EVALUATION OF ALTERNATIVE NETWORK TARIFFS – FOR RESIDENTIAL CUSTOMERS WITH HOURLY METERING OF ELECTRICITY CONSUMPTION

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ABSTRACT

This paper presents results from the Norwegian research project "SmartTariff" (2014-2017). The objective of this project is to develop the future tariffs to be introduced when full-scale roll-out of smart meters have been performed. This is done through analysing framework conditions and purposes for different tariffs, suggesting alternative tariffs and evaluate cost/benefit for actors involved. This paper presents today's status of network tariffs in Norway and some alternative network tariffs that will be investigated within the project.

INTRODUCTION

Smart meters give possibilities for developing new network tariffs. The tariffs usually consist of several parts that are structured and differentiated according to the purpose of the tariff. The research project “Smart Tariff" aims to use this new technology and available data to develop new tariffs “top-down”.

During the last years there has been a trend towards new appliances that are more energy efficient, but at the same time have a higher peak power demand and higher variability in the electricity demand compared to previous experience, for example electrical vehicles, instantaneous electric water heaters, large heat pumps and induction cookers. This trend results in increased peak load, reduced energy consumption, which again will give a reduced utilization time of the distribution grid.

Bottlenecks in the distribution power system can be solved by investments in the grid, in order to make the grid capable of handling the peak load at all times. However, if the peak load is continuously increasing, it is not necessarily always socio-economic optimal to upgrade the grid capacity to handle this. Reducing the peak load through demand response/load shifting can be a better alternative, incentivized through e.g. new network tariffs and dynamic price signals.

For a residential customer the peak load occurs in a limited number of hours during the year, as illustrated in the duration curve in figure 1. For this average customer the load exceeds 70% of peak load in only 5% of the hours of the year. The trend with higher peak power and increased energy efficiency will give a shift of the curve as illustrated in figure 1 with the dotted lines and the arrows.

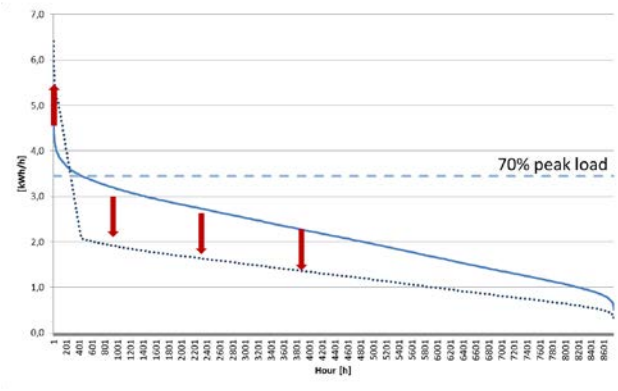

Fig. 1 Duration curve for a residential customer in Norway (average values calculated from 10 residential customers) [Source: Istad Nett]

BACKGROUND

In Norway, the electricity costs are comprised of three elements: electrical energy cost, network fee and taxes. Each of them forms nearly one third of the total electricity costs for a residential customer, as shown in figure 2.

The Distribution System Operators (DSOs) collect the network fee through network tariffs. According to the regulations in Norway, the network tariffs must be non-discriminatory and unbiased [1].The tariffs can hence only be differentiated according to unbiased and controllable criteria that are based on the relevant grid situation. At the same time, the network tariff should promote efficient use and development of the grid. A number of EU directives also affect the framework conditions for network tariffs in Norway, as discussed in [2].

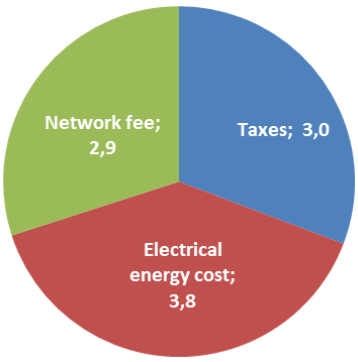

Fig. 2 Average electricity costs per kWh [€ cent/kWh] for a residential customer in Norway in 2013 [Source: www.ssb.no]

According to the regulation on tariff structure, network tariffs for customers without hourly readings consist of two parts: a fixed charge [€/year] and an energy charge [€/kWh] [1]. The fixed charge shall as a minimum, cover the costs associated with customer management and support. The energy charge is usage-dependent and shall at least cover the marginal network losses. A seasonally differentiated energy charge must be offered to all customers with consumption higher than 8.000 kWh/year.

Network tariffs for customers with hourly metering introduce a third part, a capacity charge (€/kW). The capacity charge shall be based on the customers power consumption is certain time periods, and shall be designed so that the customers pay the highest price (€/kW) for the first kWs [1].

Today, the majority of residential customers in Norway do not have hourly metering, but pay based on monthly self-readings. Primarily large commercial and industrial customers are required to pay a capacity charge. However, this is about to change with the full-scale deployment of smart meters.

Within 1. January 2019, all customers in Norway will have installed smart meters. The Norwegian Electricity Regulator (NVE) has therefore initiated the process of redefining the regulation on network tariff structure. The new tariff structure will take into account that all customers have hourly readings. A consultation document from NVE outlines three different alternatives: peak-power tariff, subscribed power tariff and fuse tariff [3].

For a *peak-power tariff* the capacity charge is determined by the customer's peak consumption during a certain time period. The peak consumption can be based on a single hourly reading or an average of several readings during the time period, whereas the time period could range from a week to a year.

With a *subscribed power tariff* the customers subscribe to a specific amount of power which yields an annual fee. Any power consumption above the subscribed power will induce a high capacity charge.

A *fuse tariff* implies a tariff where the annual fixed cost is determined by the customer's installed fuse size (€/kW or €/A). No other capacity charges apply as the fuse size indicates the customer's possible power consumption. However, fuse tariff would require a register with every customer's fuse size.

Additionally, combinations of these three tariff types could also be relevant [3].

CURRENT NETWORK TARIFFS

A study of the current network tariffs in Norway was carried out in late 2015. The 23 largest DSOs in Norway were included in the study, covering nearly 80 % of all customers in Norway.

Residential and small commercial customers

This group of customers has an annual consumption below 100.000 kWh/year and are typically charged based on monthly self-readings.

Energy tariff

The majority of the DSOs (18 out of 23) offered a simple energy tariff composed of two parts - a fixed charge and an energy charge. Several DSOs differentiated according to customer type. The fixed cost was then somewhat higher for holiday homes compared to normal households, and somewhat lower for apartment buildings and small commercial customers. At the same time, a number of DSOs offered solely a seasonally differentiated energy charge, while most others offered this as an alternative.

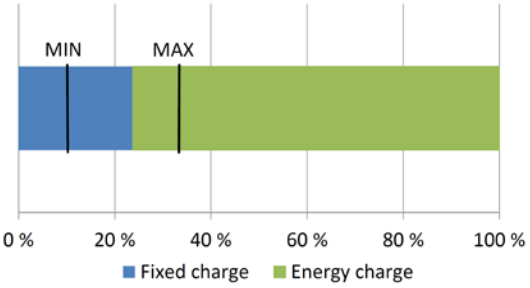

Fig. 3 Allocation of network fee for an average residential customer using 16.000 kWh/year

For an average residential customer, the fixed charge constituted on average 23,7 % of the total network fee. This is shown in figure 3, along with the maximum and minimum values encountered in the study. Thus, the majority of DSOs utilized the usage-dependent component to recover most of their costs from residential and commercial customers. The average energy charge was, in comparison, several times the marginal network losses.

Fuse tariff

The remaining five DSOs offered a fuse tariff to their customers. The number of price levels varied between two to five levels. The energy cost was more or less identical as for the energy tariff.

Peak-power tariff

Additionally, three grid companies had started their deployment of smart meters and had therefore a separate peak power tariff for customers with smart meters. Both the fixed cost and the energy cost were significantly reduced for this network tariff.

Large commercial and industrial customers

This group of customers has hourly readings and typically an annual consumption over 100.000 kWh/year. All investigated DSOs offered peak-power tariff to this customer group. The capacity prices varied greatly, but nearly 75 % of the DSOs had a volume discount. Figure 4 shows the average price reduction for the relevant DSOs. For consumption above 1000 kW, the average reduction in capacity price was 25 %.

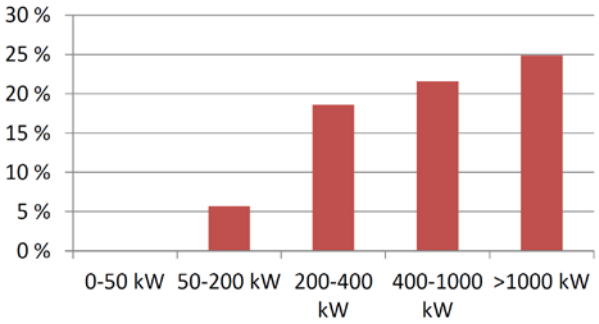

Fig. 4 Average capacity price reduction (in percent) for DSOs that offered a volume discount.

The DSOs had different methods for settlement; here classified according to the time frame for the settlement:

Monthly settlement

16 out of 23 DSOs had monthly settlement, mainly based on a single peak-hour reading during the previous month. As depicted in figure 5, more than half of the DSOs had a capacity price that varied throughout the year (shown in red). However, only two of the DSOs differentiated according to the time of day.

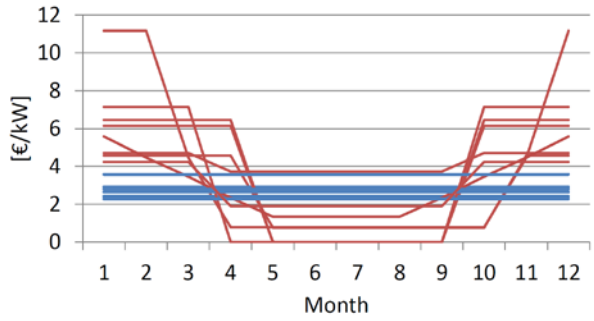

Fig. 5 Monthly capacity prices [€/kW] for DSOs with monthly settlement. Varying prices are shown in red, while constant prices are shown in blue.

Quarterly settlement

One DSO used the single peak-hour consumption in the previous quarter as basis for the capacity charge. The DSO offered a constant capacity price throughout the year.

Yearly settlement

The remaining six DSOs had a settlement based on metered consumption during the last 12 months. Some used a single peak-hour value, while others used an average of several. Typically, the peak-values during the summer months were drastically reduced or even disregarded. Some DSOs also distinguished between day/night and weekday/weekend.

FUTURE NETWORK TARIFFS

EDSO for Smart grids [5] recommends changes in framework conditions for DSOs to enable them to handle increased variations in consumption and generation, maintain stable grid operation, stable revenues, supporting distributed generation and climate goals and flexible grid services contributing to cost efficient grid operation.

A first step to achieve this is to update the tariff regime in the distribution grid. A key message from [5] is that:

Grid users should receive compensation from DSOs when adapting their energy consumption/generation in response to signals (eg. at peak times)…

… and be able to sign up for "smart contracts" with DSOs, granting them a quicker and cheaper connection, in exchange for occasional and limited curtailment/grid disconnection/activation of storage at peak times.

[5] also invites the National Regulation Authorities to *make distribution network tariffs more capacity based, and less volumetric based, in order to limit revenue uncertainty for DSOs.*

DSOs are natural monopolies that get their revenue from the customers, through the customer bill (network tariff) and a fixed price for connection to the grid (connection charge). The costs paid by the different customers can be allocated according to a set of criteria. Alternative criteria are presented in table 1.

Table 1 Alt. criteria for differentiation of tariffs [6]

Geography	Uniform charges Locational charge Voltage level
Time-of-use	Peak load pricing
Fixed and variable elements	Energy, demand charge Two-/multi-part tariffs
Payment liability	Generation – load split
Type of service	Connection charges, Network meter, etc.
Type of customer	Household, commercial, industrial

With this as a basis, the SmartTariff project will evaluate alternatives for network tariffs to customers in the distribution grid, mainly residential customers.

ALTERNATIVE NETWORK TARIFFS

To evaluate how alternative network tariffs will affect the total yearly costs for a residential customer, hourly meter

data from 8021 customers, living in single-family houses, have been analysed with use of USELOAD[1] software. The customers are sorted into five different groups according to their typical load profile. One customer from each group has been selected and used in the calculation. Metering data of electricity consumption [kWh/h] for the period 1st October 2014 until 30th September 2015 have been used. To be able to compare the costs for different customers with different profiles, the load curves are scaled to an annual consumption of 16.000 kWh (representing an average residential customer in Norway).

The following customer groups were defined:

- Highest load during night (C1)
- Highest load during day-time (C2)
- Highest load during evening (C3)
- Load with high utilization time of the grid (C4)
- Load with low utilization time of the grid (C5)

The objective of the analysis has been to calculate the consequences of alternative network tariffs. The customer response due to the price incentive has not been tested.

The evaluated network tariffs are presented in table 2.

Table 2 Alternative network tariffs

Tariff	Description of parts
1. Energy tariff	Fixed charge[1] Energy charge[2]
2. Seasonal energy tariff	Fixed charge[1] Energy charge summer/winter[2,3]
3. Peak power tariff	Fixed charge[1] Energy charge[2,4] Power charge[6]
4. Seasonal peak power tariff	Fixed charge[1] Energy charge[2,4] Power charge summer/winter[3,6]
5. Peak power tariff day	Fixed charge[1] Energy charge[2,4] Power charge day/night[5,6]

[1] Fixed costs [€/year]
[2] [€/kWh]
[3] Winter: November-March, Summer: April-October
[4] Mainly covering marginal network losses
[5] Day: 0700-1600 workdays. Night: 1600-0700 workdays and weekend/holidays
[6] [€/kWh/h]

The calculation of costs for the different customer types and alternative tariffs (table 2) are shown in figure 6. For the three alternative power tariffs (# 3-5 in table 2), the calculations are performed with settlement both based on the peak load hour per month (a), and the average of three peak load hours per month (b). With the latter alternative, the customers have a possibility to reduce their costs if a peak load hour has occurred. This is also the results in the analysis, but is not presented in figure 6.

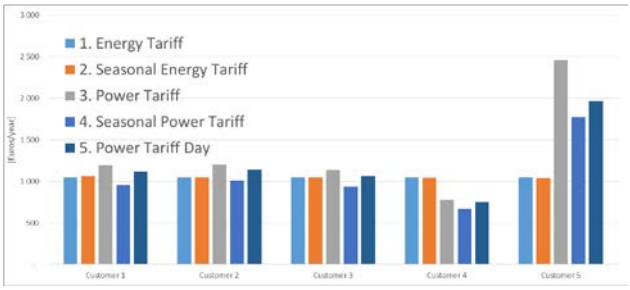

Fig. 6 Yearly costs for alternative tariffs for different customer groups

The differences in network costs for customer group C1-C3 are not large, even if the highest consumption normally occurs at different period during the day. The main differences are for the customers with high and low utilization time for the grid.

CONCLUSION AND FURTHER WORK

This paper presents initial results from evaluating alternative network tariffs. Further analysis will be performed within the SmartTariff project, and some of the alternative network tariffs will be selected for testing and demonstration among residential customers. Related to planned demonstration activities, the customer response will be analysed – both based on metering of electricity consumption and user surveys.

Acknowledgments

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