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Limits of Traditional Distribution Network Tariff Design and Options to Move Beyond

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Highlights[1]

• With more consumers installing solar PV panels, it makes sense to depart from the historical practice of volumetric distribution network tariffs with net-metering.

• However, regulators face many practical difficulties when redesigning the distribution network tariff design. Typically, there is a trade-off between cost-reflectiveness and fairness.

• We illustrate the cost-reflectiveness versus fairness trade-off and we find that some cost-reflectiveness can be sacrificed to limit the distributional impact resulting from tariff redesign.

• However, this works only up to a certain point without compromising grid cost recovery. If grid costs are mainly sunk, and cost-reflective charges are hard to implement, then smaller passive consumers are always worse off – tools other than 'standard tariff options' are needed to keep distributional impacts under control while limiting distortions.

1. This policy brief is based on RSCAS Research Paper No. 2018/19, titled "Least-Cost Distribution Network Tariff Design in Theory and Practice" by Schittekatte, T. and Meeus, L. Available at: http://cadmus.eui.eu//handle/1814/53804. Details about the assumptions, data, and formulation of the mathematical model can be found in the research paper.

1. Introduction

Technological breakthroughs at the consumer-side are challenging the use of volumetric network charges. Specifically, volumetric charges with net-metering, implying that a consumer will be charged for the net consumption from the grid over a certain period (e.g. month), are deemed inadequate with the massive deployment of solar PV. Consumers with solar PV pay far lower network charges but still rely on the distribution grid as much as they did before. This means that if cost recovery is respected, consumers that have not installed solar PV would have to contribute more.

There is no easy fix for distribution network tariff design. Next to volumetric charges, the two other traditional network tariff design options are capacity-based and fixed network charges. In Section 2 we show that if the regulatory toolbox is limited to these three traditional options, it will be hard to design a distribution network tariff that is cost-reflective and future-oriented, while at the same time also fair in the allocation of costs between active and passive domestic customers. In Section 3 we discuss show that other, more creative, regulatory tricks are needed to combine and satisfy different policy objectives.

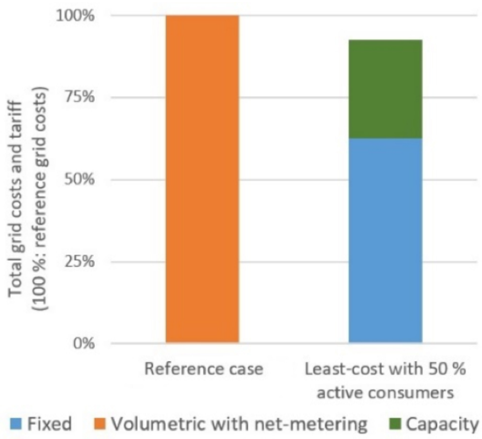
2. The Limits of Traditional Distribution Network Tariff Design

A more cost-reflective tariff will not necessarily be deemed fair. In what follows we illustrate this trade-off by using a game-theoretical model. Namely, we develop a game in which the regulator can decide about the distribution network tariff (volumetric, capacity and/or fixed charges) while anticipating the reaction of the active consumers to the tariff design. The regulator has to respect the condition that all grid costs need to be recovered from the network tariffs. The objectives of the regulator and the active consumers are different. The active consumers are self-interest pursuing, i.e. they can invest in solar PV and batteries and will do so if it results in lowering their private costs to serve their electricity needs. The objective of the regulator is instead to set the network tariff in a way that the actions of the active consumers not only benefit themselves but also the system as a whole.

In Figure and Table 1 below we show a result from the model. All results are relative to the reference. As a reference we have the 'as-it-used-to-be-scenario', i.e. no consumer installs any solar panel or battery, and the network charges are volumetric. There are three key assumptions. First, some future grid investments can be influenced by the way the grid is used, other investments are made in the past and their costs are sunk. Each country faces a different situation regarding the relative importance of prospective versus sunk costs. This depends on the grid investment cycle they are in and how local demand evolves. In this example, we assume the grid costs to originally consists of 50 % prospective and 50 % sunk grid costs. Second, we know that capacity-based charges are an imperfect proxy for the prospective network cost. Even if the individual peak demands of consumers are reduced, it does not mean that the future investment costs reduce proportionally. We assume that a reduction of 1 kW individual peak results in a 0.75 kW reduction in the investment need, which is most probably an optimistic assumption. Last, we model active consumers with a slightly higher electricity consumption than passive consumers. We assume that in the reference scenario the network charges paid by the passive consumers are 33 % lower than the network charges paid by the typically more affluent active consumers (before they are enabled to invest in solar PV and batteries).

It can be seen in Figure 1 that when the active consumers are enabled to invest in solar PV and batteries, the tariff design that gives the best result from a system point of view becomes a mix of capacity-based and fixed network charges in this example. In the next two subsections these results are further explained and discussed.

Figure and Table 1: Illustration of the result of a run of the model with active consumers enabled to invest in solar PV and batteries. 50 % active and 50 % passive consumers assumed.



Reference case (=no solar PV or batteries installed & volumetric network charges)	Least-cost with 50 % active and 50 % passive consumers
Total system costs	- 0.3 %
Increase grid charges passive consumer	15.6 %

Limitations of Capacity-Based Charges to Reflect Future Grid Costs

A popular alternative brought forward to replace volumetric network charges with net-metering are capacity-based charges.[1] With capacity-based charges, consumers pay for the grid according to their peak demand, e.g. their maximum hourly or fifteen-minute power off-take measured over a month. The rationale is that these kinds of charges are more cost-reflective as the main network cost driver is the maximum hosting capacity of the lines and feeders. However, in practice, a truly cost-reflective tariff is hard to implement and would need a very fine temporal and locational granularity. The maximal power usage of all individual consumers does not necessarily coincide and the distribution network is actually a layer of different networks with possibly different network peaks.

However, because of the fact that some prospective grid costs can be reduced by lowering the peak demand, some part of the grid costs are recuperated with capacity-based charges. With capacity-based charges in place, the active consumers are incentivised to lower their individual peak demand. And they do so as the reduction in their grid charges is worth investment cost of the batteries they need to install. As a result, the coincident peak demand at the feeders lowers, and grid cost can be reduced. The total savings of grid reinforcement costs (around 10 % as can be seen from Figure 1) are slightly higher than the total costs of all batteries purchased by the active consumers, which results in an overall net reduction of total system costs of 0.3 %. It is exactly these grid cost savings that are transferred to the active consumers through reduced network charges.

However, caution is needed when implementing standard capacity-based tariffs. With the rise of electrical storage and demand response, similar risks as with net-metering and solar PV can arise if capacity-based charges are badly implemented; active consumers lower their grid contributions by lowering their peak demand while the total grid costs would remain basically unchanged. Again, other, passive, consumers would have to contribute more to allow for grid cost recovery. Therefore, as capacity-based charges are an imperfect proxy of the network cost driver, significantly less than half of the total grid costs are recuperated by capacity-based charges, even if the ratio of prospective over sunk costs is 50/50.

1. In the US context capacity-based charges are often called ‘demand charges’.

Limitations of Fixed Network Charges to Recover Residual Network Costs

How then can we recuperate the residual remaining grid costs, which are mostly sunk? The most cost-reflective tariff in this case is one that does not reflect any cost. Fixed network charges (e.g. in € per connection) would do the job. The only way to avoid paying fixed network charges would be to go offgrid, which does not seem realistic in most parts of the world today. However, in many countries there is strong opposition to high fixed network charges. It is often argued that if fixed network charges replaced a large share of the historic volumetric network charges, a high proportion of the network costs would be shifted from often richer high-usage consumers to often poorer lower-usage consumers.[2]

Figure 1 shows that the least-cost tariff design in this example with 50 % of active consumers also consists of a fairly large share of uniform fixed network charges. The regulator chooses this kind of charge in order to recuperate the residual part of network costs without distorting the active consumer's decisions. But the fixed charges applied are uniform across all consumers. This means that smaller passive consumers will see an increase in their network charges when compared to the reference case, even though their electricity demand from the grid has not changed. More precisely, Table 1 shows that in this example the least-cost tariff results in a 15.6 % increase of the network charges paid by the passive consumers.

Limitations of Reaching Fairness with all Three Options

Even though the proposed tariff for this example is the least-cost solution, opposition against negative distributional impacts from tariff redesign is real. Therefore, we test what would happen if we constrain the increase of network charges of the passive consumers when obtaining the new tariff proposal. By doing so, we can 'sacrifice' some cost-reflectiveness in order to lower fairness concerns. Two opposing forces are working in this case. On the one hand, by lowering the fixed network charges, the fairness issue decreases. But by resorting to other network tariff components which are needed to ensure full grid cost recovery (volumetric charges or an increase in capacity-based charges), the network tariff will be distortionary. This implies that active consumers can exploit opportunities that might be beneficial for themselves but which are not necessarily optimal from a system point of view.

Moreover, the benefits active consumers obtain in this way come at the expense of passive consumers, thus aggravating the fairness issue once again. These two forces can be played out until the moment the model becomes unfeasible, i.e. there is no way to recover all grid costs while limiting the fairness concern. In this example, it is possible to reduce the increase in network charges paid by the passive consumers from 15.6% down to 10%. After, grid cost recovery is not anymore guaranteed. This reduction of the distributional impact of tariff redesign comes with a cost. Namely, in order to reduce the increase of the network charges of the passive consumers by 5.6 percentage points, 0.4 percentage points of welfare are sacrificed. The total system costs are now even slightly higher than the total system costs in the reference case. Paradoxically, with a regulatory toolbox limited to volumetric, capacity and standard fixed charges, the rise of active consumers enabled to invest in solar PV and batteries results in a situation which is worse both from the system and passive consumer perspective when compared to the reference case without active consumers. The proposed network tariff in this case is a three-part tariff, consisting of a mix of capacity-based charges, (lowered)

2. Besides, also early solar PV adopters have based their business case on volumetric charges and energy efficiency advocates fiercly oppose increased fixed network charges. See e.g. 'Ohio utility seeks to double its fixed distribution charges', link: https://energynews.us/2016/08/26/midwest/ohio-utility-seeks-to-double-its-fixed-distribution-charges/

fixed network charges and net-purchase volumetric charges. This result shows that even when the accumulated electricity volume flowing through the network does not drive the costs, it can make sense to recuperate part of the grid costs through (net purchased) volumetric charges to reduce fairness concerns.[3]

Nonetheless, fairness is even more of a challenge as it goes beyond cost allocation among domestic consumers but also lives between voltage levels. Historically, electricity flowed from the high voltage levels all the way down. As a result, it was acceptable that transmission grid users did not pay for distribution while distribution grid users paid for transmission too. Also, within the distribution grid, this cascading practice is applied with domestic grid users paying more than industrial clients connected to higher voltage distribution networks. To the extent that the direction of the flows is changing, also this cascading principle could be challenged from a fairness but also from a cost-efficiency point of view. New entities such as Local Energy Communities (LECs) which unite active consumers will only make this debate more topical in the near future.

3. Options to Move Beyond

We showed that if the regulator only has the three options available that we consider in this policy brief, it will be difficult to implement a fair tariff design. This is especially true if the proportion of sunk grid costs is high and cost-reflective charges are hard to implement. However, in practice, our results regarding fairness might be overestimated as such issues can be improved through other solutions than standard tariff design.

Negative distributional effects could be remedied through specific low-income programmes. Another solution would be not to implement uniform fixed network charge as we did, but to differentiate the fixed network charges per consumer or consumer groups without distorting the use of electricity, e.g. by income, property value, property size, kW connection capacity.[4] It might also be possible to improve fairness by introducing some form of taxation for active consumers. However, taxation is also difficult to implement and could conflict with other public policy goals. In the case of high sunk grid costs, under-recovery of the grid costs could be an option as full cost recovery leads to inefficiencies. Not recovered sunk network costs could be recuperated through other means than the electricity bill, an option also discussed in the report by the MIT Energy Initiative. An alternative could be to let taxpayers pay for these costs, as is done for roads in some countries. Lastly, instead of capacity-based charges, time-varying network charges might be more suitable to reflect the underlying network costs, even though they remain hard to implement and should comply with other regulatory objectives such as predictability and simplicity.

On the other hand, our results could underestimate the challenges of implementing cost-reflective and fair distribution network tariffs in practice. We did not assume policy costs and taxes in the electricity bill to interfere with the analysis. In most countries the share of these costs in the electricity bill is increasing year by year and the way these costs are recuperated from consumers, mostly volumetrically, can seriously distort network tariff design and can aggravate cost-reflectiveness and fairness issues.

3. This is true when excluding losses. Net-purchased volumetric tariffs are volumetric tariffs for which only the gross energy withdrawn from the network is accounted for in the calulcation of network charges.

4. As also discussed in: Pollitt, Michael G. 2018. “Electricity Network Charging in the Presence of Distributed Energy Resources: Principles, Problems and Solutions.” Economics of Energy & Environmental Policy 7 (1): 89–104. doi:10.5547/2160-5890.7.1.mpol and MIT Energy Initiative. 2016.” Utility of the Future”. An MIT Energy Initiative Response to an Industry in Transition.

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