UNIVERSITY OF COLOGNE

ewi Institute of Energy Economics at the University of Cologne

VISE Virtuelles Institut Smart Energy

May the tariff be with you – How effective tariff designs reduce DSO interventions

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Chair of Energy Economics

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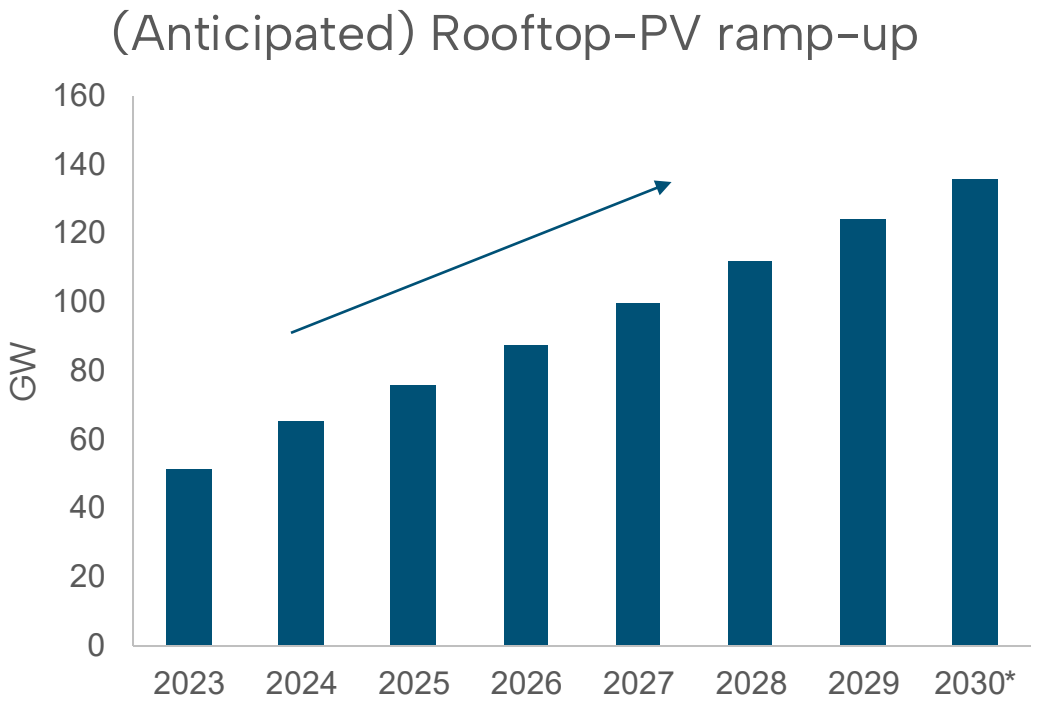
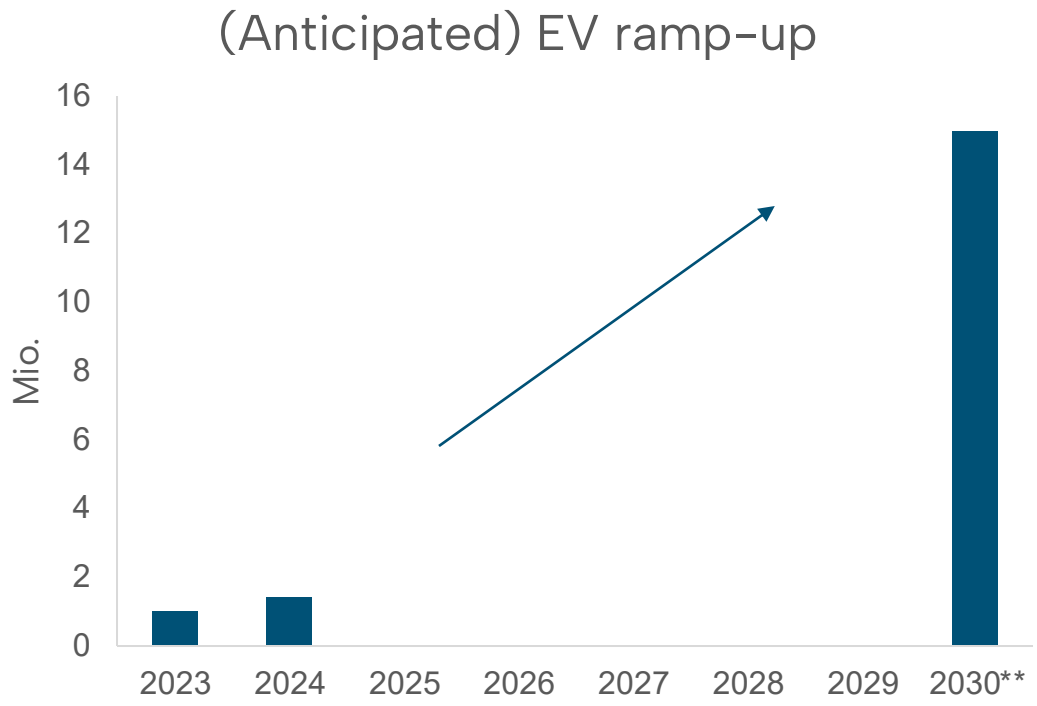
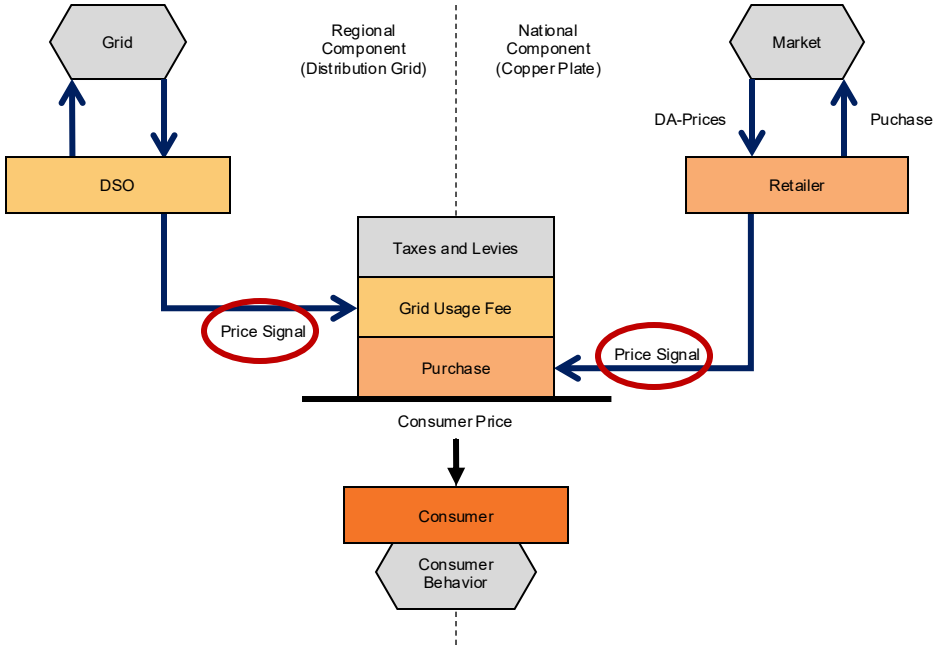
The energy transition largely takes place at the distribution grid level – a coordination problem

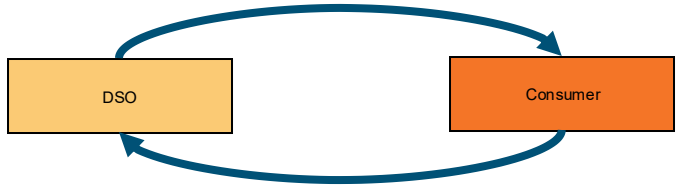




Sources: EWI 2024, KBA 2025, * interpolated, **policy target

Price signals can help to solve the coordination problem with rising complexity – but how exactly?





- What happens if variable grid charges apply to variable electricity prices?
- How often does the distribution grid operator have to intervene to mitigate grid congestion?

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METHOD

Variable grid usage fees may apply to various types of electricity tariffs – the analysis framework

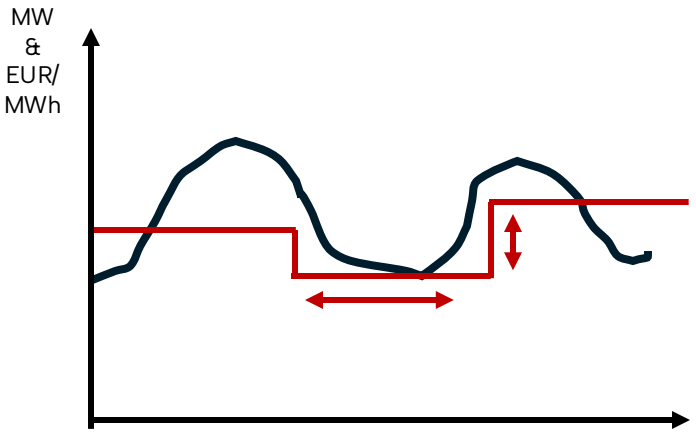
Retailer: Electricity Tariffs

DSO: Grid Usage Fee	Fixed tariff (Fix) Time independent flat price	Time-of-Use tariff (ToU) Tariff with three price levels (low, mid, high) in different time windows	Real-Time tariff (RT) Flexible tariff representing the wholesale price fluctuations
Fix (status-quo)	Fix-Fix	ToU-Fix	RT-Fix
ToU – Seasonally	Fix-Seasonally	ToU-Seasonally	RT-Seasonally
ToU – Weekly	Fix-Weekly	ToU-Weekly	RT-Weekly
ToU – Daily	Fix-Daily	ToU-Daily	RT-Daily
Optimal Benchmark	Central Planner	Central Planner	Central Planner

Metrics

- Quantity and quality of necessary DSO interventions to mitigate congestion

The tariff combinations are analyzed based on a bi-level problem



Upper-Level Problem (MILP)

- Decision-maker: DSO
- Minimization of costs
- Coverage of grid costs (small delta allowed)
- Sets shape and level of ToU tariff

Lower-Level Problem (MIP)

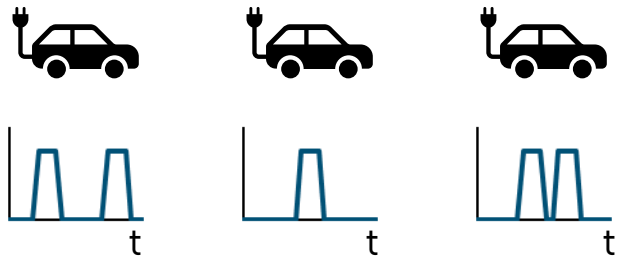
- Decision-maker: Consumer
- Minimization of costs
- Chooses demand in response to consumer prices
- Virtual storage approach to model distribution grid

- Based on Schittekatte and Meeus (2020)
- Translation into an MPEC using KKT conditions
- Linearization via discretization of grid usage fee
- Three windows and levels

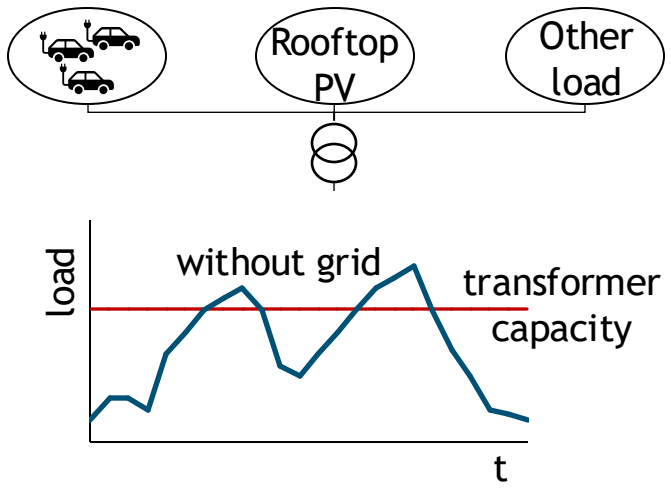
I use a virtual storage approach to model individual distribution grids in an aggregated way for the year 2030

Aggregated modelling of distribution grids

Deriving flexibility profiles at the vehicle level



Deriving flexibility profiles at the distribution grid level



Integrating flexibility profiles in wholesale electricity market models

Based on joint research with Oliver Ruhnau and Nils Namockel

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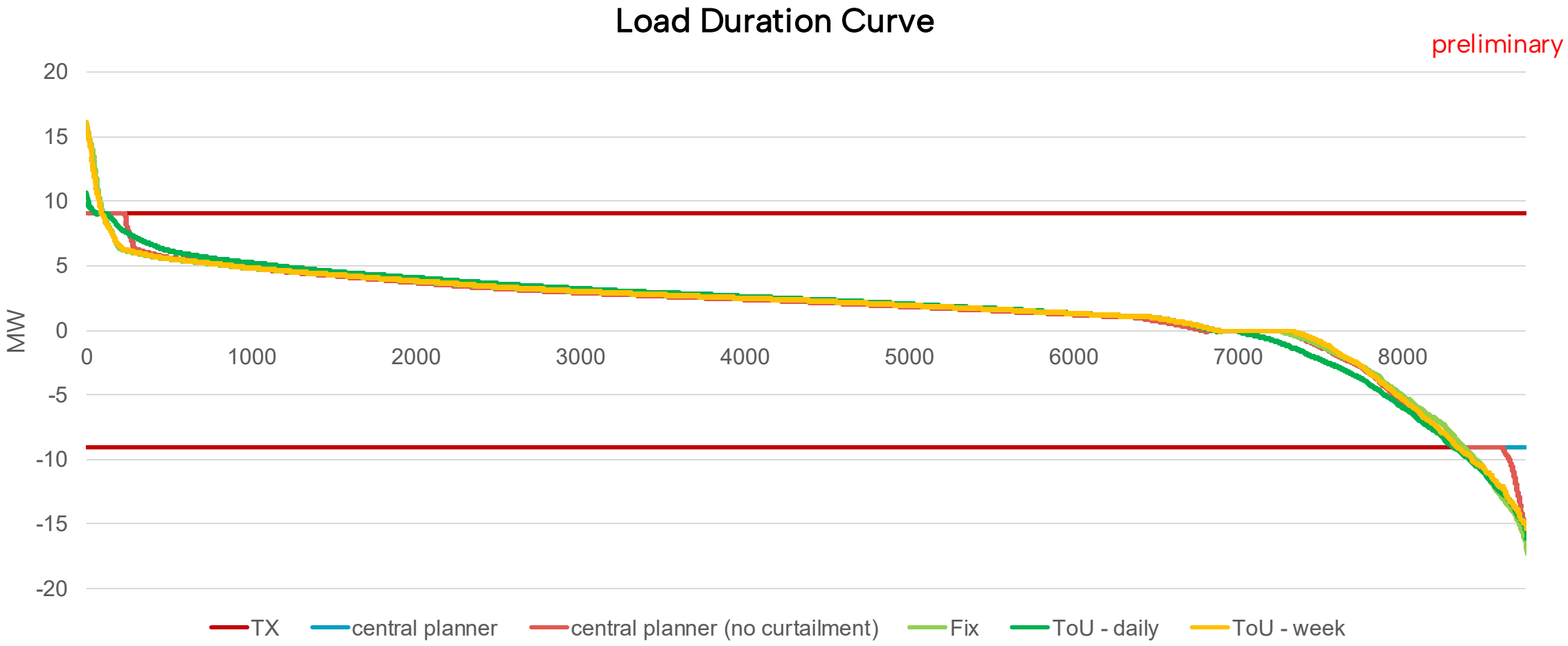
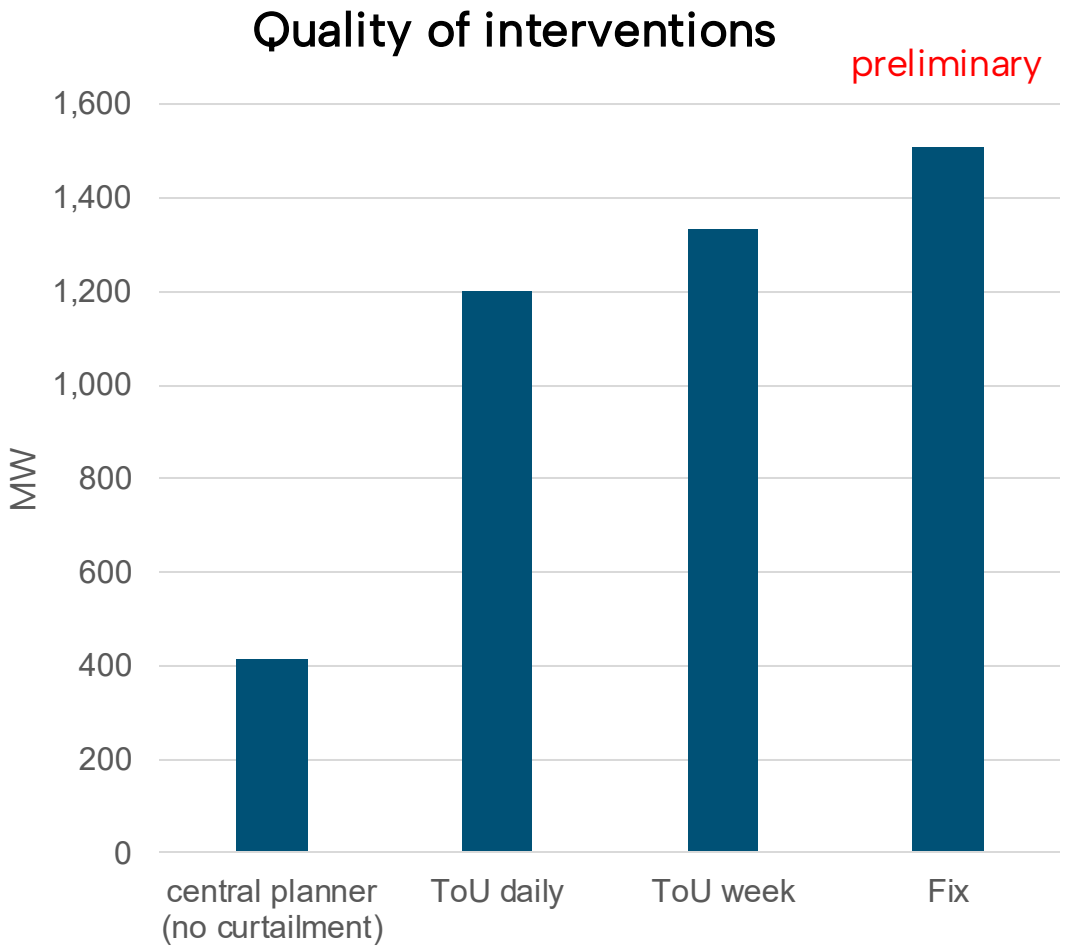
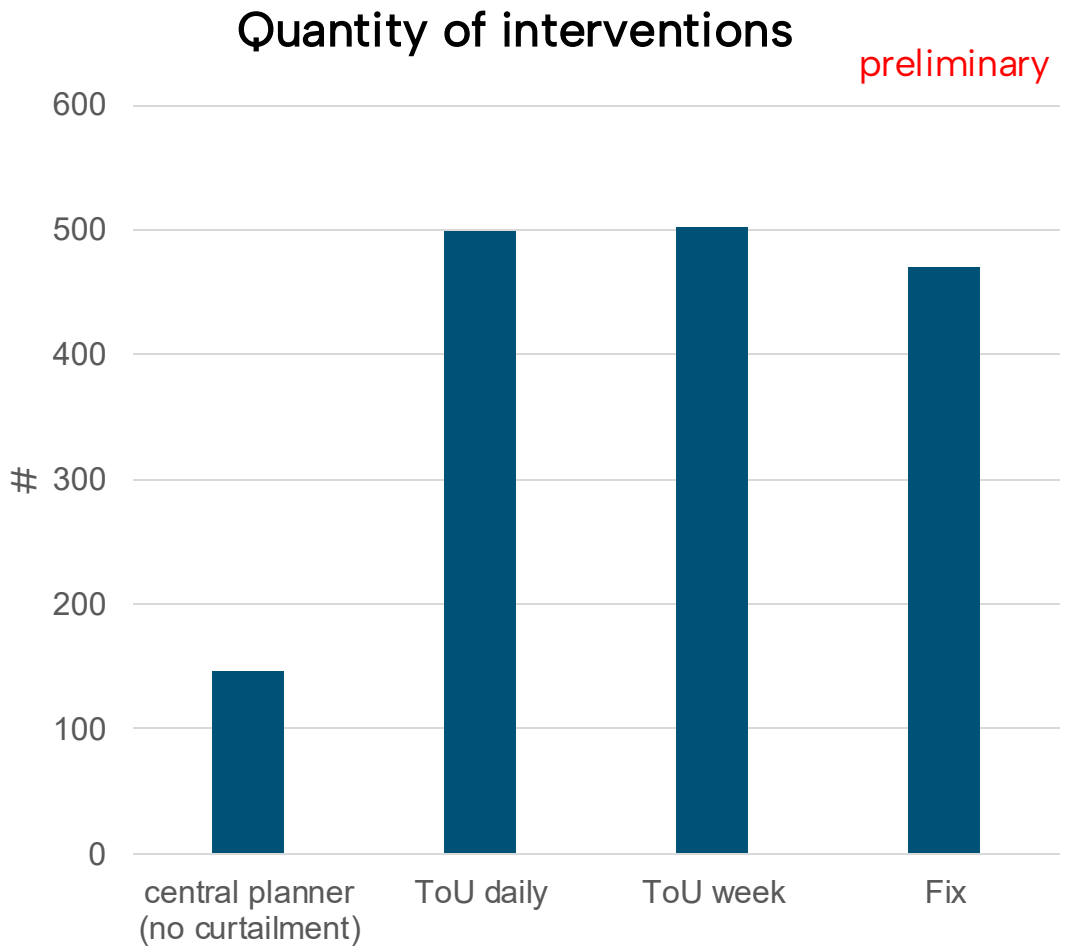
PRELIMINARY RESULTS

ToU tariffs reduce the amount of necessary DSO interventions



More granular ToU tariffs reduce the quality of interventions rather than the quantity





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DISCUSSION & CONCLUSION

Conclusion and our next steps…

Conclusion

- ToU tariffs reduce the amount of necessary DSO interventions
- More granular ToU tariffs reduce the quality of interventions rather than the quantity

Next steps

- Analyse costs
- Calculate other price signal combinations
- Implement other grid usage fee designs (capacity-based)
- Application to disaggregated grid
- Get in touch with you and discuss further improvements.

Thank you for your attention!