Contribution ID: **34** Type: **not specified**

Signals In, Reactions Out: Navigating Design and Modeling Challenges in Dynamic Grid Fees

Friday, April 4, 2025 2:30 PM (25 minutes)

Introduction
A major change in future energy systems is that, unlike before, demand will follow available capacities. In Europe, generation and demand are allocated in zonal markets, yielding one clearing price per zone. This zonal price does not reflect local grid restrictions—such as transmission limits and physical boundaries (line loading, voltage, power quality). Under the current market structure, grid enhancement is the main option to relieve these constraints. A local grid signal can also induce demand adjustments in specific areas, helping avoid congestion and ultimately reducing grid enhancements. This signal might be a price derived from load flow calculations of predicted load and generation. Currently, such signals see limited use in Europe, where flat grid fees don't reflect the load situation (ACER, 2023). If a price signal that varies in time and location is added to a flat grid fee, automated systems could optimize consumption to minimize costs—assuming perfect compliance—while promoting grid-friendly behavior.

Design options and difficulties
There are many design options for grid fees in general. A comprehensive assessment of criteria can be found in (Winzer, 2022) e.g. allocative efficiency, fairness and cost-reflectiveness, but also cost-recovery. For the implementation of a grid fee, transparency and simplicity are relevant criteria. It needs to be pointed out that one grid fee design cannot satisfy all possible criteria to the same extent. The theoretically most effective grid fee is dynamic, meaning that it changes as often as possible (e.g. 15min like the spot market price) with a high spatial granularity (e.g. low-voltage transformer) to in fact reflect the grid situation. The effectiveness of a dynamic grid fee has been shown for example in (Winzer, 2022; Vaughan 2023; Blume, 2022) and relevant stakeholders have expressed openness to the proposal (ACER 2023, E.DSO, 2024; CEER, 2020).

Most network operators recover their costs through a base price in combination with a capacity- and a volumetric tariff today (ACER, 2023) Developing a dynamic tariff component would increase cost reflectivity, i.e. consumption causing higher grid cost is more expensive (Winzer, 2022; E.DSO, 2024; VITO 2022). Some costs such as for metering infrastructure are time-independent and could therefore still be recovered through a flat base tariff. A combination of flat and dynamic components of the grid fee would therefore both be cost reflective and reduce the grid operators' risk of not recovering all cost.

To achieve its full impact, a dynamic grid fee has to cover all voltage levels. The signal can be derived from a load flow calculation of predicted load and generation patterns on every voltage level. Care must then be taken in the interrelation of the signals of different voltage levels. It remains a topic of research whether a top-down or a bottom-up approach is most efficient and whether a feedback loop needs to be included. In the former, TSOs first calculate a signal and transmit the signal to lower voltage levels ending with the signal that the local DSO needs to resolve congestion in the local grid. For the reverse direction, a proposal based on the cellular approach exists (Zapf, 2024). In any case control interventions by the grid operators will not be obsolete, however, reduced.

One disadvantage of tariffs is that in general they decrease economic welfare and distort the equilibrium of supply and demand. As in the current situation (e.g. Germany), where the Redispatch following zonal market clearing causes high cost and inefficiencies, a dynamic grid fee could potentially cause less distortions than the actual system. To let market actors react to grid restrictions, the signal should be fixed prior to market clearing of the day-ahead market. With more experience, an intraday adjustment of the dynamic grid tariff can solve problems due to forecast errors.
An important discussion to be held in all systems with large amounts of autonomous systems is the so-called

avalanche effect. When all Home-Energy-Systems and industrial consumers of a network optimize consumption based on a common signal, many of them could increase or decrease network use at the same time, aggravating congestion (Winzer, 2022).
In some European countries storage facilities, electrolysers and industrial consumers are exempt from grid charges. To unleash their full flexibility potential, every consumer should be exposed to the price signal in the long term. Attractive opt-in options for the exemptions mentioned could incentivize their participation in the short-term.

Outlook
The previous aspects are the basis for future research. Further study is needed for the details of the grid fee designs, the calculation of the price signal across voltage levels and the effects it causes. Of course, input assumptions regarding the willingness to pay for different consumers, the amount of flexibility on the consumer side and the chosen design influence modeling outcome. Executing many model runs with different parameter set and design options could foster our understanding of the outcomes. This understanding will enable us to study systems endogenous reactions without including an expected behavior in the model assumptions. This lays the foundation for DSOs to weigh the benefits of dynamic grid fees against their costs (such as metering infrastructure and digitization).

Primary authors: GRIMM, Gunter (Universität Freiburg); HOFMANN, Rebecca (Universität Freiburg)

Presenter: HOFMANN, Rebecca (Universität Freiburg)

Session Classification: Tariff designs