NETWORK TARIFF STRUCTURE FOR A SMART ENERGY SYSTEM

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ABSTRACT

The paper addresses the need to reconsider the most common network tariff structure for household customers as an important regulatory issue for European distribution system operators in the years to come. It demonstrates that volumetric (€/kWh) network tariffs do not provide the right incentives to customers for efficient use of the network and lead to cross-subsidies between different categories of users. Countries in which alternative network tariff structures for small customers have already been introduced are taken into account as learning cases. Appropriate approaches that increase the incentive for customers to use energy more efficiently may include more capacity/power demand based network tariffs such as two-part network tariffs with a prevailing capacity component or volumetric time-of-use network tariffs with different prices for peak and off-peak energy.

INTRODUCTION

The key mission of European distribution system operators (DSOs) is to deliver reliability and quality of the grid to their customers. Within the transition to the low carbon economy, additional network investments will be necessary to maintain the high level of service that European customers expect. Most of these investments are to be paid by DSOs, because their networks need to accommodate an increasing amount of distributed generation, including renewables and other distributed energy resources like electric vehicles. Against this backdrop, DSOs' ability to collect, through network tariffs, the revenue required to cover their network costs and needed investments is a key issue for the years to come. This paper explains why a reconsideration of the current network tariff structure for household customers is necessary and outlines alternative network tariff structure options. It also studies the cases of the Netherlands and Spain where such alternative forms of tariffs already exist.

CURRENT DISTRIBUTION NETWORK PRICING

Cost included in network tariffs

In most countries, network tariffs make up a significant share of a household customer's electricity bill, and they are expected to grow further. On average, network costs reflect 40% of the electricity bill [1]. Costs included in network tariffs include distribution network costs (including capital cost, operation cost, customer service cost, etc.), transmission network costs (for market models with one and two bills) and other regulatory charges. Most direct network costs are determined by peak demand (kW) and are largely independent of the actual energy delivered – at least in the short term. In fact, investment and maintenance costs are determined by the network development, taking into account the peak power requested on the network itself. Those costs are thus unlikely to decrease with the rise of decentralised generation: the grid must still be designed to cover peak demand when there is no local production. This paper focuses on the allocation of costs directly related to the network. Other types of regulated cost included in network tariffs (such as charges for renewables (RES)) are not considered in our paper, as they may evolve differently from network costs.

Network tariff structure

Today, recovering network costs heavily depends on how much electricity is sold. Network tariffs for households and small businesses are almost entirely based on energy volume (kWh). In 2012, EURELECTRIC conducted a survey on network tariff structures, in which respondents from 19 countries (industry associations, network associations and DSOs) participated. The results showed that about 50-70% of the allowed DSO revenue is usually recovered using such volumetric charges [2]. In the countries analysed, network tariffs were at least partially volumetric, i.e. based on energy (€/kWh). In addition, capacity/power demand charges (€/kW) and fixed charges designed to recover costs associated with consumer management and support (€) (sometimes also called customer charge), are common for household customers in most countries (see Figure 1). In some countries, the fixed charge depends on demand (e.g. size of fuse).

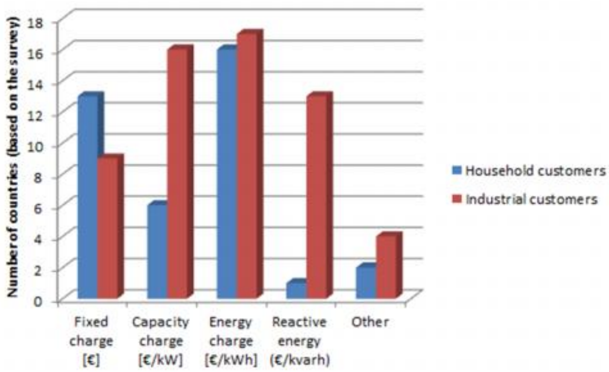


Figure 1 Network tariff components in countries participating in the EURELECTRIC survey

FUTURE NETWORK PRICING

Why should the network tariff structure change?

Regulators strive for a balance between multiple conflicting objectives, in particular revenue adequacy, cost-reflectiveness, economic efficiency and intelligibility. However, if network tariffs are not cost-reflective, several problems may arise:

1. Cross subsidies take place between different classes of customers;
2. Tariffs do not send the right price signals to final customers; and
3. DSOs may face a problem of revenue recovery.

Network tariffs with a significant volumetric part, i.e. where the tariff is based on the energy consumption of household customers, are the typical example of a non-cost reflective tariff. As a result, customers with very low energy consumption and a high peak power (which takes place during the highest usage of the network) pay much less than the costs they generate on the network.

Typically, customers with their own production request peak power only when the production plants occasionally do not work, e.g. for maintenance. These customers would pay an insignificant amount for the network usage (just a few kWh may be withdrawn from the network) compared to the cost they generate on the network (always based on the peak power).

In other words, volumetric network (non-cost reflective) tariffs provide a distorted incentive to invest in self-generation (household customers as prosumers). In addition such tariffs do not incentivise an efficient use of the network. Such prosumers will not reduce peak power requested from the network, since peak power has only a minor impact on their electricity cost. Volumetric tariffs create a risk of a significant economic impact on non-prosumers (if tariffs are adjusted to compensate the drop of energy taken off from the network) and on DSOs.

In fact, due to the strong development of own-production and due to the unstable economy, regulators are in a more difficult position to reliably predict the volumes of energy that will be withdrawn from the network in the upcoming years.

This can generate economic and/or financial deficits for DSOs. If actual volumes are lower than the predicted volumes, the revenues will not recover the costs. Even if ex-post adjustments can be made in order to correct the deviation between actual revenue and allowed revenue, temporary deficits may jeopardise the implementation of investment plans that are crucial for the whole electricity sector.

More capacity/power demand based network tariffs to provide better incentives

The Energy Efficiency Directive (2012/27/EU) requires the removal of network tariffs that would impede energy efficiency and/or demand response. Network tariff structures should incentivise demand response and energy-efficient behaviour while providing a stable framework for both customers’ bills and DSO revenues.

A new tariff structure should represent the different nature of fixed costs and of variable costs (depending on actual energy use). In addition, these new tariff options should allocate additional costs of reinforcement and grid losses to the network customers that cause these costs.

To increase the incentive for customers to use energy and the network more efficiently, appropriate approaches may include two-part network tariffs with a prevailing capacity component and an energy component or volumetric time-of-use network tariffs with different prices for peak and off-peak energy. Moreover, dynamic pricing (which requires smart meters) may encourage customers to change their peak moments, which would have a positive impact in terms of a more optimal use of the network capacity. Several studies conclude that cost-reflective pricing is necessary and recommend regionally differentiated or dynamic pricing [3] [4] [5].

In our view, network tariffs should, therefore, mainly be based on capacity/power demand. Such a network tariff reflects the costs more adequately because network costs are mainly capacity driven. A tariff with this structure does not impede energy efficiency, as required by the Energy Efficiency Directive, because there are other significant parts of the tariff which are, correctly in this case, based on energy consumption.

Figure 2 compares the impact of fixed volumetric tariffs (A) to capacity based (B), time-of-use volumetric (C), and two-part tariffs with a power/capacity and an energy component (D).

The main advantage of (A) is its simplicity and historic acceptability in some countries. This approach however does not represent a good adherence to the true nature of network costs, therefore putting DSO revenue adequacy at risk.

Fixed volumetric tariffs (A) incentivise only a reduction of overall consumption regardless of time but may have little or no impact on network peak demand. Due to their strong price signal during peak hours, time-of-use tariffs (C) induce higher overall (not just peak-hour) consumption reduction than fixed volumetric pricing (A).

All three approaches (B, C and D) better represent the induced costs than (A), which could lead to a more efficient use of the network. Revenue adequacy is better guaranteed with approaches (B) and (D), although ex post revenue adjustments and a good definition of allowed revenues may provide the same result. Approaches (C) and (D) have higher complexity and measurement requirements. Approach (B) may have the lowest incentive to reduce overall consumption compared to the other approaches.

Peak demand is one of the main drivers for network costs. All three approaches (B, C and D) have a higher potential for reducing network costs than (A). They incentivise a reduction of peak consumption, for example by shifting consumption to off-peak hours.

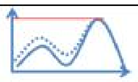
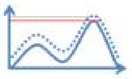
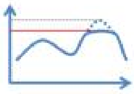
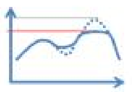
Network Tariff Type	Possible Effects on Load	Impact on overall energy consumption reduction	Impact on network costs reduction (losses excluded)	Intelligibility / Complexity	Economic efficiency	Cost reflectiveness	Revenue adequacy (for DSOs with no ex post adjustment)
A. Fixed volumetric (€/kWh)	 	✓	✗	✓	✗	✗	✗
B. Capacity based (€/kW)				✓	✓	✓	✓
C. Time-of-use volumetric High €/kWh (peak hours) Low €/kWh (off-peak hours)		✓	✓	✗	✓	✓	✗
D. Two-part tariff Power component (€/kW) and Energy component (€/kWh) (with flat or ToU energy charge)		✓		✗	✓	✓	✓

Figure 2 Impact of major tariff options on energy consumption and network costs

COUNTRY CASE STUDIES

Dutch capacity based tariffs

From 2009 onwards, Dutch small customers and businesses have paid a flat capacity tariff for their electricity distribution. This tariff is based on the capacity of their connection, the maximum power admissible by the connection or the customer installation based on the size of the fuse, and no longer on the actual usage or the time of consumption. Most small customers have a limited electricity connection, i.e. 3*25A. For customers with a larger connection (i.e. 3*35A or 3*50A), such as households with heat pumps or elevators, a much higher capacity tariff is applied. Although these customers may need a higher power connection, they also may have a lower annual electricity usage than the average Dutch customer. Therefore, during the first two years after the introduction of the tariff, these customers were compensated either by a reduced tariff to reduce their capacity connection or they received a lump-sum transition compensation.

Another solution that has been applied, especially for electricity customers with below average consumption, is that every household receives a yearly fixed tax credit (i.e. tax rebate on the total energy bill, electricity and gas combined). For the DSOs, the introduction of the capacity tariff resulted in less complex administration costs and lower capacity for errors due to a reduced amount of data exchange. It also facilitates the retail centric market model (supplier responsible for correct and on-time billing of customers). It must be noted that the allowed revenues for Dutch DSOs depend, among other things, on their market share. The market share per DSO changed after the introduction of the capacity tariff because the distribution revenues for DSOs changed as well.

In spite of the above listed benefits, the current Dutch capacity tariff may lack sufficient incentives to stimulate energy efficiency and renewable sources. Therefore, not only was the capacity tariff introduced but the structure of the energy tax also changed in 2009. The energy tax was increased to encourage energy efficiency. Currently, for small customers (<10,000 kWh) are taxed €11.85 ct/kWh. In the end, the capacity tariff is designed in such a way that, including taxes and tax credit, the net effect on small customers is minimal.

Dutch pilot testing impact of dynamic pricing on network capacity use

"Your Energy Moment", a pilot project currently running in the Netherlands, aims at better understanding how willing consumers are to use electricity in a more flexible way. Within this pilot, participants are offered one integrated hourly-varying kWh-tariff including supply and network. This tariff is based on the local network loading (e.g. towards the end of the afternoon and early evening, network electricity is more expensive than during noon hours) and the prices on the wholesale market (represented by the day-ahead APX market).

Participants produce their own energy using photovoltaic (PV) panels and own a smart meter, an energy computer and a smart washing machine, which communicate with each other. This system enables balancing on a local scale. Participants are offered two different incentives to choose their electricity use: financial incentives, i.e. participants receive a 24h forecast of the price per hour, or sustainability incentives, i.e. participants receive a 24h forecast on solar production.

These smart appliances allow participants to make rational decisions based on actual energy use and increases in electricity efficiency.

The first pilot results show that, firstly, financial incentives represent an important motivation for participants to shift their energy consumption. Of the two incentives provided, the majority (95%) chooses the financial incentive and approximately 77% identify the cost savings that are 'worth it'. Secondly, customers are keen on joining the pilot and believe that it is important to be future-oriented and environmentally friendly. The application of smart grids and dynamic tariffs can help to change the behaviour of customers regarding their energy use. As a result less expansion in the grid is needed because the grid can be used more efficiently through ICT.

Spanish more power demand based tariffs

In Spain, network access represents around 50% of the electricity bill for households and small businesses (without taxes). Network access tariffs include not only the network costs but also other costs related to energy, such as social and territorial policies. They are two-part with a demand charge (€/kW) and an energy charge (€/kWh). Consumer categories are defined by voltage level. In LV and MV, two categories are differentiated according to the subscribed demand (LV: ≤ />15 kW; MV: ≤/>450 kW). Small customers subscribe to a power demand (kW) capped by a power control switch that is usually below the installation capacity. Normally there is a capacity reserve for a future demand increase due to the enlargement of customers' electrical equipment, i.e. subscribed demand can be increased/reduced. Reactive power is billed when the power factor is below 0.9.

The network tariff methodology applied until 2013 allocated around 30 % of regulated network access costs to the demand charge and 70% to the energy charge in the households and small businesses category (tariff 2.0A). Consequently, more than 80% of electricity supply costs (network service + other costs + energy) were allocated to the energy charge in the electricity bill of this customer category. This share gave an excessive incentive for self-generation.

Having held a public consultation on the methodology for the allocation of network access costs, the National Energy Commission (CNE) issued a new methodology proposal in June 2012. It consisted of allocating network costs (transmission and distribution) with a share between 82.1% and 91.4% to the power demand charge and between 17.9% and 8.6% to the energy charge. For the remaining regulated costs not related to the network usage, CNE did not propose any allocation criteria.

The two network access tariff reviews of August 2013 and January 2014 implied a significant change in the charges structure. After the two tariff reviews, the demand charge provides 59% and the energy charge 41% of the network revenues in the households and small businesses category. Overall, the power demand charge increased by 28% to 112.6% and the energy charge decreased by 20.58% to 36.20%, depending on the tariff. The Spanish government claims this change in the charge structure to be one of the measures taken to ensure the economic sustainability of the electricity system.

For the average household consumer the change was neutral. However, for customers with a very low load factor such as second homes and seasonal agricultural irrigation, the increase has been considerable. For other customers with a low load factor such as vulnerable customers, the impact has been mitigated by a social bonus in form of a discount in the electricity bill.

Some customers have reacted by lowering the subscribed demand. Reductions of 2% to 10% have been reported, depending on the distribution area. This reduction means a higher usage of distribution assets.

CONCLUSION

The paper demonstrated that incentivising demand response and efficient consumer behaviour while providing a stable framework for both customers' bills and DSO revenues leads to a reform of the – today most common – volumetric network tariff structures. As volumetric network tariffs do not provide the right price signals, customers are not incentivised to adopt efficient consumption behaviours; higher costs for the system arise and these costs are not paid by the customers that caused them.

Therefore, the paper recommends more capacity/power demand based network tariffs such as two-part network tariffs with a prevailing capacity component and an energy component or volumetric time-of-use network tariffs with different prices for peak and off-peak energy. In this way, cross-subsidies between different categories of users would be minimised, ensuring that customers only pay for what they use.

The Dutch and Spanish experiences show that information and a gradual transition are key for getting customers on board. A structure of dynamic network prices reflecting more closely the marginal costs that would allow the promotion of demand response and energy efficiency should be further explored. In addition, different customers' potential and the outcome of the national cost-benefit analysis for the roll-out of smart meters should be taken into consideration when designing new tariff structures.

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