IMPACT OF GRID CHARGE MECHANISMS ON PROSUMERS AND THE ENERGY SYSTEM

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Overview

The transformation of our energy system towards zero net CO_2 emissions goes hand in hand with a stronger use of low energy density renewable energy sources (RES). This brings numerous distributed stakeholders into play, who evolve from passive energy consumers to active market participants (prosumers). Distributed photovoltaic (PV) power systems in combination with controllable flexibility elements such as electric and thermal storages and heat pumps are expected to play a major role, in particular. While prosumer storage and heat pump capacities can provide a necessary source of needed flexibility in general, in reality, these flexibilities oftentimes run inflexibly for individual profit maximization[1]. In principle, three run-modes of distributed capacity of flexibilities (and linear combination thereof) can be distinguished:

a) Distributed flexibilities can run for individual profit maximization, depending on the regulatory framework. This oftentimes equals self-consumption maximization, n = one household.

b) Distributed flexibilities can run (distribution) grid-beneficially, to reduce height of demand and feed-in power peaks, n = tens to hundreds of households.

c) Distributed flexibilities can run market-beneficially, to maximize portfolio effects for optimal renewable energy integration. Wholesale market (system) level, n = thousands to millions of households.

Additionally, smoothing effects arise both at distribution grid and wholesale market level, affecting the actual impact of prosumer behaviour on the energy system [1]. The prosumer behaviour, in turn, is strongly driven by the specific policy instruments being in place. For regulatory frameworks with allocation based re-financing mechanism of grid infrastructure and RES support cost, profit maximization oftentimes results in self-consumption ratio (SCR) maximization [2]. From a system perspective, SCR maximization by means of predetermined prosumer heuristics results in overall flexibility reduction, potentially burdening both the distribution grid and the wholesale market.

The basic idea of our research approach is to analyze these effects for two exemplary grid charge mechanisms. We will evaluate and compare the effects based on the work of [3], with novelty value being in a fully consistent consideration of both system and stakeholder level perspective.

Methods

To quantify the effects on system and stakeholder level for the three flexibility run modes, the fundamental linear optimization model E2M2[2] is fully interlinked with a prosumer full cost of energy analysis (FCOE) of a single prosumer household, including regulatory cost components relevant to the end customer. For the FCOE analysis actual quarter-hourly household profiles for electric and thermal demand as well as PV production are applied. By means of statistical analysis, profile smoothening at higher aggregation level is conducted. Also the intermediate aggregation at distribution grid level is considered to evaluate network stress through resulting power peaks. To account for the different flexibility run modes, *the order of optimization and aggregation* will be varied – in doing so, also the objective functions themselves change, see Figure 1. For run mode a), self-consumption at household level is maximized, resulting in corresponding smoothed aggregated residual load profiles at distribution grid and system level, finally impacting total system cost. For run modes b) and c), optimization starts at distribution grid level (minimize extremal power peaks) and system level (minimize total system cost), respectively.

[1] At least in regulatory frameworks comparable to the German one.
[2] European Electricty Market Model [4].

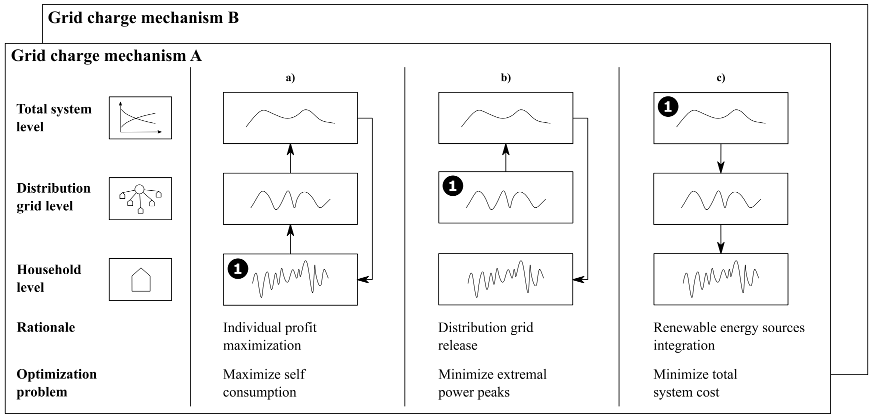

Figure 1: Schematic modelling scheme to analyze effects of different optimization strategies at household, distribution grid and system level. The numbers in circles denote the starting point of the respective analysis.

The analysis will be conducted for volumetric grid charges and capacity based grid charges. In each case, normalized system cost and FCOE will be quantified and compared.

Results

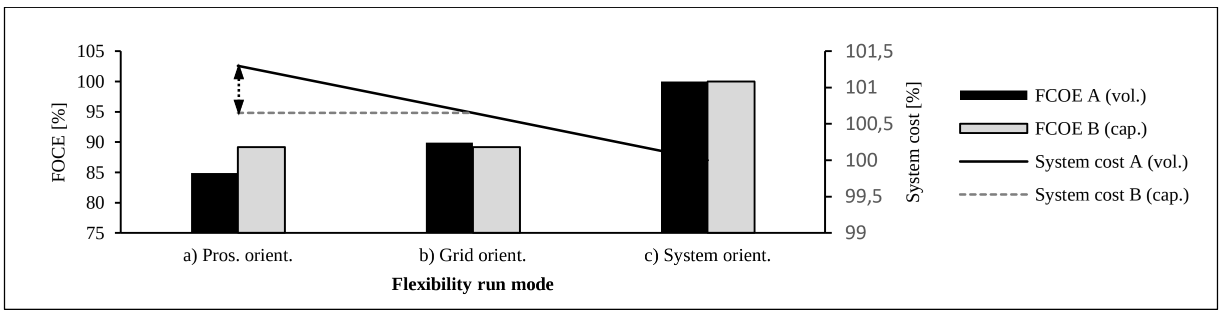

Figure 2: Total system cost (lines) and full cost of energy (FCOE) (bars) as a function of the flexibility run mode. For volumetric (A) and capacity based (B) grid charges. Shown values are partly preliminary and schematic, respectively.

For volumetric grid charges (A), system cost differ significantly between the prosumer oriented and the system oriented run mode, see Figure 2. The situation can be altered by means of capacity based grid charges (B). In this case, prosumer and grid optimum tend to coincide while the increase of total system cost compared to the system-beneficial run mode is lower than for scheme A (indicated by the arrow in the figure).

Conclusions

The analysis shows that the current regulatory framework of volumetric grid charges fails to set incentives for system oriented prosumer behaviour. It can be shown that the switch to capacity based grid charges leads to higher prosumer full cost of energy on the one hand, but to a distribution grid oriented behaviour with overall lower system cost on the other hand. In view of the cost-by-cause principle, such a grid charge mechanism appears fairer, considering that the current framework of volumetric grid charges constitutes a subsidy for prosumers, potentially burdening the system as a whole and specific household groups through cost allocation mechanisms, in particular.

References

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