The Impact of Electricity Price Forecasting Uncertainty on Network Tariff Performance with Flexible Residential Loads

Roman Hennig, PhD Researcher at TU Delft

Supervisors:
Prof. Dr. ir. Laurens de Vries
Dr. Simon Tindemans

With: Niels Goedegebeure, Msc student

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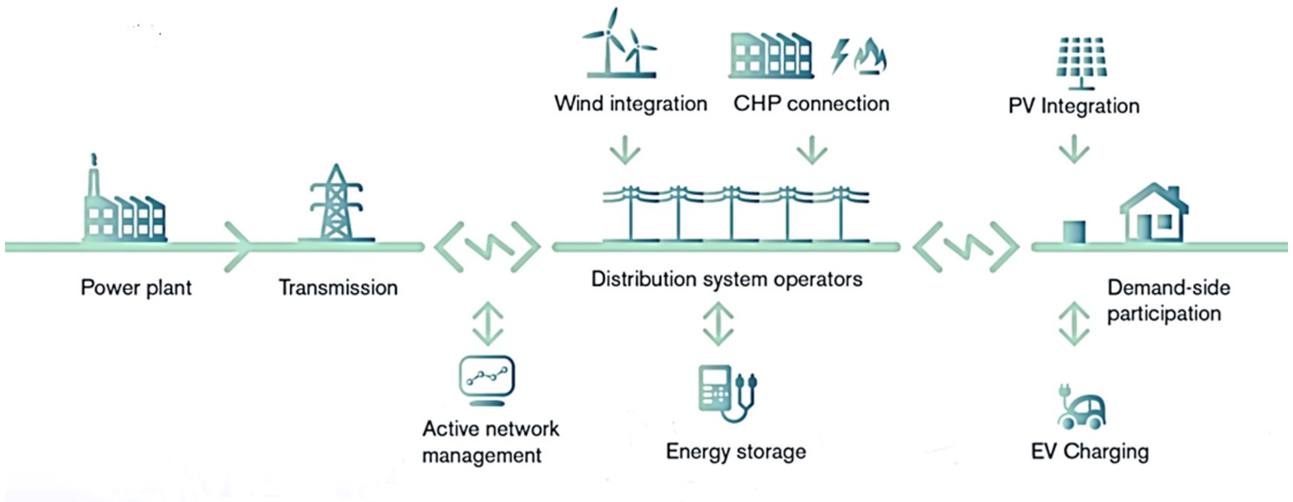
Outline

1. Introduction to research problem: network tariffs and their objectives
2. Network tariff assessment framework
3. Results without price uncertainty
4. Adding uncertainty: results with probabilistic price scenario forecasts
5. Conclusion

Background: Changing Landscape for Electric Distribution Grids, new Challenges for DSOs

BEFORE

NOW



Source: E.DSO, https://www.edsoforsmartgrids.eu/home/why-smart-grids/

Problem Statement

- Network tariffs are charged to recover costs for the network and can be used to steer flexible loads
- Network Tariffs regulatory principles:
  - Cost-reflectiveness
  - Network security, in particular: congestion management, incrementalism of changes
  - Consumer facing: transparency, simplicity, predictability
  - Efficiency, making use of flexibility
  - Non-discrimination and fairness
- These are widely accepted and cited, <u>however:</u>
  - Objectives are **antagonistic** and
  - Difficult to **measure**

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Tariff Assessment Framework

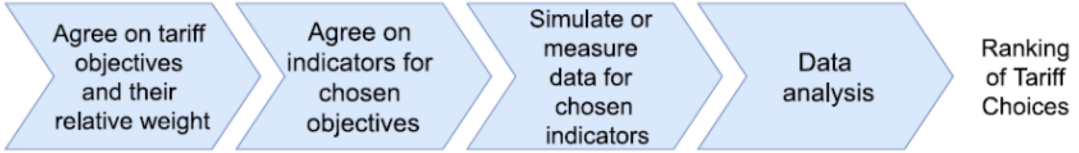

Fig. 1. Assessment process for network tariffs.

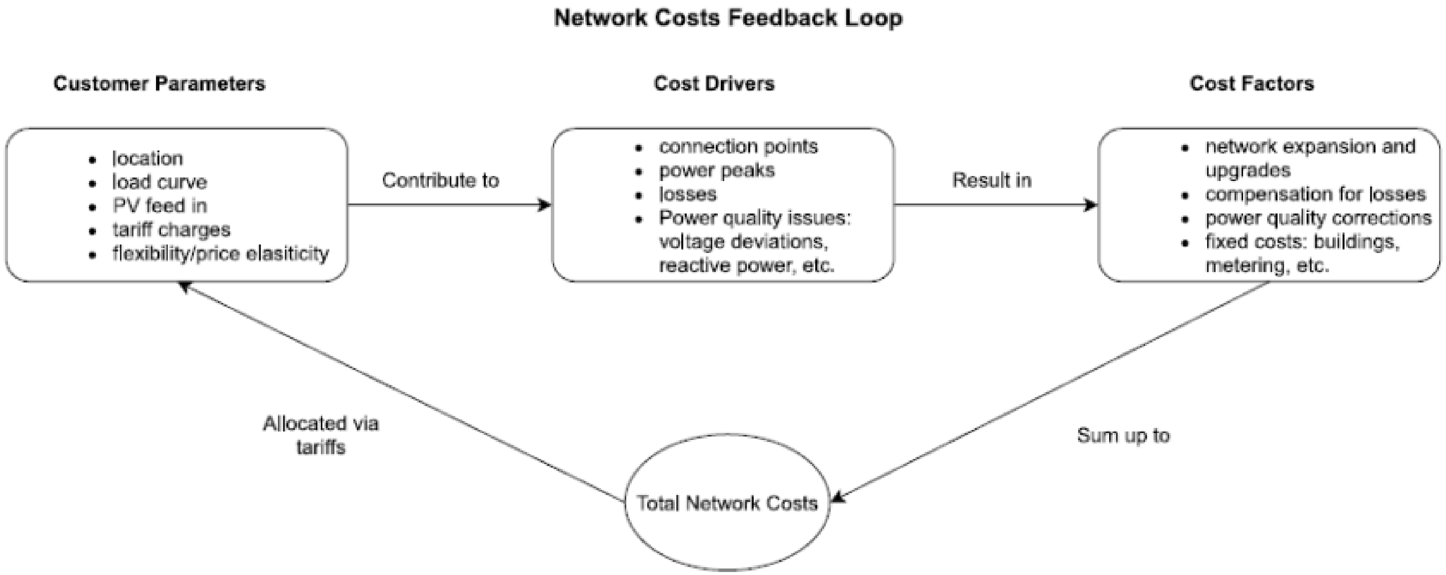

Fig. 2. Feedback between network costs and tariffs.

Hennig et Al., “What is a good distribution network tariff?—Developing indicators for performance assessment”, https://www.sciencedirect.com/science/article/pii/S0306261922005554

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Indicators for tariff performance assessment

Objective	Possible Indicators
Cost recovery	• Expected value and variance of expenses and revenues, based on plausible distribution of consumption patterns
Cost Reflectiveness	• Tariff charges relative to individual contributions to short- and long-term marginal costs and fixed costs
Non-discrimination	• Difference of tariff charges for the same load curve in different pricing locations • Variations in tariff that are not explained by total consumed energy and personal peak
Cost-Efficiency	• Network operation and infrastructure costs • Other user costs: e.g., cost of charging EV at wholesale prices • Congestion management: peaks relative to network capacity, average loading of network assets
Simplicity	• Degree of temporal and spatial variation • Complexity score: 1. Fixed or flat volumetric tariffs; 2. vol. ToU with 2-3 time periods; 3. capacity based or vol. ToU with >3 periods; 4. mix of vol. and capacity, or near real-time. • Implementation burden score: 1. No change required; 2. Smart meters required; 3. Near real-time communication required; 4. New market platform required.

Table 1: A selection of possible performance indicators for the chosen objectives

Hennig et Al., "What is a good distribution network tariff?—Developing indicators for performance assessment", https://www.sciencedirect.com/science/article/pii/S0306261922005554

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ANTS model for tariff assessment

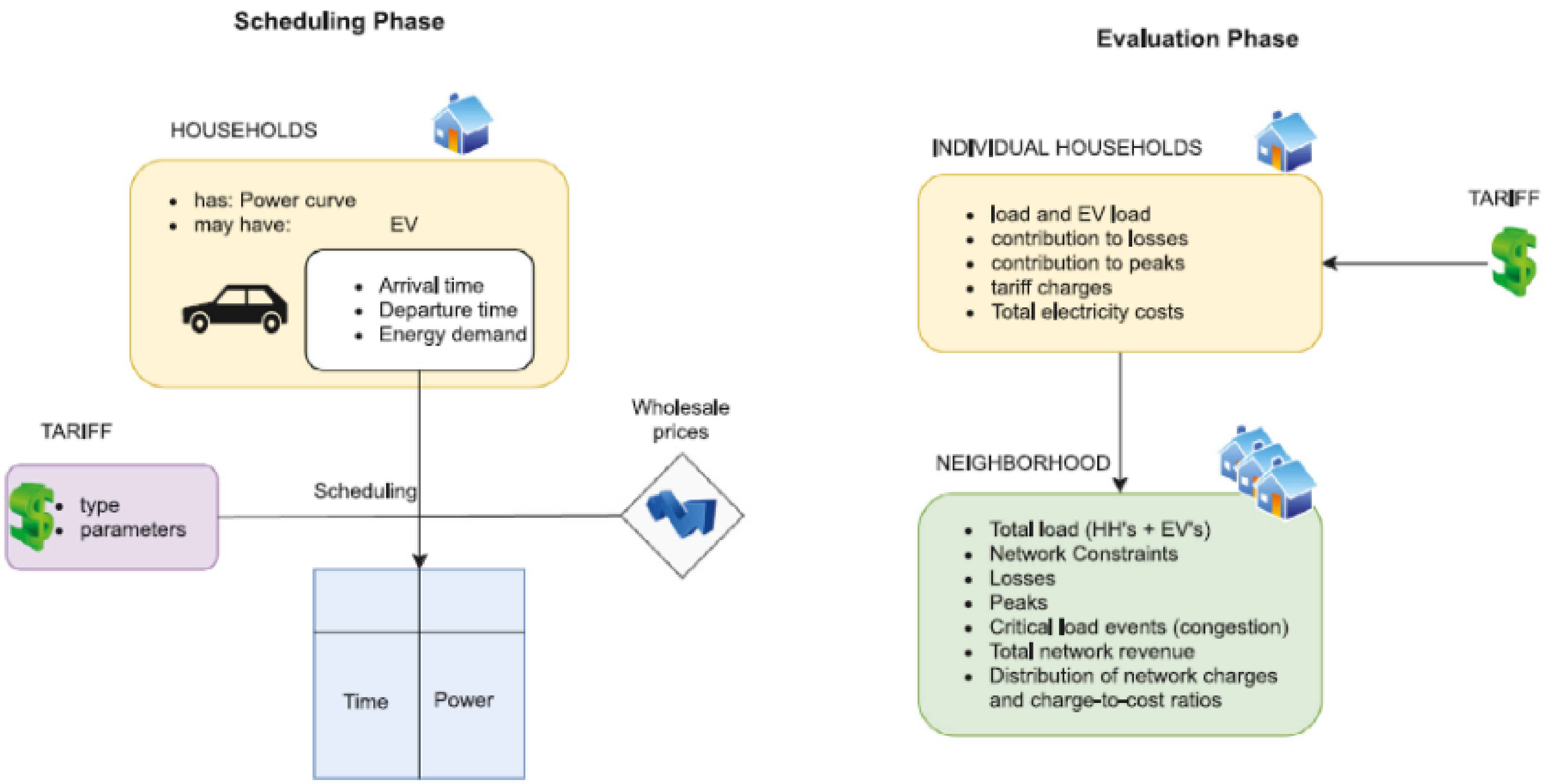


Fig. 5. Scheduling and evaluation phases in ANTS-model.

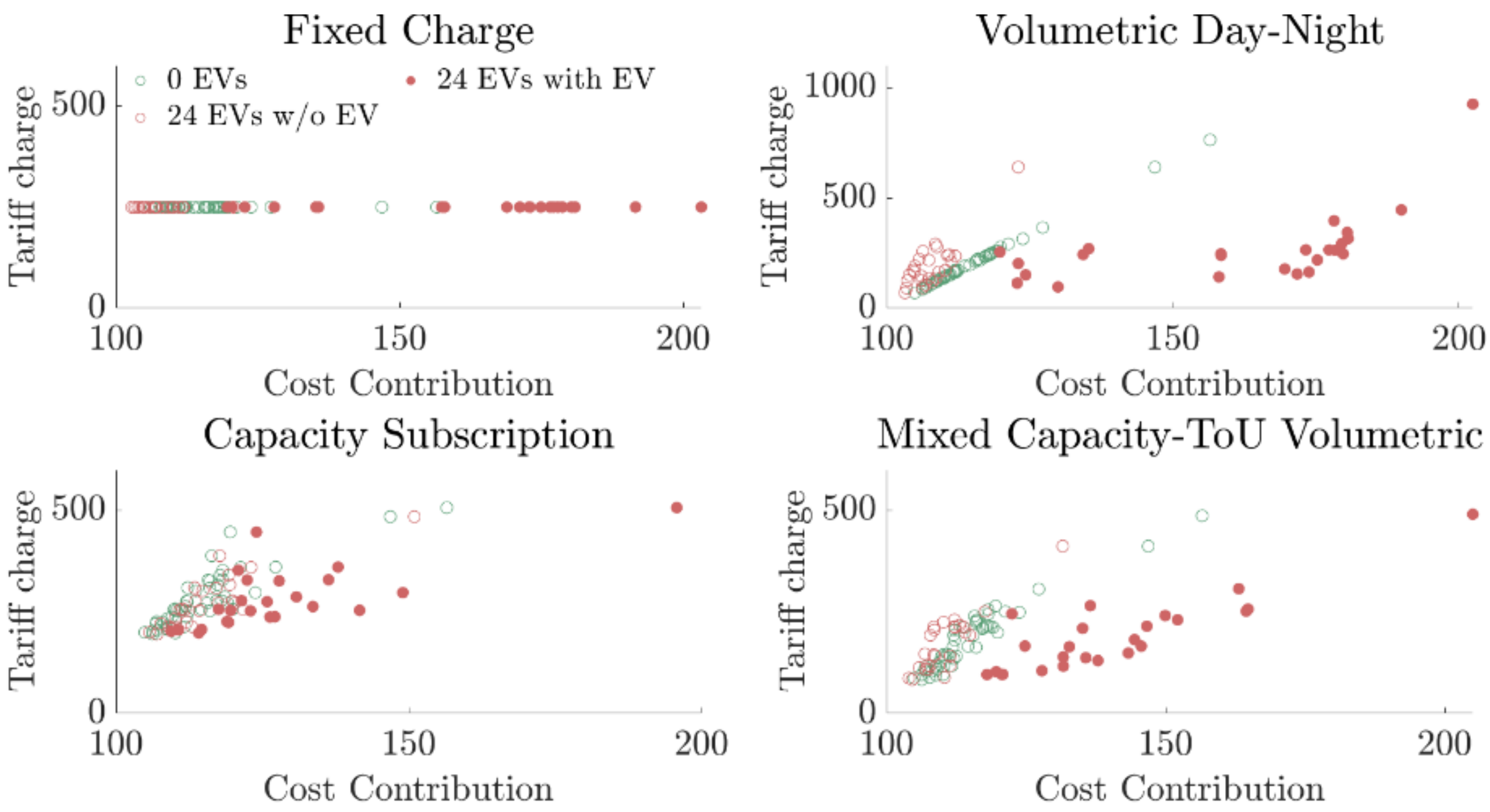
Hennig et Al., "What is a good distribution network tariff?—Developing indicators for performance assessment", https://www.sciencedirect.com/science/article/pii/S0306261922005554

Model equations in PMAPS contribution T4C 40. with Niels Goedegebeure:
[Generating Electricity Price Forecasting Scenarios To Analyze Whether Price Uncertainty Impacts Tariff Performance]()

Case study tariffs

- Fixed tariff:
  - 250 Euro per year
- Volumetric Day/Night tariff:
  - 6 ct / kWh day time, 3 ct / kWh night time
- Mixed peak capacity/volumetric ToU tariff:
  - multiple time periods for both volumetric and capacity charges
- Capacity Subscription tariff:
  - free usage up to a contracted capacity limit, penalty payment above

Case Study: cost-reflectiveness



Hennig et Al., “What is a good distribution network tariff?—Developing indicators for performance assessment”, https://www.sciencedirect.com/science/article/pii/S0306261922005554

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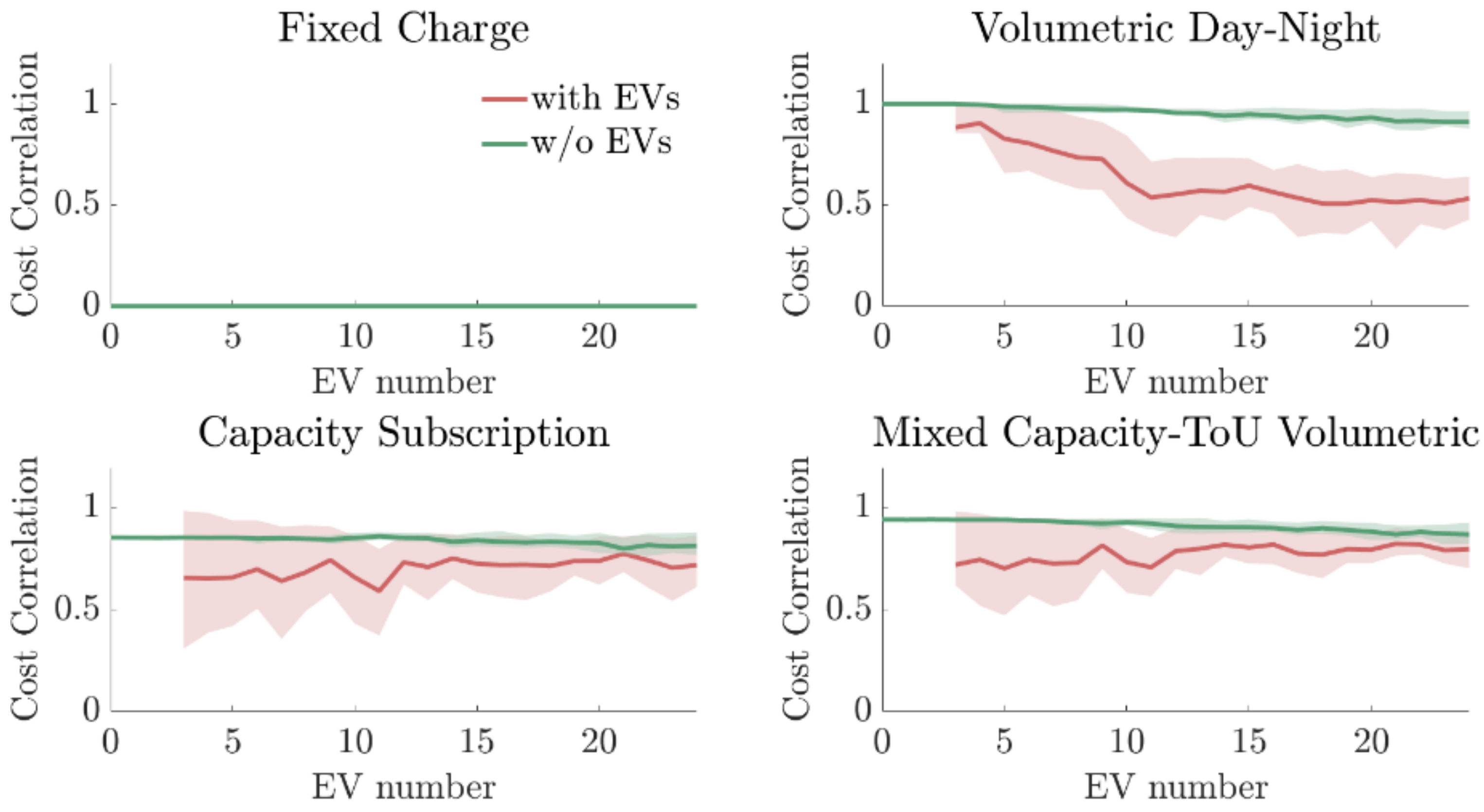
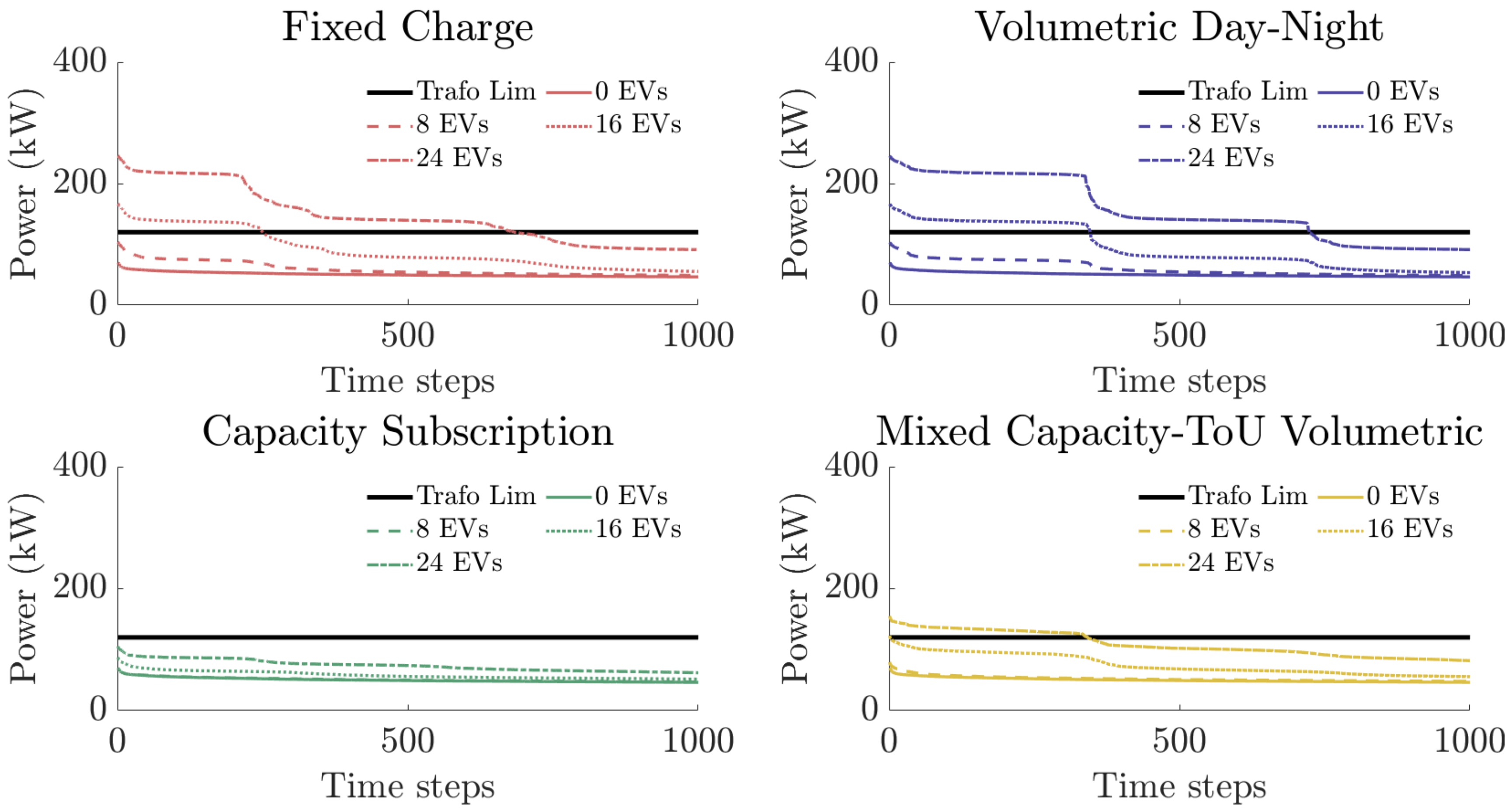
Case study cost-correlation



Hennig et Al., "What is a good distribution network tariff?—Developing indicators for performance assessment", https://www.sciencedirect.com/science/article/pii/S0306261922005554

Case study transformer loading



Hennig et Al., “What is a good distribution network tariff?—Developing indicators for performance assessment”, https://www.sciencedirect.com/science/article/pii/S0306261922005554

Case study summary results

Tariff	Cost-refl. low EV	Cost-refl. high EV	Efficiency high EV	Simplicity
Fixed	- -	- -	- -	+ +
Vol. Day-Night	+ +	-	- -	+
Capacity Subscription	+	+ +	+ +	-
Mixed Capacity-ToU Vol.	+ /+ +	+	+	- -

Table 4: Comparative assessment of the performance of the four tariffs relative to each other.

Hennig et Al., “What is a good distribution network tariff?—Developing indicators for performance assessment”, https://www.sciencedirect.com/science/article/pii/S0306261922005554

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Adding uncertainty: price forecasting scenarios

- In the previous results, we used deterministic knowledge of wholesale prices for up to 2 days in advance for scheduling EV charging.
- In reality, prices are not known and forecasting methods have to be used.
- In a contribution to this conference, we investigated the question of how this uncertainty impacts tariff performance.

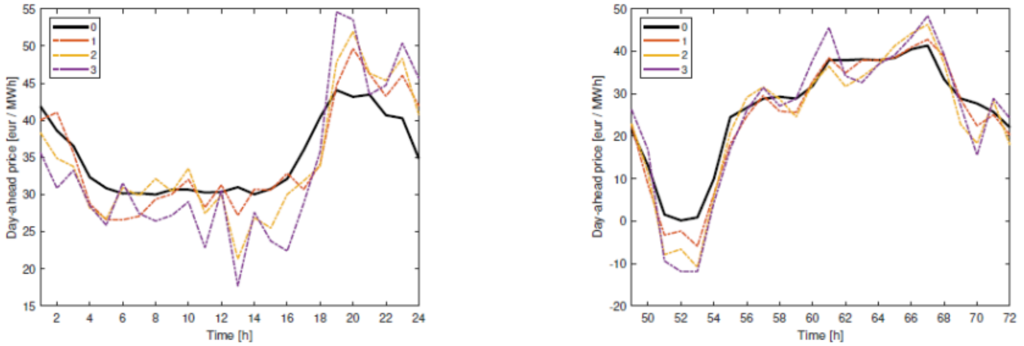

Fig. 3: Results of generated forecast scenarios for two days in the January 2020 data set (january 1 and 3). Forecasted prices are shown 1, 2 and 3 days in advance, together with the actual price (0, black).

PMAPS contribution T4C 40. with Niels Goedegebeure:
[Generating Electricity Price Forecasting Scenarios To Analyze Whether Price Uncertainty Impacts Tariff Performance]

Adding uncertainty: results with probabilistic scenario inputs

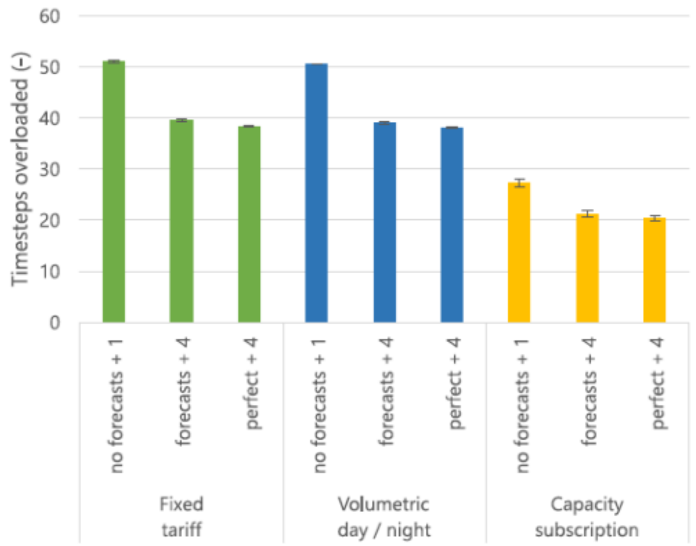

Fig. 4: Model results: average number of timesteps overloaded.

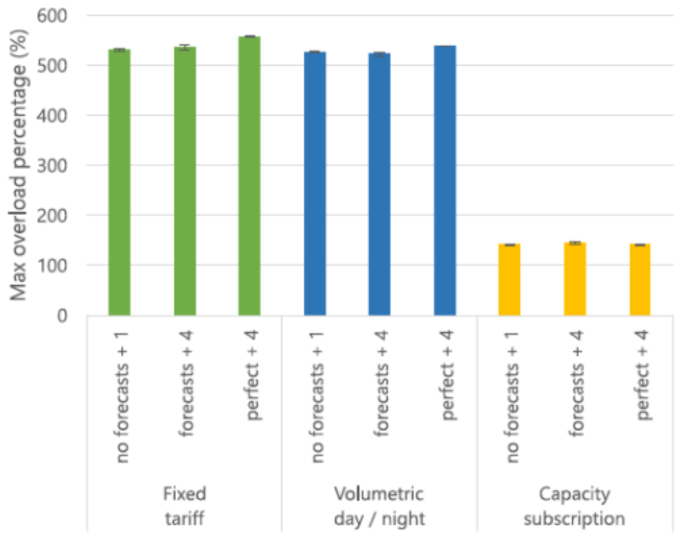

Fig. 5: Model results: maximum overload percentage.

- price uncertainty did not impact tariff performance significantly
- The difference between using perfect knowledge and probabilistic forecasts was much smaller then the difference between knowledge of prices for 1 or multiple days ahead

Conclusions

- There is a need for updating residential distribution network tariffs.
- Tariffs are expected to fulfil a range of regulatory objectives, yet it is unclear how performance for these should be assessed.
- We developed a methodology based on quantifiable indicators for this.
- We demonstrated the method with in a case study with the help of a simulation model.
- Adding price forecasting uncertainty did not significantly impact the results.
- Further uncertainties should be investigated, e.g., how do consumers react to tariff signals.
- More details on the scenario forecasting method in Niels Goedegebure’s talk this afternoon at 15:30 in session T4C: *Generating Electricity Price Forecasting Scenarios To Analyze Whether Price Uncertainty Impacts Tariff Performance*

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Thank you for your attention!

Questions? Comments?
E-mail me at r.j.Hennig@tudelft.nl

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