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POLICY BRIEF

How future-proof is your distribution grid tariff design?

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Highlights[1]

- The assumption that people cannot react to the way distribution grid tariffs are designed does not hold anymore. This is mainly true due to breakthroughs in two game-changing technologies: photovoltaics (PV) and batteries.
- By investing in PV and batteries, active consumers push the sunk costs towards passive consumers (equity issue). Ironically, the active consumers can even end up paying more (efficiency issue). To avoid being screwed by the others, active consumers could overinvest. They are in a non-cooperative equilibrium.
- We find that the outcome of this game between the DSO (and the regulator) trying to recover sunk costs, and active consumers reacting to the distribution grid tariff, depends heavily on the way the tariff is designed.
- It is clear that current distribution grid tariffs are not future-proof. The historical conventional practice in the EU is net-metering, which creates significant equity issues and is an implicit subsidy for the adoption of PV. The solution that is advocated in the current debate, capacity charges, creates significant efficiency issues and is an implicit subsidy for the adoption of batteries.
- 'Bi-directional' volumetric charges can outperform capacity-based charges to recover sunk costs, so they should at least be considered as an option.

1. This policy brief is based on: RSCAS Research Paper No. 2017/22 by Schittekatte, T. and Momber, I. and Meeus, L. Available at: *http://cadmus.eui.eu//handle/1814/46044*. Details about the assumptions, data, and formulation of the mathematical model can be found in the research paper.

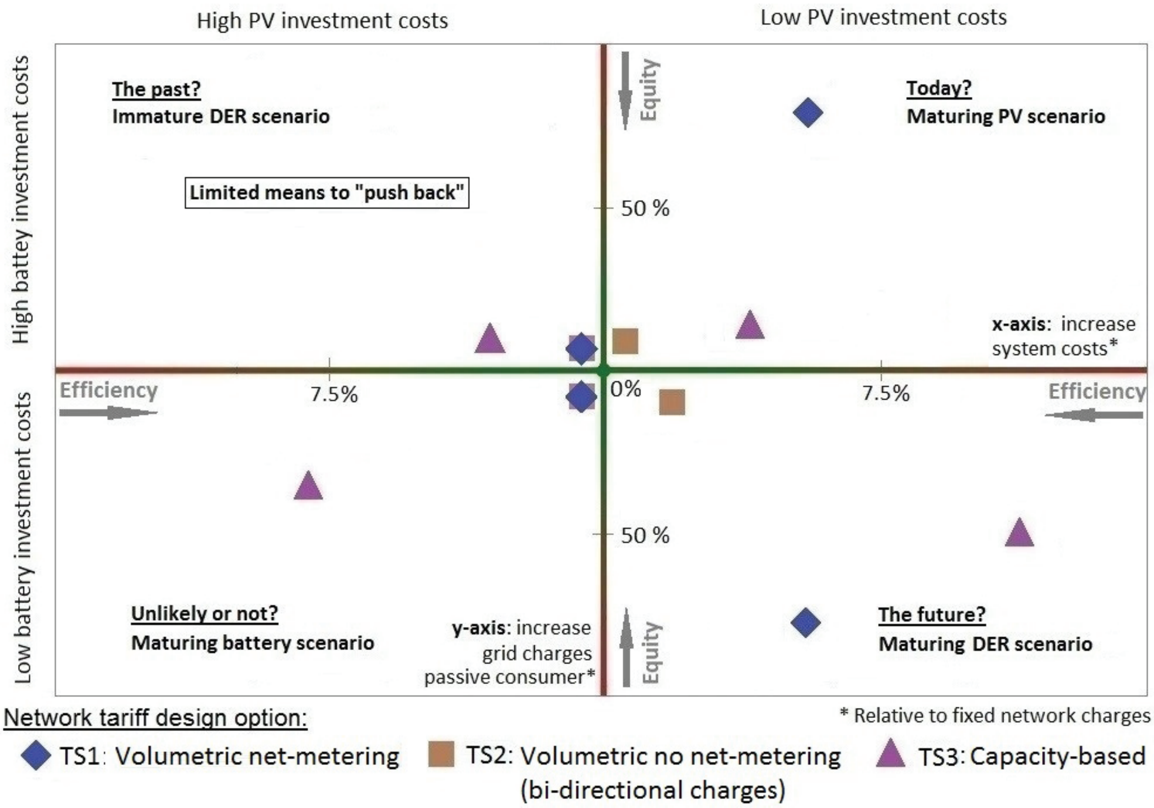
1. Introduction

As Borenstein puts it: *"Something is dying alright, just not the utility. It's the ability of regulators, utilities, and interest groups to push around revenue collection among customers without the customers pushing back."*[1]

The assumption that people cannot react to the way the network charges are accounted for does not hold anymore. The rise of distributed energy resources (DER) offers increased opportunities to exploit the existing system of network charges in ways that were not originally envisaged.[2] This is mainly true due to breakthroughs in two game-changing technologies: photovoltaics (PV) and batteries. PV enable consumers to significantly reduce their net volume of electricity needed from the grid. Batteries enable consumers to play with their capacity needs and regulate their electricity flows from and to the grid.

Nowadays, the grid cost recovery problem is a game between the DSO and low-voltage consumers. The DSO has the objective to recover its costs, which are assumed sunk, and consumers react to the method of recovering these sunk costs by installing PV and/or batteries.

In this policy brief, we look at the four states of the world, illustrated in the figure below, with high or low PV and battery costs. In each state of the world, we have 50% active consumers connected to the grid, and we look at how they respond to three main distribution grid tariff designs that are currently debated, i.e. volumetric net-metering, volumetric no net-metering[3], and capacity charges.



1. Borenstein, S. (2015). The Decline of Sloppy Electricity Rate Making. Energy Institute at Haas Blog Post. https://energyathaas.wordpress.com/2015/08/24/the-decline-of-sloppy-electricity-rate-making/
2. These are the words of M. Pollitt in his paper "Electricity network charging for flexibility." (https://doi.org/10.17863/CAM.7821)
3. Under 'bi-directional' volumetric network charges the sum of the electricity withdrawn and injected into the grid is used to calculate the network charges per consumer.

The closer the result of a tariff design is near to the origin of the matrix in this figure, the better its performance; we look at efficiency (i.e. total system cost) and equity (i.e. network charges paid by passive versus active consumers). Performance is illustrated relative to a reference case in which fixed network charges are applied. Fixed charges perform optimally in our illustration because we do not consider the possibility of going off-grid entirely.

In what follows, we look at each state of the world and conclude that main distribution grid tariff designs are not future-proof.

2. The past? (High PV, and High Battery cost)

Two observations are made in this state of the world.

Firstly, the results show that applying volumetric network charges with net-metering, the network tariff design historically in place, does not create efficiency or equity issues for the recovery of the sunk costs. The same result is found for volumetric network charges without net-metering. This can be explained by the fact that consumers do not have means to change their volume of electricity needed from the grid. PV is simply too expensive to invest in.

A second observation is that with capacity-based network charges some inefficiencies and very limited equity issues arise. This result could also be interpreted as consumers having limited means to regulate the capacity needed from the grid. They will make some investment in batteries, but very limited because the cost is too high.

Overall, consumers have very limited means to "push back" in this state of the world.

3. The unlikely? (High PV, Low Battery cost)

A state of the world with high PV investment costs and low battery costs is unlikely because the cost of PV is already coming down faster than the cost of batteries.

However, this technology cost scenario could be the thought of as the future for places where electricity generated by PV is too expensive due to low levels of solar irradiation combined with few or no government subsidies.

Two observations from this state of the world are described below.

Firstly, results for volumetric charges with and without net-metering do not change. Net-metering does not incentivize investments in batteries for active consumers. Therefore, the investment cost of batteries does not have any effect on the results for this tariff structure. Under volumetric network charges without net-metering, there is an incentive to install batteries, although not strong enough in this state of the world.

Secondly, increased inefficiencies and a more severe equity issue for passive consumers resulted with capacity-based charges as compared to the previously described state of the world. In this state of the world, active consumers install a high capacity of batteries. However, the increase in system costs, which is the proxy for efficiency, is dampened due to the low battery costs. An equity issue for passive consumers results as the active consumers can significantly shave their peak demand, and thus their contribution to the sunk costs, with the high battery capacity installed per active consumer.

4. The present? (Low PV, High battery cost)

Three observations can be made for this state of the world.

Firstly, volumetric network charges with net-metering create severe equity issues and inefficiencies. Since active consumers install the maximum amount of PV of which the excess generation is fed into the grid, the netted-out grid electricity consumption of the active consumers is significantly lowered. Consequently, the network charge coefficient in €/kWh must increase to allow for cost recovery. This means that the network charges paid by the passive consumers increase strongly. Additionally, investment distortions are created with this network tariff structure. Under the parameter settings, a kWh of electricity from the grid (excluding network and other charges) is still slightly cheaper than a kWh of electricity produced by a PV panel. With a fixed network tariff in place (in €/consumer to be paid), no investment in PV is expected from the rational cost minimising active consumer. However, with volumetric network charges with net-metering in place (in €/kWh), investing in PV becomes a lot more attractive as not only energy costs can be avoided but also network charges. In other words, net-metering acts as an implicit subsidy for the adoption of PV.

Secondly, the result for volumetric network charges without net-metering does not change as compared to all the previously discussed scenarios. PV is inexpensive, and if active consumers installed PV, they would avoid paying network charges for withdrawing electricity from the grid. However, electricity demand does not always coincide with PV production and vice-versa. Under this tariff structure, a PV owner would also have to pay network charges to inject excess energy into the network. These charges render the business case for an active consumer to install a large capacity of PV unattractive. Batteries can increase the amount of electricity produced on-site that could be used for self-consumption. As such, the exchange of electricity with the grid, and thus the network charges paid, will be limited. However, in this state of the world, the installation costs of the batteries does not outweigh the potential gains made by self-consumptions.

Thirdly, the performance of capacity-based charges is slightly impacted by a change in the PV investment cost while keeping the battery investment cost constant. This effect is even stronger when comparing the two states of the world with low battery costs and different PV investment costs. Lower PV costs incentivise investment in PV under this tariff structure and consequently investment in batteries too becomes more attractive.

5. The future? (Low PV, Low Battery Cost)

Three highlights are described for this state of the world.

Firstly, the results for volumetric charges with net-metering in this state of the world do not change when compared to the previously described state. This is expected as the only parameter changing between those two states is the battery investment cost. As described before, with net-metering and no time-varying electricity prices or network charges in place, there is no incentive for consumers to install batteries.

Secondly, the results for volumetric charges without net-metering change slightly. In this state of the world, the active consumers invest in PV and batteries. However, the installed capacities of both PV and batteries remain small, and the amount of avoided network charges is limited. Volumetric network charges without net-metering are found to be rather robust against investment distortions and equity issues, even with low DER costs and 50 % of active consumers connected to the grid.

Thirdly, the results for capacity-based charges worsen significantly, both regarding efficiency and equity, when comparing to the other state of the worlds. Ironically, the active consumers even end up paying more. To avoid being screwed by the others, active consumers indeed overinvest in PV and batteries in this scenario up to the point that they are all worse off than if they would not invest at all. They are in a low-level non-cooperative equilibrium.

Note that the last observation only happens in this future state of the world, and if the share of active consumers is assumed to be high (50% or more), but it is an important insight for policy makers.

6. Main distribution grid tariff designs are not future-proof

We find that the outcome of this game between the DSO (and the regulator) trying to recover sunk costs, and active consumers reacting to the distribution grid tariff, depends heavily on the way the tariff is designed. Tariff design makes or breaks the business case for distributed energy resources at the low-voltage level, and in its turn, the adoption of these technologies can complicate the grid cost recovery problem.

It is clear that current distribution grid tariffs are not future-proof. The historical conventional practice in the EU is net-metering, which creates significant equity issues and is an implicit subsidy for the adoption of PV. The solution that is advocated in the current debate, capacity charging, creates significant efficiency issues and is an implicit subsidy for the adoption of batteries. 'Bi-directional' volumetric charges can outperform capacity-based charges to recover sunk costs, so they should at least be considered as an option.

The story is even more complicated because implementation matters and the context matters. First, implementation matters because capacity charges can be implemented in many different ways. Second, context matters because the level and the way policy costs are recovered via the energy bills differs significantly across Europe; and for some countries, the main issue might not be to recover sunk costs, but rather to give the right incentives for future distribution grid expansion. These issues will be discussed in our future work.

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