Operation and market mechanisms: from dynamic electricity tariffs to day-ahead and intraday auctions

Christian Winzer (ZHAW) &
Thomas Hübner (ETH Zürich)

**School of
Management and Law**

Dynamische Tarife

Building Competence. Crossing Borders.

Christian Winzer
winc@zhaw.ch

Einleitung: Hintergrundarbeiten

- **Projekte**:
  - <u>NETFLEX</u> (2019-22): mit ENIWA zu Netztarife für flexible Lasten
  - <u>PATHFNDR</u> (2021-27): zu approaches for linking markets
  - <u>PEDALO</u> (2022-26): mit Primeo zu Zahlungsbereitschaft für Senkung der Raumtemperatur
  - <u>NEDELA</u> (2023-27): mit Groupe-E zu „Netztarifen für dezentrale Laststeuerung" (NEDELA)
  - <u>ESIT</u> (2023-27) mit Swisspower zu „Entlastung Stromnetz durch Intelligente Tarife"

- **Workshops:**
  - Forum Energiespeicher Schweiz (2021-11)
  - VSE Netztagung (2021-11)
  - Strommarkttreffen (2023-04)
  - Florence School of Regulation (2023-06)

Einleitung: Hintergrundarbeiten

- Die vorliegenden Arbeiten wurden im Rahmend der Projekte <u>NETFLEX</u>, <u>PATHFNDR</u>, <u>NEDELA</u> und <u>ESIT</u> mit Unterstützung des Bundesamts für Energie durchgeführt.

- Für Inhalt und Schlussfolgerungen sind ausschliesslich die Autoren verantwortlich.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie

zh
aw School of Management and Law

Übersicht

1. **Einleitung**: Auf welchen Analysen basieren die Empfehlungen?

2. **Akzeptanz**: Welche Tarife wünschen Kunden?
   => *Konstante Preise*

3. **Effizienz**: Welche Tarife bewirken netzdienliches Verhalten ?
   => *Dynamische Preise + automatische Laststeuerung*

4. **Synthese+ Ausblick**: Welche Tarife werden empfohlen?
   => *ÜNB/VNB: dyn.Preise, EVU/AGG: konstante Preise +DLC*

NB ➡ **EVU**

zh aw School of Management and Law

Kunden wollen konstante Preise

Table 5
Utilities of the analyzed attributes.

Attribute	Specification	Coeff.	S.D.	t	Sig.
Dynamics	Static	0	–	–	–
	Dynamic	−.383	.072	−5.300	< 0.01
	Variable	−.579	.088	−6.547	< 0.01
Rates: price spread	Low	0	–	–	–
	High	−.126	.057	−2.204	< 0.01
Demand response	Manual	0	–	–	–
	Automated	.565	.057	9.900	< 0.01

Abnehmender Nutzen bei Verträgen mit zunehmender Preisschwankung

School of Management and Law

Opt-out Rekrutierung erhöht Teilnahme aber senkt Wirkung
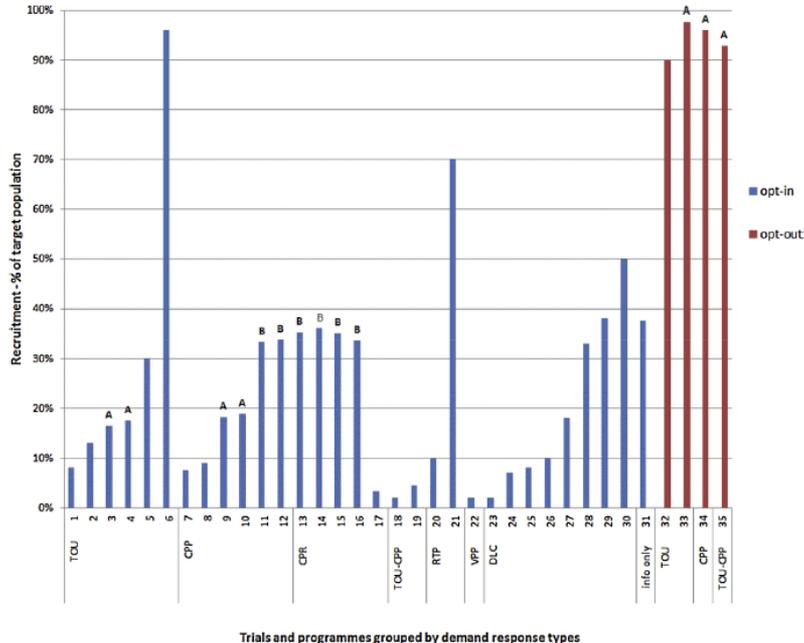
Fig. 3. Reported recruitment by type of demand response[5].

- Hohe Schwankung bei Rekrutierung für denselben Tarifansatz

- Unterschied zwischen Tarifansätzen kaum erkennbar

- Deutlich mehr Rekrutierung über Opt-out als über Opt-in Tarifwahl

School of Management and Law

Übersicht

1. **Einleitung**: Auf welchen Analysen basieren die Empfehlungen?

2. **Akzeptanz**: Welche Tarife wünschen Kunden?
   => *Konstante Preise*

3. **Effizienz**: Welche Tarife bewirken netzdienliches Verhalten ?
   => *Dynamische Preise + automatische Laststeuerung*

4. **Synthese+ Ausblick**: Welche Tarife werden empfohlen?
   => *ÜNB/VNB: dyn.Preise, EVU/AGG: konstante Preise +DLC*

NB ➤ **EVU**

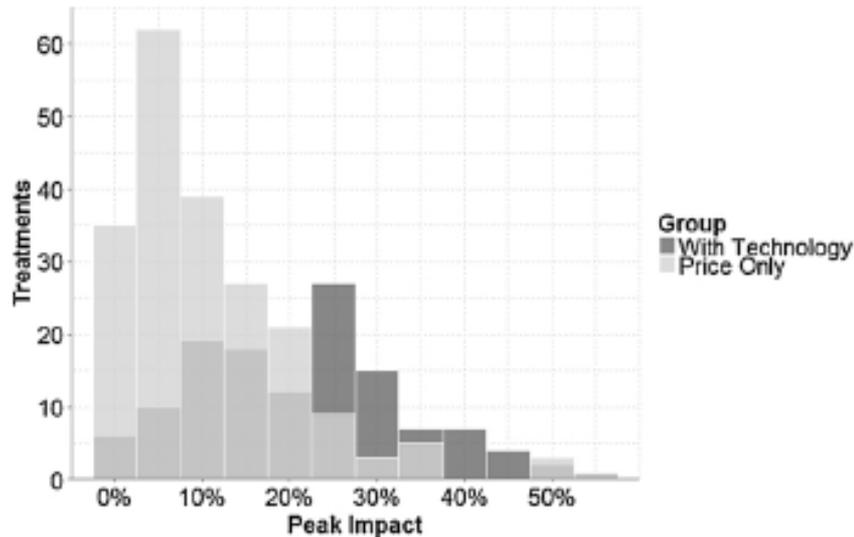# Automatisierung und höhere Preisspitzen erhöhen Tarifwirkungs
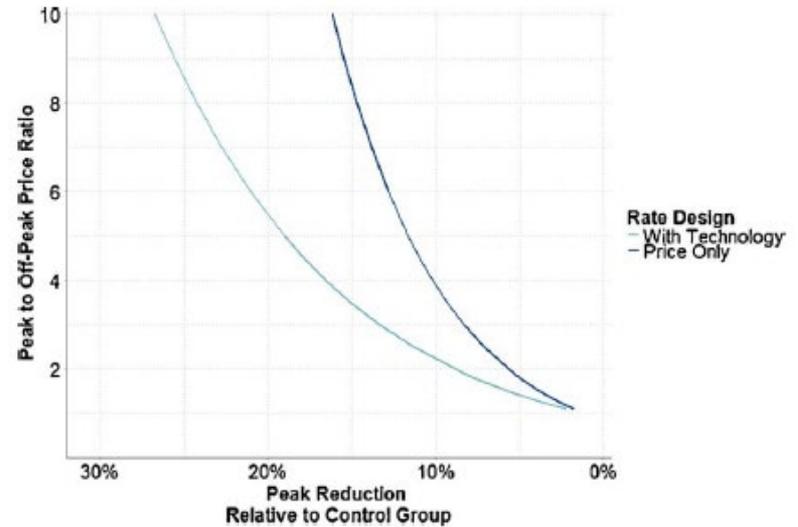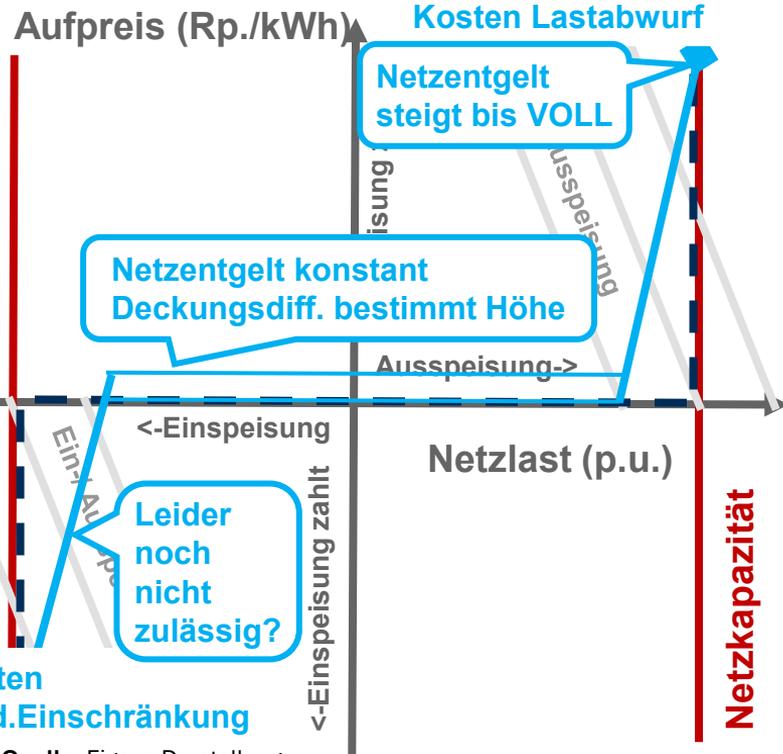

Fig. 8. Comparison of all treatments.

Fig. 14. The arc of price responsiveness.

Quelle: Faruqui, A., Sergici, S., & Warner, C. (2017). Arcturus 2.0: A meta-analysis of time-varying rates for electricity. The Electricity Journal, 30(10), 64–72.
https://doi.org/10.1016/j.tej.2017.11.003

zh
aw School of
Management and Law

Effiziente Gestaltung und Kalibrierung von dynamischen Tarife

First-Best: Nodale Preise:

- Ausserhalb Engpass: kein Aufpreis
- Bei Engpass: marg. Kosten der Lastanpassung

Second Best: Dynamische Tarife

- Vor Engpass: steigende/fallende Preise für alle Anlagen

Third Best: Produktionsbeschränkung, Batterietarife...
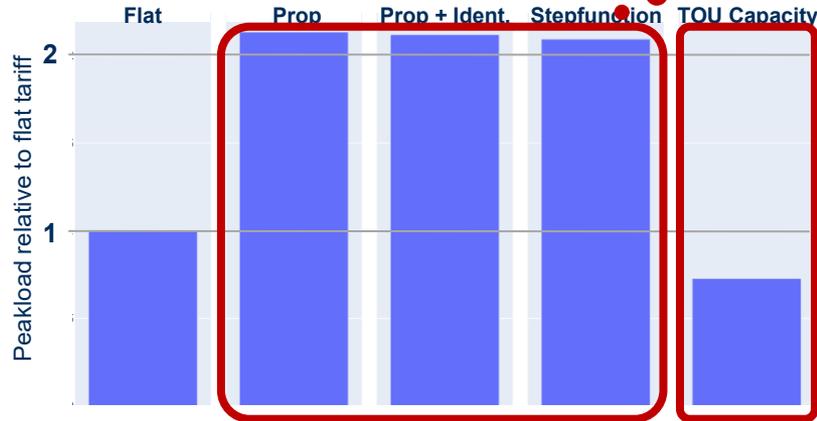
- Vor Engpass: Anreize nur für Erneuerbare, Batterien…

Literatur:

- Boiteux, Marcel. 1960. "Peak-Load Pricing." J. of Business 33 (2): 157–79.
- Chao, Hung-Po, and Stephen Peck. 1996. "A Market Mechanism for Electric Power Transmission." *Journal of Regulatory Economics* 10 (1): 25–59.
- Pérez-Arriaga et al. 1995. "Marginal Pricing of Transmission Services: An Analysis of Cost Recovery." IEEE Trans. on Power Systems 10 (1): 546–53.
- Caramanis et al. 2016. "Co-Optimization of Power and Reserves in Dynamic T&D Power Markets." Proc. of IEEE 104 (4): 807–36.
- Winzer, Christian, Conceptual Recommendations for Optimal Grid Tariff Design (June 19, 2023). https://ssrn.com/abstract=4484167 or http://dx.doi.org/10.2139/ssrn.4484167

Quelle: Eigene Darstellung.

Ansätze zur Vermeidung von Überkoordination

Quelle: Winzer, Christian, and Ali Darudi (forthcoming)

Management and Law
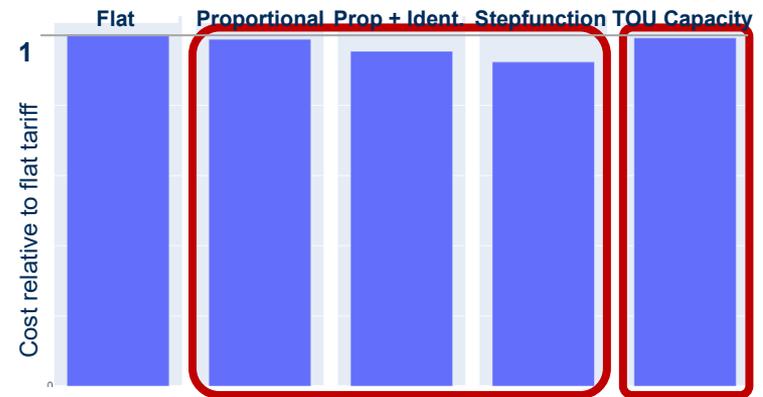
In der Praxis: reagieren selbst Kunden mit automatisiertem Lastmanagement häufig nicht optimal

good:

Customer:customer_1, region:region_1, group:group_1, EMS:EMS_2
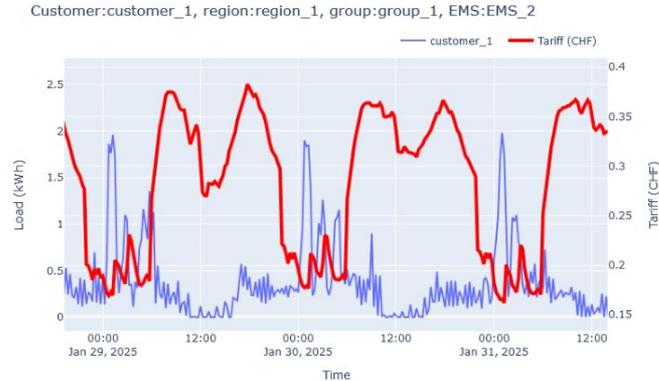
- Im Rahmen der Feldstudie reagierten:
  - 9 Kunden optimal
  - 15 Kunden akzeptabel
  - 32 Kunden nicht, oder widersinnig

bad:

Customer:customer_35, region:region_2, group:group_2, EMS:EMS_3

ugly:

Customer:customer_52, region:region_1, group:group_1, EMS:EMS_2
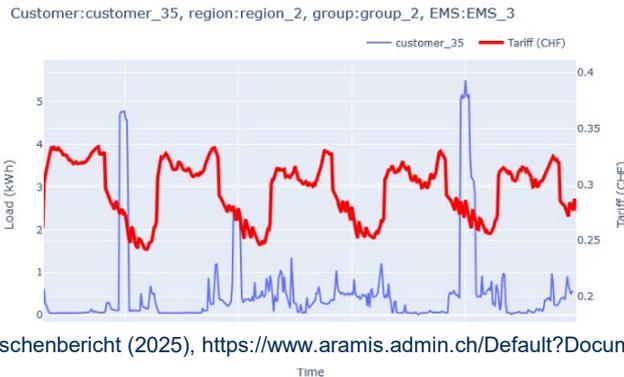
Quelle: ESIT Zwischenbericht (2025), https://www.aramis.admin.ch/Default?DocumentID=73404

Übersicht

1. **Einleitung**: Auf welchen Analysen basieren die Empfehlungen?

2. **Akzeptanz**: Welche Tarife wünschen Kunden?
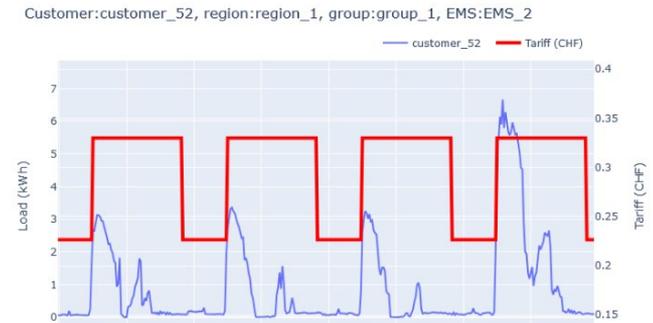   => *Konstante Preise*

3. **Effizienz**: Welche Tarife bewirken netzdienliches Verhalten ?
   => *Dynamische Preise + automatische Laststeuerung*

4. **Synthese+ Ausblick**: Welche Tarife werden empfohlen?
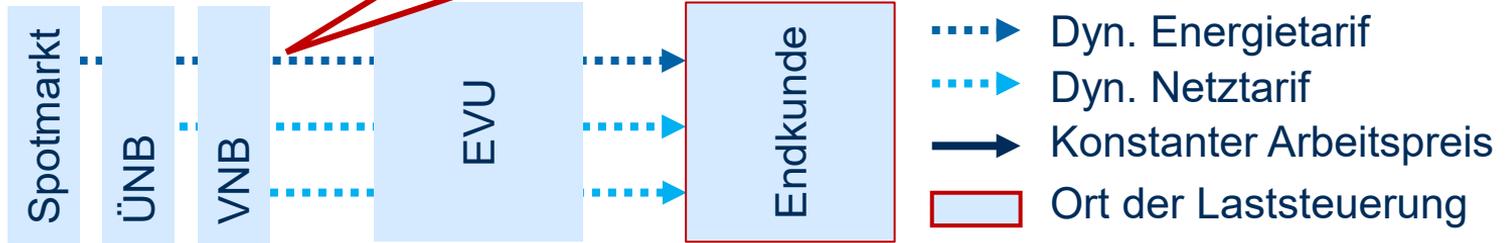   => *VNB: dyn.Preise, EVU, or AGG: konstante Preise +DLC*

VNB ➡ **EVU** ➡

zh aw School of Management and Law

Synthese & Ausblick

Dyn.Preise wichtig, für optimale Priorisierung zwischen Markt und versch. Netzebenen

a) Dynamische Preise/ mehrst. Leistungspreis

Spotmarkt — ÜNB — VNB — EVU — Endkunde

- - - ► Dyn. Energietarif
- - - ► Dyn. Netztarif
——► Konstanter Arbeitspreis
☐ Ort der Laststeuerung

b) Direkte Laststeuerung

Spotmarkt — ÜNB — VNB — EVU/ AGG — Endkunde

Preisabsicherung durch EVU oder Aggregatoren erhöht Akzeptanz
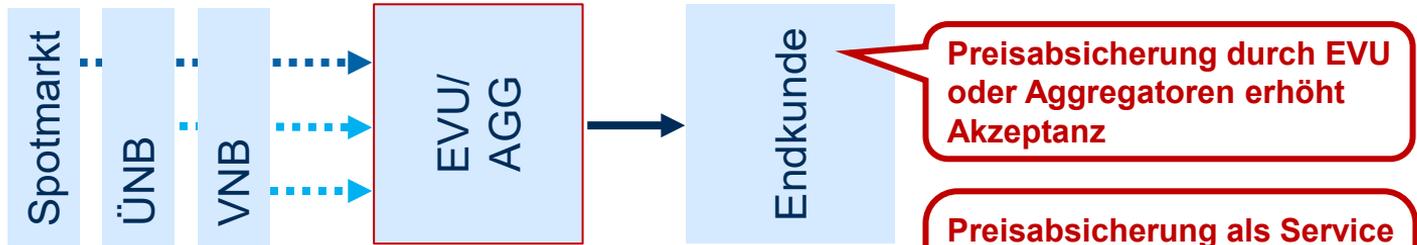
c) Geräte- spezifische Verträge

Spotmarkt — ÜNB — VNB

AGG1 → Boiler

AGG2 → Elektroauto

EVU → Übrige Last

Endku...

Preisabsicherung als Service der Aggregatoren verbessert Laststeuerung und erhöht Einsparpotenzial?

Win...dynam...arife

zh School of
aw Management and Law
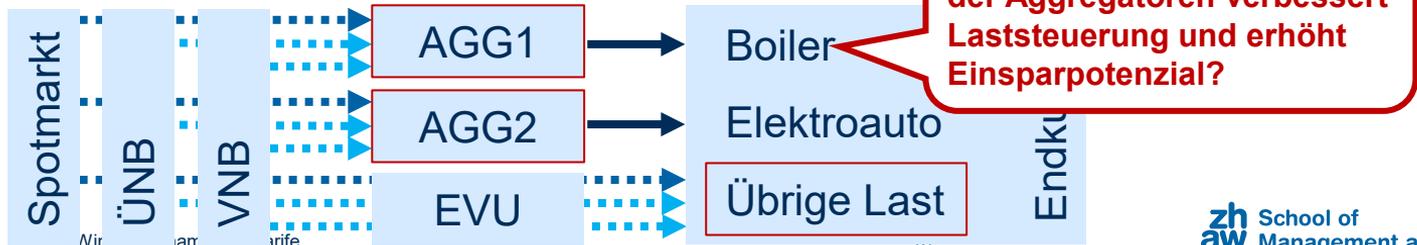
Profilverträge: könnten Anreize für Laststeuerung auch schon vor Marktöffnung verbessern.. und Kosten flexibler Kunden senken.

- **Voraussetzung: EVUs verrechnen dyn.Tarife +Strompreis (ggf. mit Aufschlag)**

- Aggregatoren bieten Preisabsicherung und Laststeuerung als Service

- Kunden reagieren auf Strompreis und sparen

Profile contracts for electricity retail customers

Christian Winzer [a], Héctor Ramírez-Molina [a], Lion Hirth [b c], Ingmar Schlecht [a b]

Show more ∨

+ Add to Mendeley   ⭿ Share   " Cite

https://doi.org/10.1016/j.enpol.2024.114358 ↗

Under a Creative Commons license ↗

Get rights and content ↗

● Open access

Highlights

- Profile contracts reduce bill volatility to similar levels as fixed price contracts.

- Profile contracts restore flexibility incentives suppressed by fixed price contracts.

- Profile contracts may reduce bill of flexible customers compared to fixed prices.

- Demand for profile contracts expected to increase as load flexibility increases.

Quelle: Winzer, C., Ramírez-Molina, H., Hirth, L., & Schlecht, I. (2024). Profile contracts for electricity retail customers. *Energy Policy*, *195*, 114358. https://doi.org/10.1016/j.enpol.2024.114358

zh aw School of Management and Law

Weitere Informationen

Fachtagung Dynamische Tarife

Wann: **22. Mai 2026, 10:00 bis 16:00**
Wo: ZHAW, St.-Georgen-Platz 2,
8400 Winterthur, Lageplan

Anmeldung: Link

swisspower

zh aw

zh aw

School of
Management and Law

Neue Energiewirtschaft

Certificate of Advanced Studies (CAS)

In Kooperation mit

aeesuisse
Dachverband der Wirtschaft für
erneuerbare Energien und Energieeffizienz
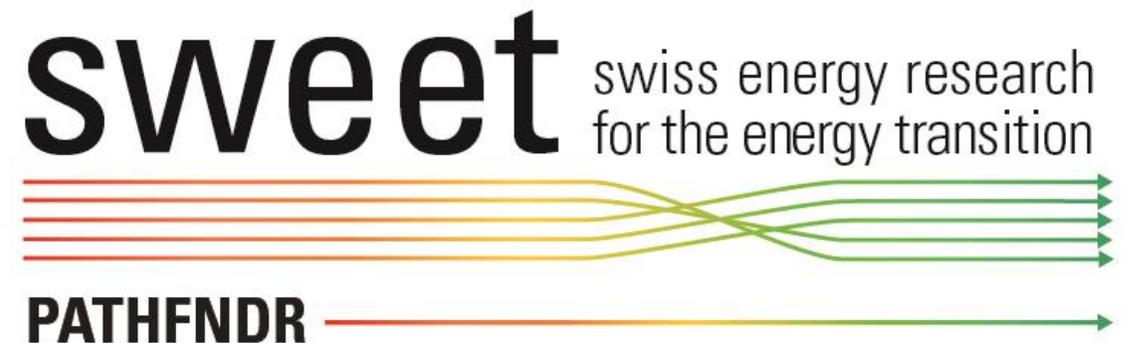
Danke für Ihr Interesse!

Dr. Christian Winzer

ZHAW School of Management and Law

Zentrum für Energie und Umwelt

Gertrudstrasse 8

8400 Winterthur

📞 +41 (0) 58 934 49 45

✉ christian.winzer@zhaw.ch

zh aw School of Management and Law

Lunch talk series V:
Flexibility provision from buildings and electromobility

1. Impacts of electric vehicles and heat pumps flexibility: European and Swiss perspectives

2. End-user flexibilities for electrical distribution grid planning

3. Modelling flexibility from electric vehicles: where, when, why, and how

4. Modelling flexibility from heat pumps: a bottom-up approach for Swiss buildings

5. Electrification, flexibility or both?

6. Emerging trends in recent Swiss and European policy

7. **Operation and market mechanisms: from dynamic electricity tariffs to day-ahead and intraday auctions**

Dynamic Tariffs and Auctions: Two Sides of the Same Coin

- Dynamic tariff **prices are determined** in the day-ahead auction

- Utilities must bid aggregated flexibility in the day-ahead auction to **avoid losses** when offering dynamic tariffs

"If consumers buy at low prices, the utility must also buy at low prices."

Day-Ahead Auction

Bidding Flexible Demand

Payment

Electricity

Utility / Aggregator

Dynamic Tariffs

Payment

Electricity

End-Consumers
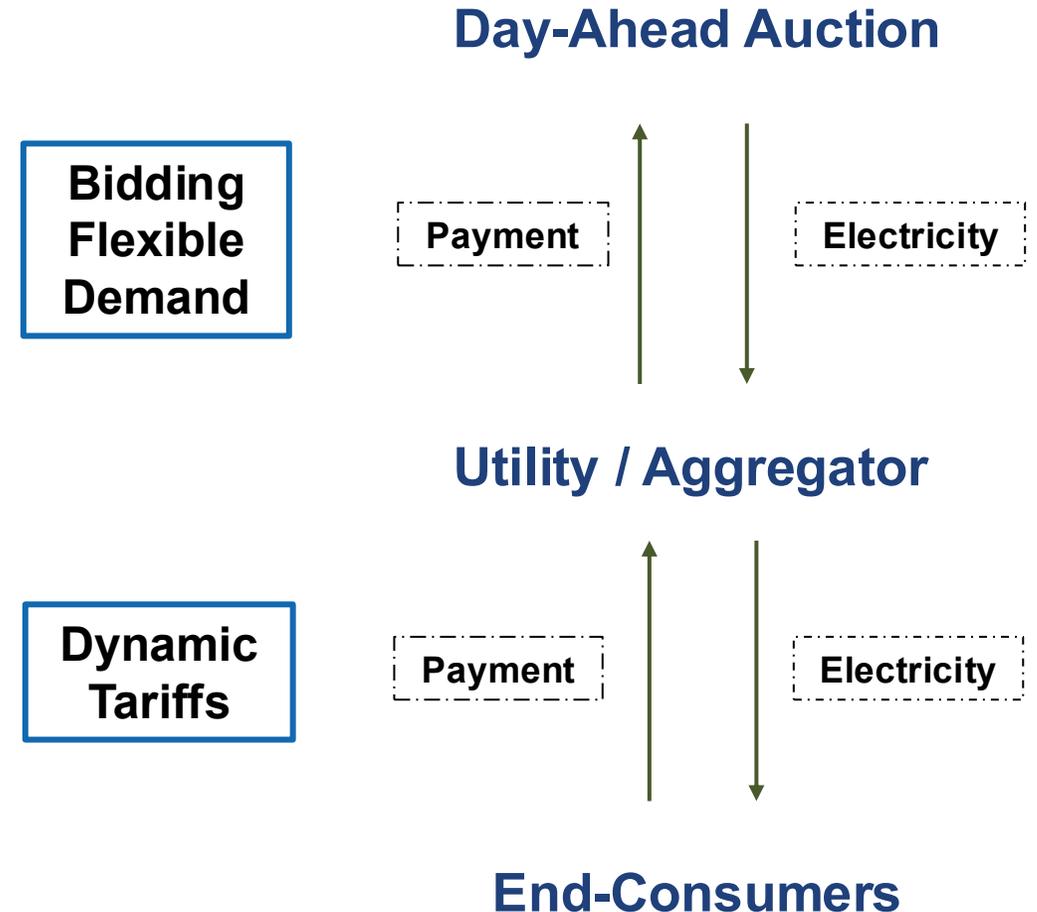
How to Bid Flexibility?

- **Flexibility bids** offered by EPEX Spot (Swiss Nominated Electricity Market Operator)

- Signal the potential to **shift electricity demand over time**

- **Auction algorithm** matches demand profiles with renewable generation to minimize utilities' procurement costs
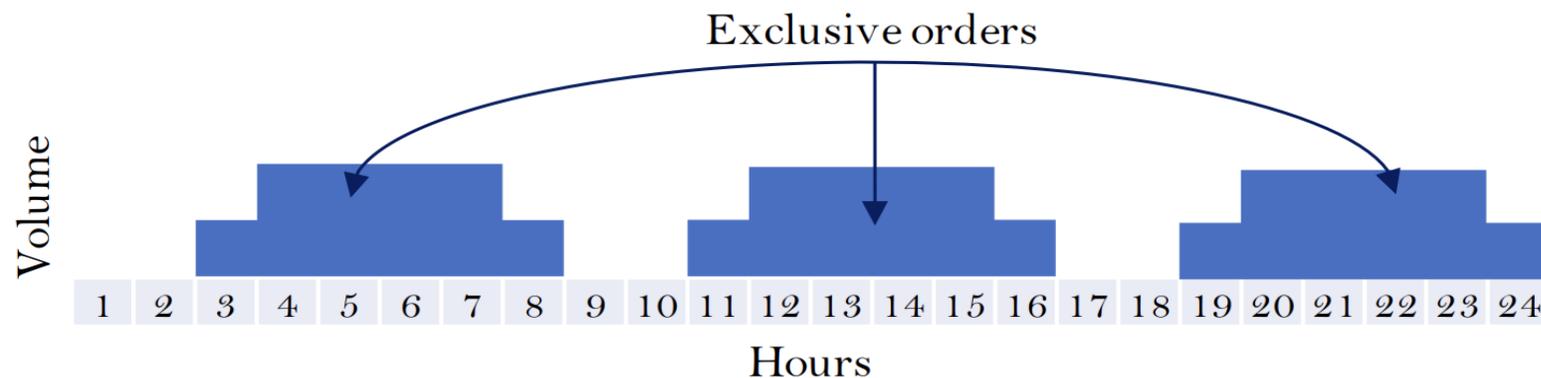
Herrero, I., Rodilla, P., & Batlle, C. (2020). *Energies*.

Demand Side Flexibility in the Day-Ahead Auction: Switzerland compared to Europe

BID DATA OF SUBMITTED EXCLUSIVE GROUPS IN 2024.

Bidding zone	Demand-side EGs	Median buy bids/group	Supply-side EGs	Median sell bids/group
AT	52	1	1	2
BE	448	24	2,483	21
FR	2,259	17	11,260	22
DE/LX	2,101	13	12,589	15
GB	711	8	12,083	24
NL	298	12	5,923	24
CH	19	12	272	20

Switzerland has significantly <u>fewer flexible demand-side bids</u> compared to other countries

Our Work

- **Decision-Support Tools for Utilities**

  - Fast, simple, and robust algorithms to determine demand-side bids

- **Economic and Mathematical Analysis**

  - Assessment of welfare impacts and mathematical properties of package bids

- **Case Study: Losone, Ticino**

  - Simulation for the town of Losone to demonstrate proof of concept

Contextual Areas

Package Bids in Combinatorial Electricity Auctions: Selection, Welfare Losses, and Alternatives

Thomas Hübner,[a,*] Gabriela Hug[a]

[a] Power Systems Laboratory, Department of Information Technology and Electrical Engineering, ETH Zürich, 8092 Zurich, Switzerland
*Corresponding author
Contact: thuebner@ethz.ch, https://orcid.org/0009-0002-9837-6606 (TH); ghug@ethz.ch, https://orcid.org/0000-0002-4312-616X (GH)

Abstract. A key challenge in combinatorial auctions is designing bid formats that accurately capture agents' preferences while remaining computationally feasible. This is especially true for electricity auctions, where complex preferences complicate straightforward solutions. In this context, we examine the XOR package bid, the default choice in combinatorial auctions and adopted in European day-ahead and intraday auctions under the name "exclusive group of block bids." Unlike parametric bid formats often employed in U.S. power auctions,

Bidding Aggregated Flexibility in European Electricity Auctions

Gabriel Ellemund, Thomas Hübner, Quentin Lété, Stefano Bracco, Matteo Fresia, Gabriela Hug

Abstract—Bidding flexibility in day-ahead and intraday auctions would enable decentralized flexible resources, such as electric vehicles and heat pumps, to efficiently align their consumption with the intermittent generation of renewable energy. However, because these resources are individually too small to participate in those auctions directly, an aggregator (e.g., a utility) must act on their behalf. This requires aggregating many decentralized resources, which is a computationally challenging task. In this paper, we propose a computationally efficient and highly accurate method that is readily applicable to European day-ahead and intraday auctions. Distinct from existing methods, we aggregate only economically relevant power profiles, identified through price forecasts. The resulting flexibility is then conveyed to the market operator via exclusive groups of block bids. We

temporal mismatches between supply and demand, supporting RES integration while reducing curtailment and dependence on costly storage solutions [3]. Yet, the flexibility of these small-scale resources remains largely unexploited, as they are typically operated individually and without optimization. To unlock this potential, aggregators must offer the aggregated flexibility of individual resources on the market [4].

For this purpose, the aggregator needs to compute the aggregated flexibility of the individual resources. Mathematically, the flexibility of a single resource can be represented as a set in a multi-dimensional power space, encompassing all feasible operating states of the resource over a given time horizon.

Recommendations

Swiss Utilities

- Make use of demand-side flexibility bids to reduce procurement costs and shift load

- We offer decision-support tools and a detailed case study to illustrate the approach

Swiss Nominated Electricity Market Operator (EPEX Spot SE)

- Allow profile bids to include both purchase and sale quantities

- Increase the maximum number of profiles per exclusive group from 24 to 100

Lunch talk series V:
Flexibility provision from buildings and electromobility

1. Impacts of electric vehicles and heat pumps flexibility: European and Swiss perspectives

2. End-user flexibilities for electrical distribution grid planning

3. Modelling flexibility from electric vehicles: where, when, why, and how

4. Modelling flexibility from heat pumps: a bottom-up approach for Swiss buildings

5. Electrification, flexibility or both?

6. Emerging trends in recent Swiss and European policy

7. Operation and market mechanisms: from dynamic electricity tariffs to day-ahead and intraday auctions

Thomas Hübner
thuebner@ethz.ch
ETH Zürich
Power Systems Laboratory
Department of Information Technology and Electrical Engineering

PATHFNDR: www.sweet-pathfndr.ch