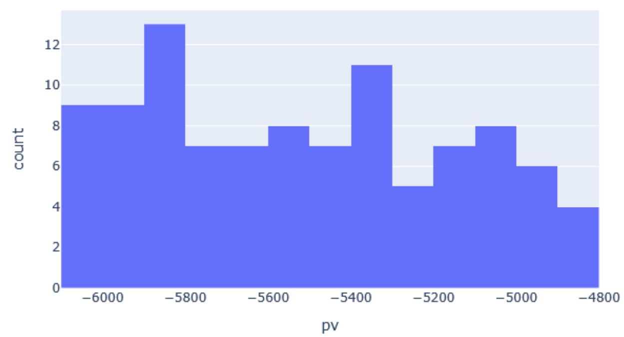
Histogram of annual reference load sum per customer



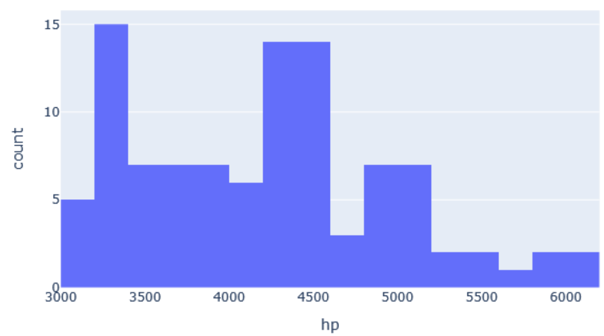
Histogram of annual load sum per customer for device: ev



Histogram of annual load sum per customer for device: pv



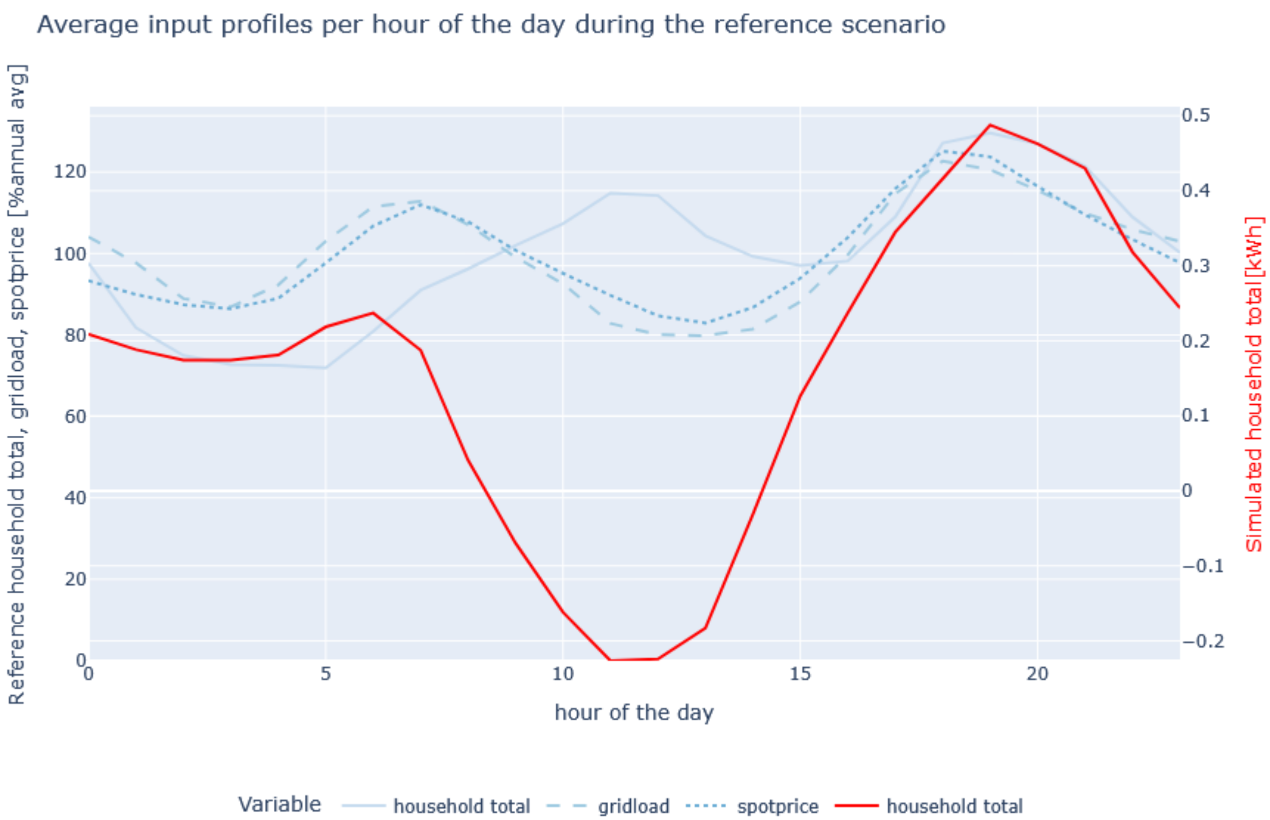
Histogram of annual load sum per customer for device: hp



Conclusion:

- Little diversity regarding houshold and PV load
- Considerable diversity regarding HP and EV load

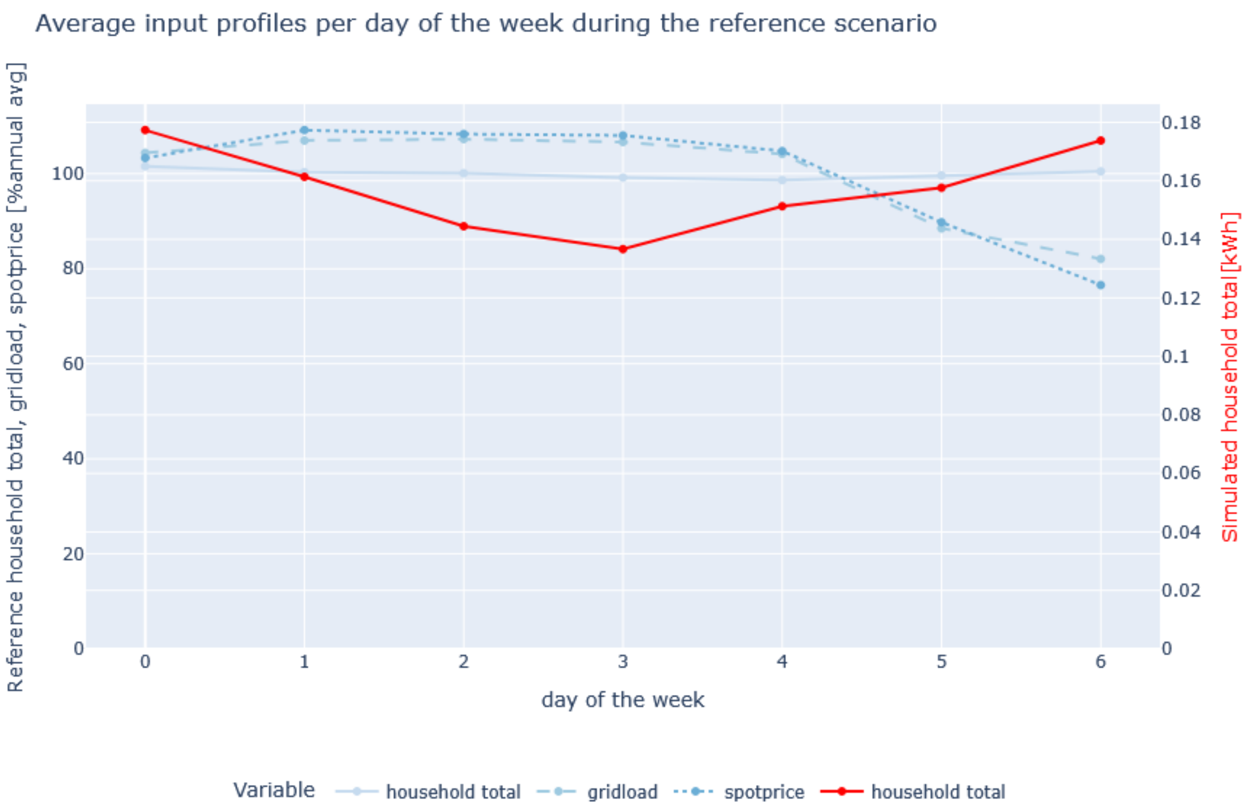
Model and Input: Daily Load Profiles



Conclusion:

- Good match between simulated household total and gridload and spotprice profile
- **Less baseload** than gridload profile
- **More PV** than reference households

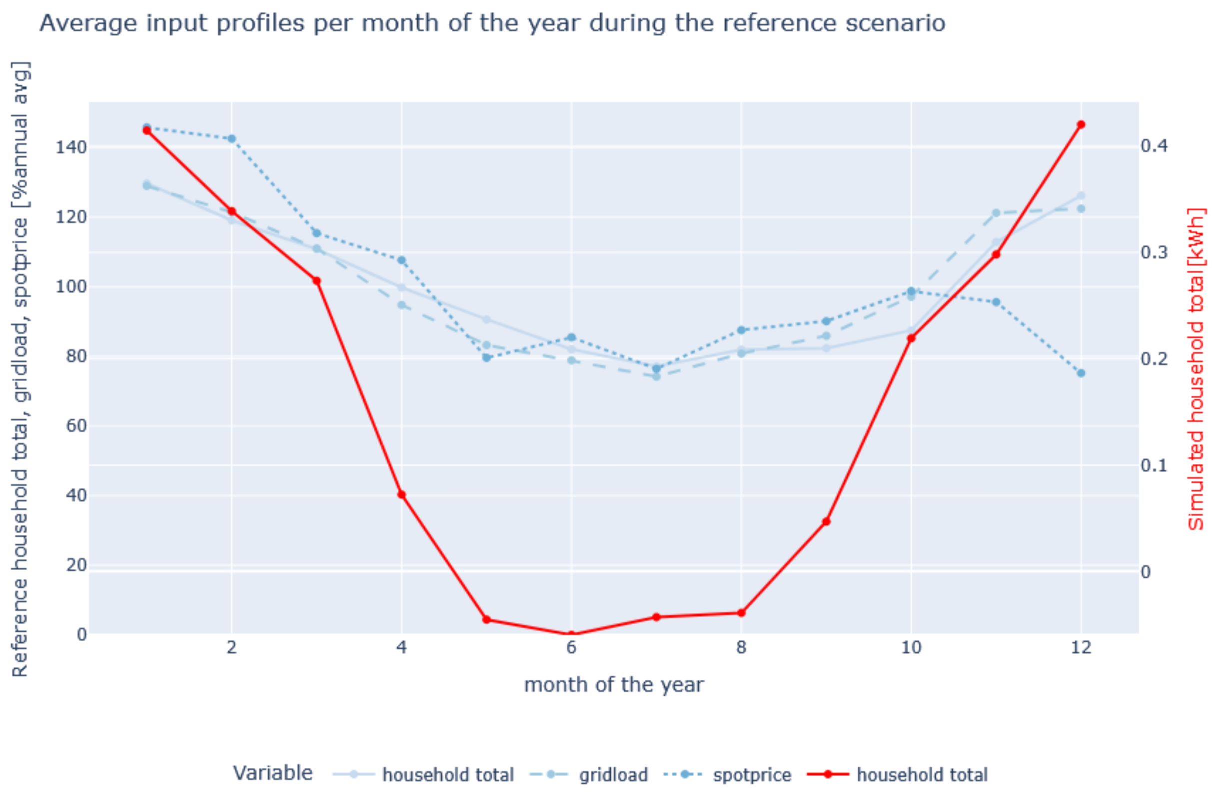
Model and Input: Weekly Load Profiles



Conclusion:

- Small difference between weekend and weekday
- Pattern different from gridload and spotprice (due to focus on **only household load**?)

Model and Input: Monthly Load Profiles



Conclusion:

- Similar seasonal pattern as gridload and reference household
- Stronger seasonal variation (caused by **more PV**?)

Table 3: Tariff Scenarios (Part 1)

kWh tariffs

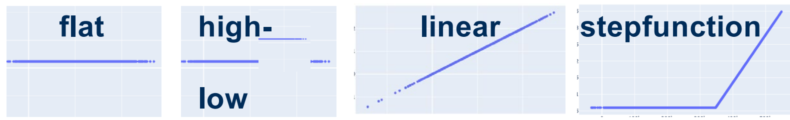
kWp tariffs

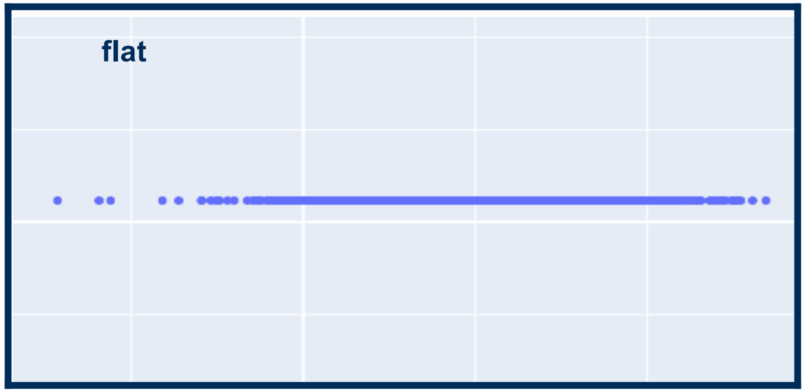
kWp only

kWp combined

Group	Label	#
dynamic kWh only	FlatSymmetric	1
	FlatAsymetric	2
	High-Low per kWh	3
	Spot only	4
	Spot+grid(linear)	5
	Spot+grid(stepfunct)	6
Flat kWp only	year	7
	month	8
	week	9
	day	10
	4h	11
	1h	12
Flat kWp combined	year	13
	month	14
	week	15
	day	16
	4h	17
	1h	18
High-Low kWp only	fixed hour	19
	fixed month-hour	20
	dynamic hour	21
High-Low kWp combined	fixed hour	22
	fixed month-hour	23
	dynamic hour	24

Stylized illustration of tariffs:





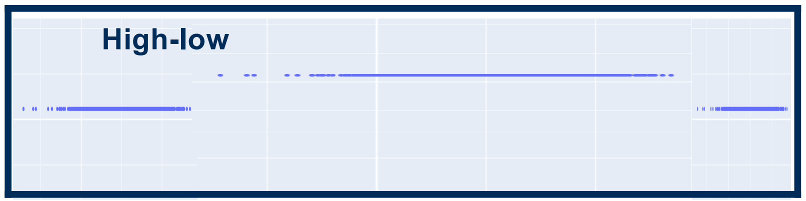
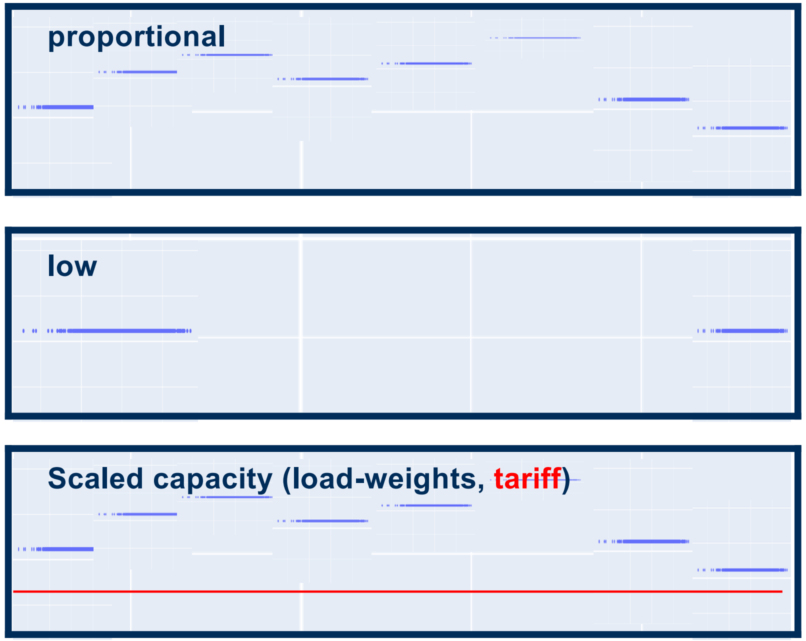


Table 3: Tariff Scenarios (Part 1)

kWp tariffs

Group	Label	#
Proportional kWp only	month	25
	week	26
	day	27
	4h	28
Proportional kWp combined	month	29
	week	30
	day	31
	4h	32
Low kWp combined	spotprice fixed hours (daily)	33
	spotprice <Q50% (daily)	34
	gridload <Q72%	35
	gridload <Q72%, weeks	36
	gridload <Q72%, days	37
Scaled kWp only	linear	38
	convex	39
	concave	40
Scaled kWp combined	linear	41
	convex	42
	concave	43

Stylized illustration of tariffs:



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Results: across scenarios

Conclusion:

- **energy cost** reductions **up to 20%**
- especially **dynamic kWh**, and **kWp combined**

- **grid cost** reductions **up to 12%**
- especially **flat kWp**, and **prop.kWp**

- **total cost** reductions **up to 10%**
- especially **flat kWp**, and **prop.kWp**

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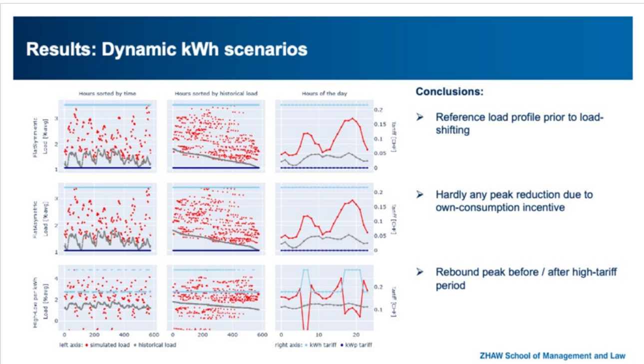
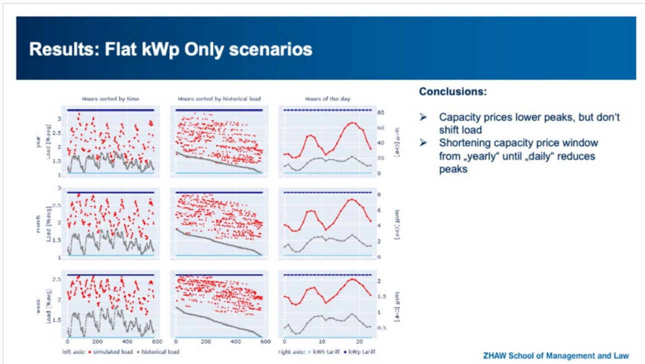
Results: selected scenarios

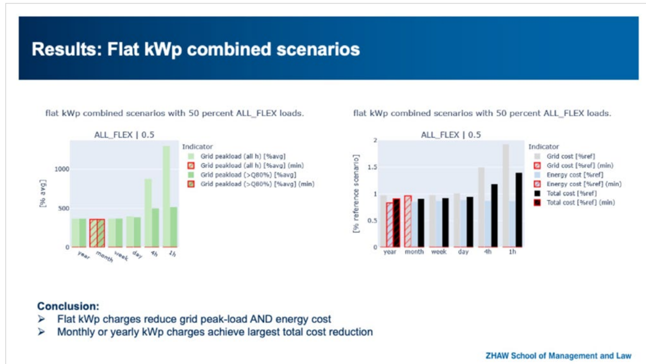
Dynamic kWh

Flat kWp only

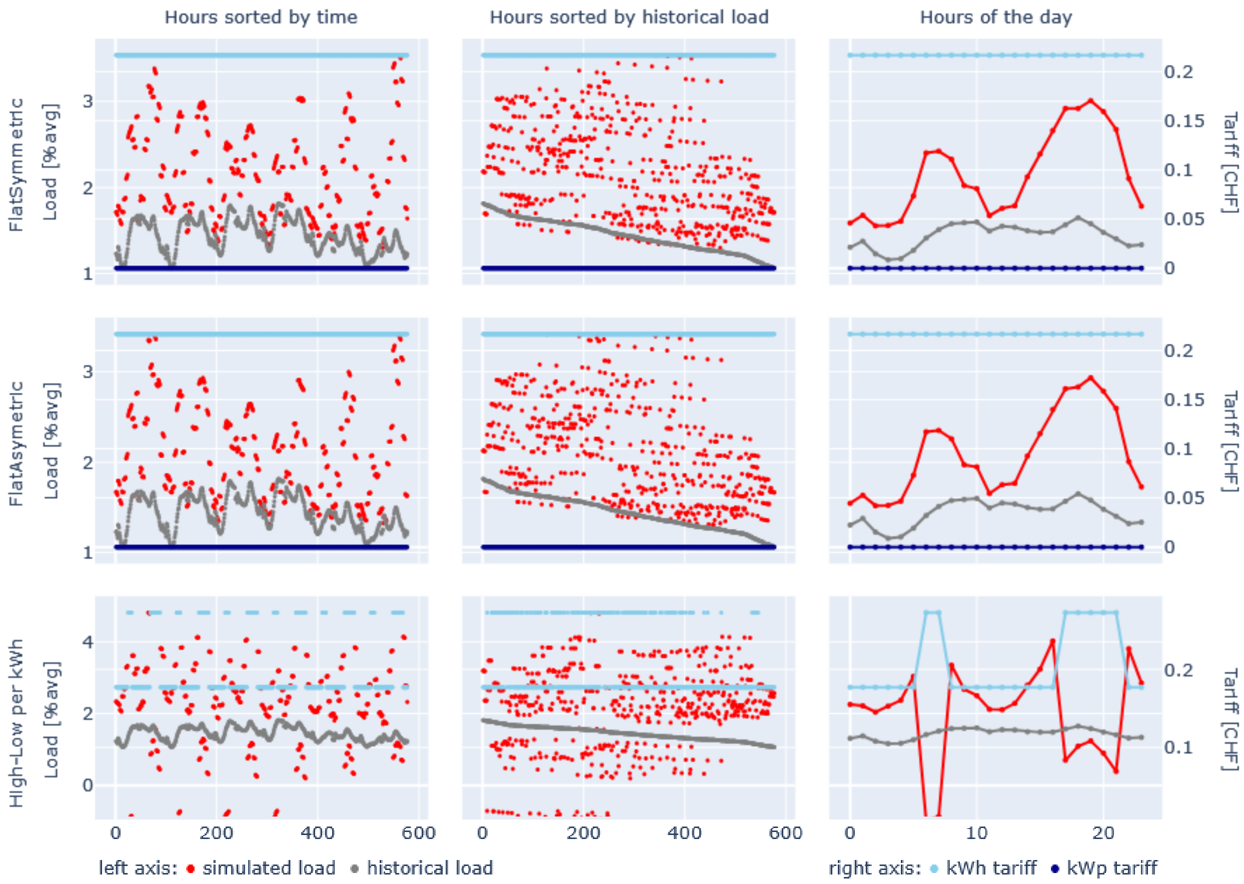
Flat kWp combined







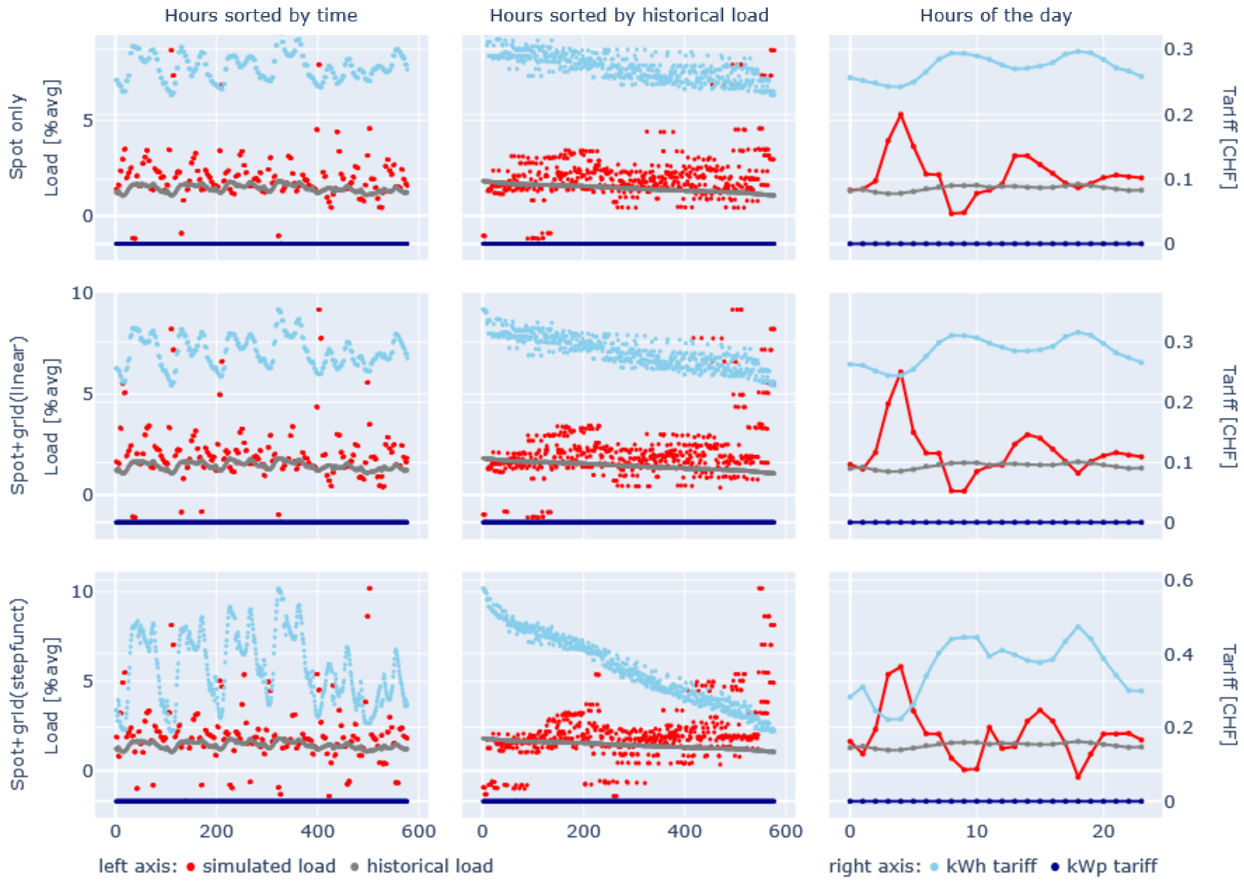
Results: Dynamic kWh scenarios



Conclusions:

- Reference load profile prior to load-shifting
- Hardly any peak reduction due to own-consumption incentive
- Rebound peak before / after high-tariff period

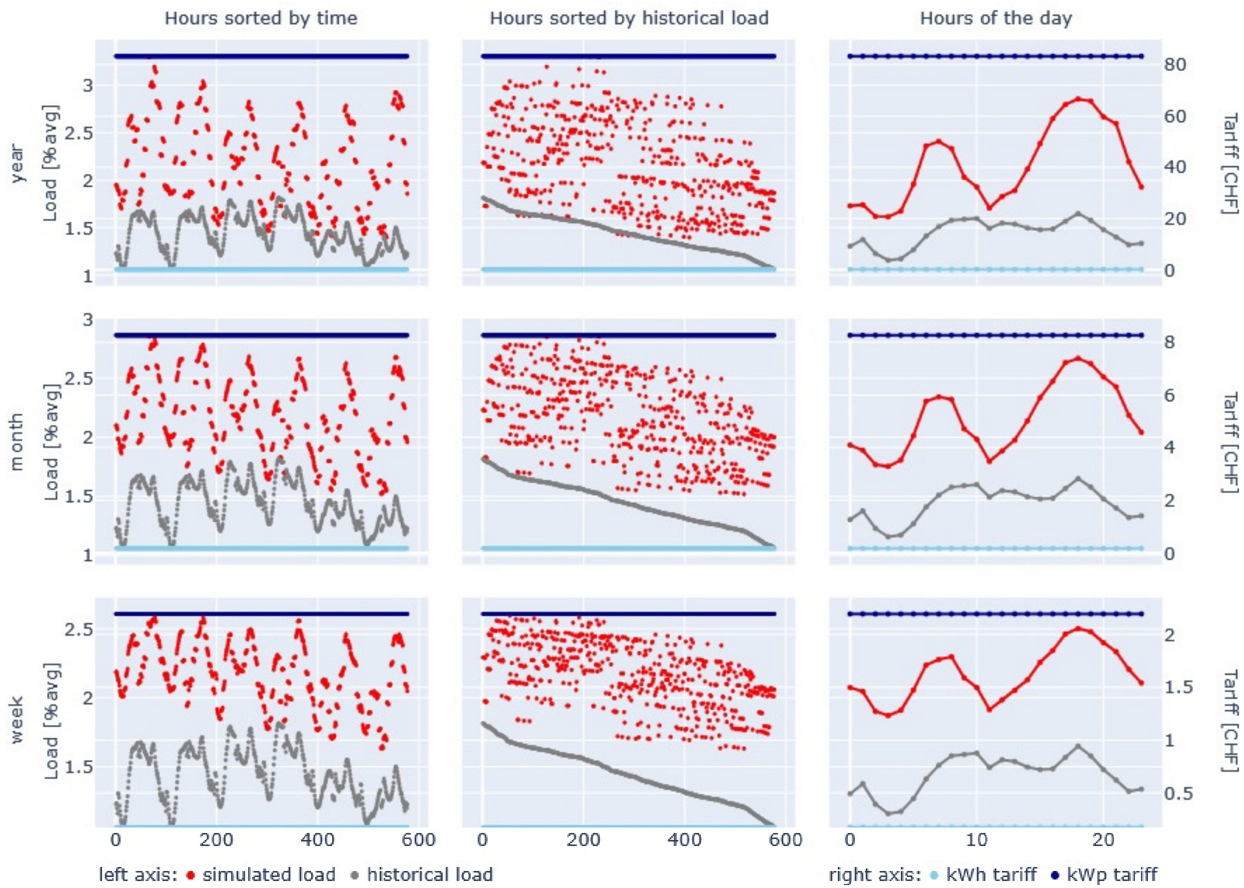
Results: Dynamic kWh scenarios



Conclusions:

➢ Excessive load-shifting to periods with low kWh price causes rebound peaks (in all 3 scenarios)

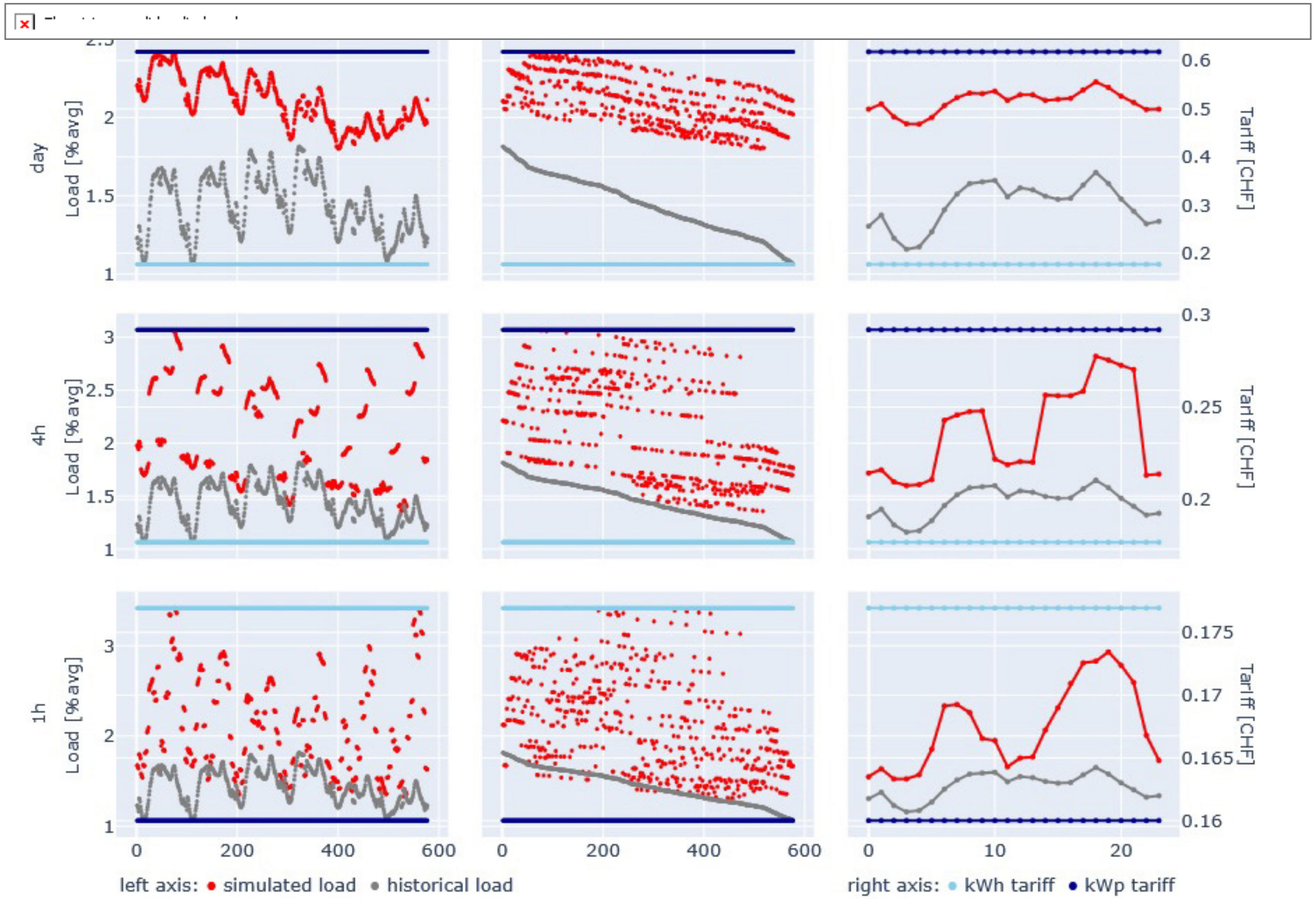
Results: Flat kWp Only scenarios



Conclusions:

- Capacity prices lower peaks, but don't shift load
- Shortening capacity price window from „yearly" until „daily" reduces peaks

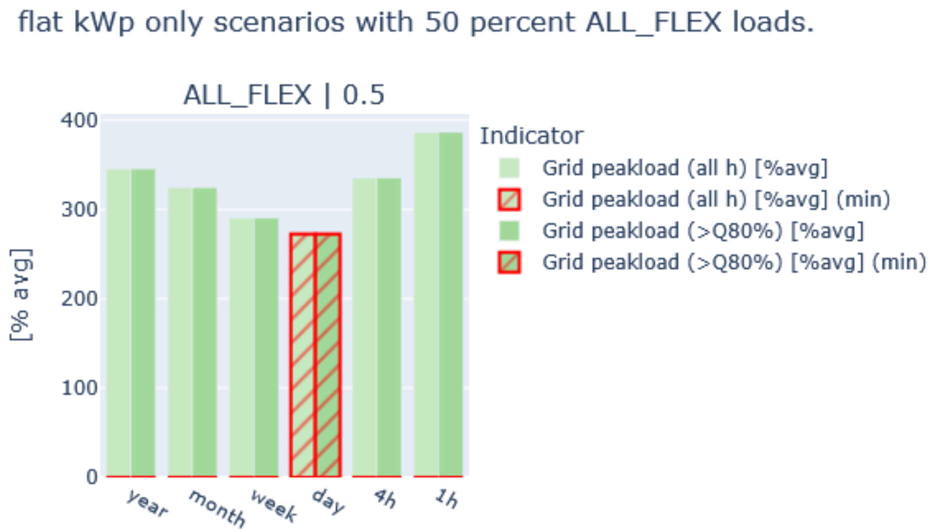
Results: Flat kWp Only scenarios

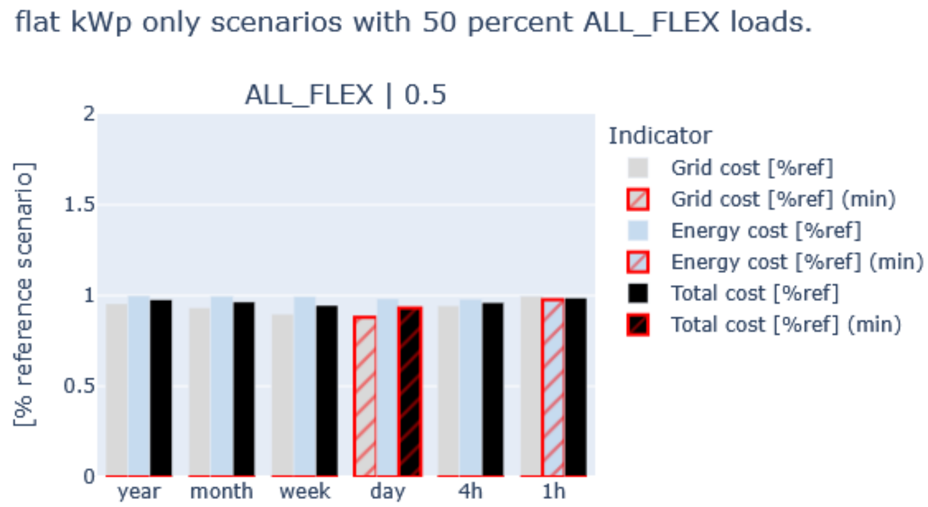


Conclusions:

- Daily capacity price achieves lowest peak
- Further shortening capacity price window from „day“ to „1h“ increases peaks

Results: Flat kWp Only scenarios

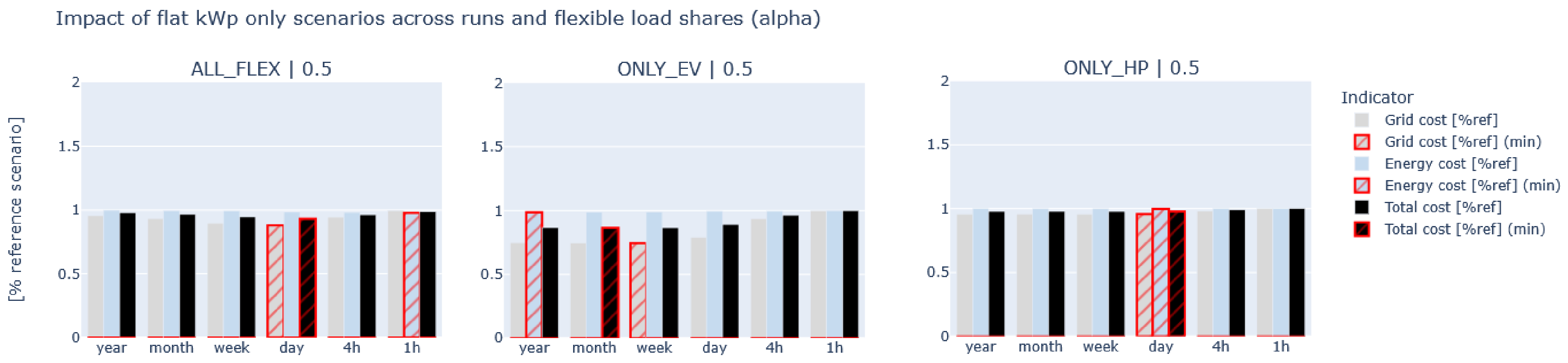




Conclusion:

- Daily kWp charges achieve largest peak-load and cost reduction
- Flat kWp charges reduce grid peak-load but don‘t reduce energy cost

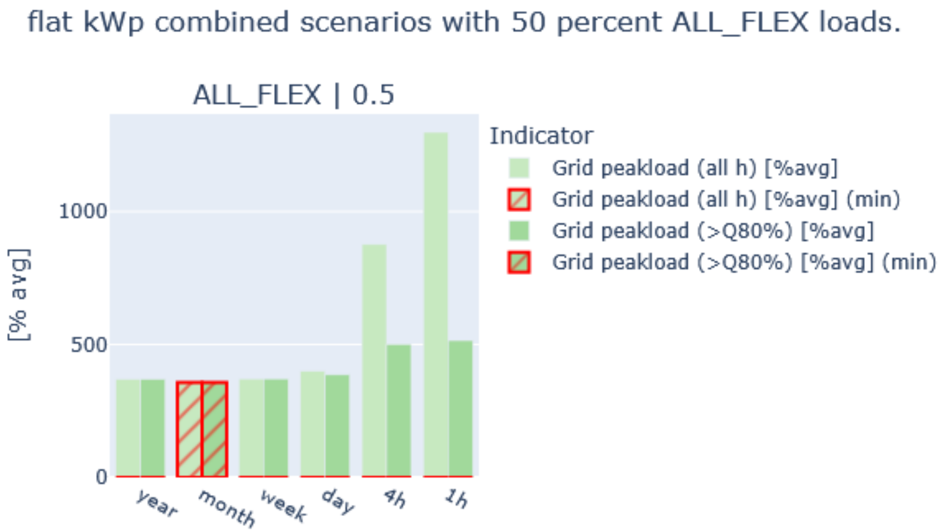
Results: Flat kWp Only scenarios – sensitivities

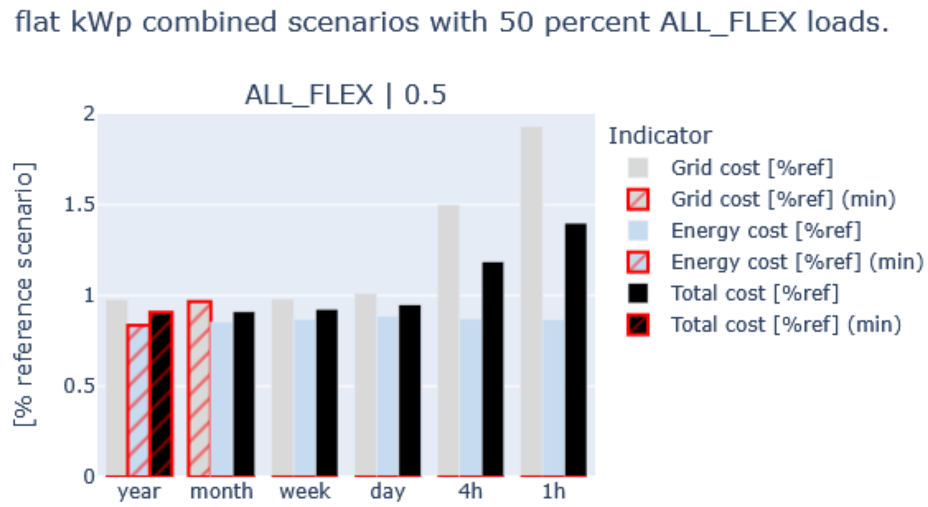


Conclusion:

- Optimal duration of capacity price for EVs („month“, „week“) longer than for HP („day“)
- Optimal duration longer for more flexible devices

Results: Flat kWp combined scenarios

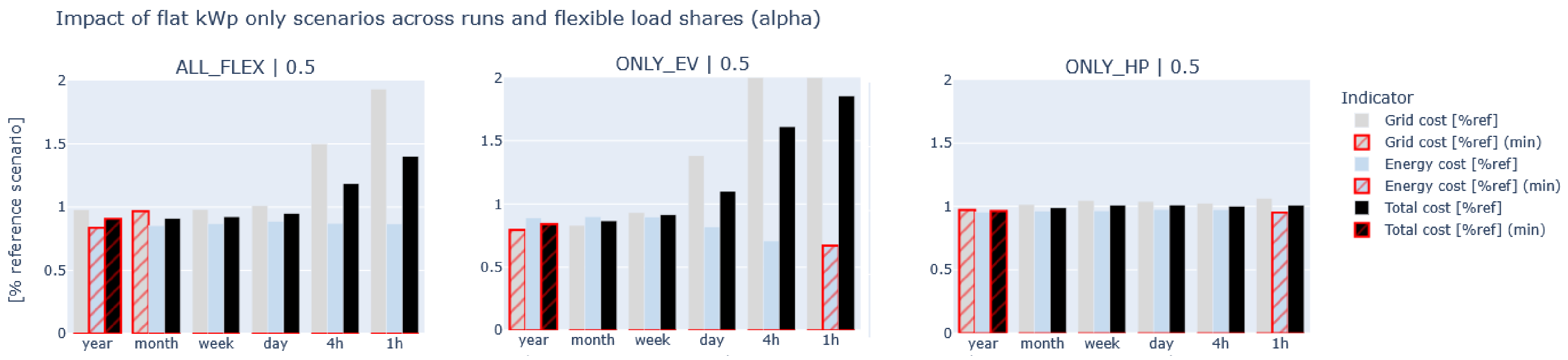




Conclusion:

- Flat kWp charges reduce grid peak-load AND energy cost
- Monthly or yearly kWp charges achieve largest total cost reduction

Results: Flat kWp combined scenarios – sensitivities



Conclusion:

➢ Optimal duration for flat kWp *combined* scenarios is *longer* than for flat kWp only, and *independent* of the device

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Preliminary Conclusions

- **Trade-off between energy cost and grid cost**
  - Best **energy cost reduction (20%)**: in case of **dynamic kWh charges** only
  - Best **grid cost reduction (12%)**: achieved by **capacity charges only**
  - Best **total cost reduction (10%)**: achieved by combination of **dynamic kWh** charges and **capacity charges**

- **Yearly or monthly Flat kWP** charge combined with **dynamic kWh** energy charge achieves most efficiency gains - more advanced tariff designs provide little benefit.

- **Optimal duration** of capacity charges:
  - Should **match the maximum load-shifting duration** of flexible loads (in case of capacity charges only)
  - [May **exceed maximum load-shifting duration** (in case of capacity charges combined with dynamic kWh tariffs)?]

Limitations

- Preliminary results: further sense-checks required
- Overestimation: 100% efficient automatic load control; no baseload;
- Consistency: tariff calibrated on historical grid-load (prior to load-shifting); no feedback from load-shifting on tariff levels

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Next steps

- Further **consistency checks** (e.g. verify shielding effect of unflexible loads)

- Calculate **different levels** of capacity charge:
  - E.g. 10%, 30%, 50%, 70%, 90% of fixed cost
  - Compare best performing charge across all scenario groups

- Others?

Disclaimer

– Die vorliegenden Arbeiten wurden im Rahmend der Projekte PATHFNDR und NEDELA mit Unterstützung des Bundesamts für Energie durchgeführt.

– Für Inhalt und Schlussfolgerungen sind ausschliesslich die Autoren verantwortlich.

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Confédération suisse
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Confederaziun svizra

Bundesamt für Energie

Thank you for your attention !

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