SMART TARIFFS – IN AN ACTIVE DISTRIBUTION GRID

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ABSTRACT

New technology such as smart meters gives possibilities for developing new network tariffs. Usually the tariff contains several parts, and how these parts are structured and differentiated, depends on the purpose of the tariff. A new research project "Smart Tariff" (2014-2017) will use smart meters and available data to develop new tariffs "top-down", ensuring different purposes of the tariff. The paper discusses different purposes for the network tariff in interplay with power market pricing and demand response, and how different tariff element can be designed based on technical challenges in the local grid.

INTRODUCTION

During the last years there has been a trend towards use of 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 than previously experienced. Examples of such appliances are electrical vehicles, instantaneous electric water heaters, large heat pumps and induction cookers. In the future there will be larger variations in customers behaviours, where some will be active related to consumption, generation and storage of electrical energy.

Bottlenecks and other technical restrictions in the distribution system can always be solved through investments in the grid, in order to make the grid always capable of handling the peak load. But if the peak load is continuously increasing, it is not necessarily socio-economic optimal to upgrade the grid capacity to manage grid constraints. Reducing the peak load trough demand response/load shifting might be a better alternative, incentivized through e.g. new network tariffs and dynamic price signals.

Different incentives to influence electricity use can be allocated to different tariff elements (energy, peak power, reactive power, fixed part, etc.) and the different elements can further be differentiated with regards to time, customer type, load etc.

The most suitable way of developing tariff elements and the differentiation of these, depends on the purpose of the tariff. For example if a tariff should motivate for peak power reduction, the tariff should have a strong peak power price signal, or if energy efficiency is the main objective, a high energy price will be a reasonable solution.

RESEARCH PROJECT

The SmartTariff research project (2014-2017) aims at developing the future smart tariffs for both electrical energy contracts, grid fees and taxes – since these element in sum represents the total price signal to the customers.

This will be achieved through the following work:

- mapping alternative purposes of a tariff, and how it can be used to solve the main objectives and needs for the total energy systems,
- describe how new technology can enable demand response according to different tariffs,
- mapping possible restrictions for tariffs,
- suggest optimal tariff structures,
- evaluate distribution effect for different alternative tariffs and
- evaluate cost/benefit for actors involved, based on demonstration activities.

The main hypothesis in the project is that today's practice for energy contracts and network tariffs is not sufficient to meet the new challenges on the consumption side. Nor can today's tariffs fully utilize the possibilities that full-scale deployment of smart meters will give from 2019. (Smart meters should be installed in Norway by January 1. 2019. In most of Europe smart meters will be installed at 80% of customers by 2020 and 100% by 2022.)

ELECTRICITY IN NORWAY

In Norway, the cost the customers pay for access to and utilization of the power system and the power markets can be divided into three main cost elements:

1. Network fee (costs for grid connection)
2. Electrical energy cost (energy contract)
3. Taxes.

In Fig. 1 the costs per kWh [€ cent/kWh] for a residential customer in Norway is presented – divided into the three main elements.

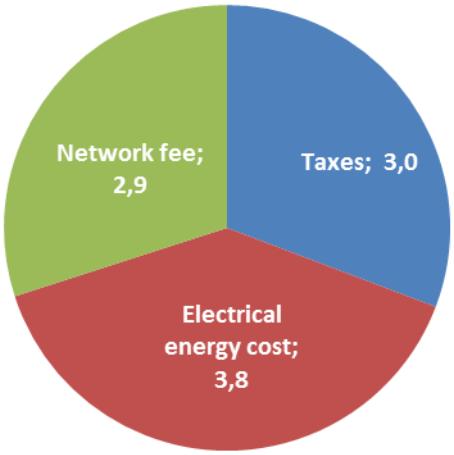

Fig. 1 Average electricity costs per kWh [€ cent/kWh] for a residential customer in 2013 [Source: www.ssb.no]

In the common spot price market of the Nordic power system, the price for electricity is expected to be quite low in the next decades due to electric energy surplus. But, grid investments both in the transmission and distribution grids are expected to increase substantially due to planned investments and reinvestments. Societal acceptance of future grid cost levels will be a challenge in Norway, which can motivate for smart tariffs, smart monitoring and control technologies that can reduce the need for traditional investments in network hardware - cables, overhead lines and transformers.

FRAMEWORK CONDITIONS

Norway is not a member of the European Union (EU), but is through the Agreement on the European Economic Area (EEA) obliged to implement the EU directives and the Network Codes authorized by Regulation (EC) 714/2009. A number of provisions exists that provide the playing field for tariff constructions. The most important are discussed below.

Directive 2009/72/EC – Internal electricity Market [1]

In Directive 2009/72/EC common rules for generation, transmission, distribution and supply of electricity is given, also including customer protection when improving and integrating the internal electricity market in EU.

The Directive gives i.e. the following requirements for tariffs:

- Further measures should be taken in order to ensure transparent and non-discriminatory tariffs for access to networks. Those tariffs should be applicable to all system users on a non-discriminatory basis
- In order to ensure effective market access for all market players, including new entrants, non-discriminatory and cost-reflective balancing mechanisms are necessary.(...)
- (...) transmission and distribution tariffs are non-discriminatory and cost-reflective, and (...) take account of the long-term, marginal, avoided network costs from distributed generation and demand-side management measures.
- Member States shall ensure the implementation of a system of third party access to the transmission and distribution systems based on published tariffs, applicable to all eligible customers and applied objectively and without discrimination between system users.
- The regulatory authorities shall be responsible for fixing or approving sufficiently in advance of their entry into force at least the methodologies used to calculate or establish the terms and conditions for connection and access to national networks, including transmission and distribution tariffs or their methodologies. (Article 37-6-a)
- In fixing or approving the tariffs or methodologies and the balancing services, the regulatory authorities shall ensure that transmission and distribution system operators are granted appropriate incentive, over both the short and long term, to increase efficiencies, foster market integration and security of supply and support the related research activities. (Article 37-8)

Directive 2012/27/EC – Energy efficiency [2]

Common rules for energy efficiency are specified in Directive 2012/27/EC, in such a way that EU will meet its targets of 20% energy efficiency by 2020. The Directive also includes requirements for removing barriers in the energy markets that hinder energy efficiency in supply and use of energy.

The Directive gives i.e. the following requirements for tariffs:

- Demand response is an important instrument for improving energy efficiency, (...) and, through the more optimal use of networks and generation assets, in energy generation, transmission and distribution.
- Demand response can be based on final customers' responses to price signals or on building automation. (...) Taking into account the continuing deployment of smart grids, Member States should therefore ensure that national energy regulatory authorities are able to ensure that network tariffs and regulations incentivise improvements in energy efficiency

and support dynamic pricing for demand response measures by final customers.

- Member States may permit components of schemes and tariff structures with a social aim for net-bound energy transmission and distribution, provided that any disruptive effects on the transmission and distribution system are kept to the minimum necessary and are not disproportionate to the social aim. (Article 15-3)
- Member States shall ensure the removal of those incentives in transmission and distribution tariffs that are detrimental to the overall efficiency (including energy efficiency) of the generation, transmission, distribution and supply of electricity or those that might hamper participation of demand response, in balancing markets and ancillary services procurement. (Article 15-4)

Energy law with regulations

The national Energy law with its regulations give the framework for development of tariffs in Norway. The objective of the Energy law is to secure that generation, conversion, transmission, trade, distribution and use of energy should be performed in a socio-economical rational way, but at the same time taking into account public and private interests that are affected.

OBJECTIVE HIERARCHY FOR TARIFFS

Development of tariffs for access to and use of the power system and energy markets should be based on the purpose of the tariffs – what you want to achieve. For example the purpose can be limited to only cover the costs in a simple and understandable way, or the opposite - contribute to a sustainable and environmental friendly energy system.

Following up the project objective to develop the future smart tariffs, the SmartTariff project has evaluated alternative purposes for a tariff.

The purpose of the tariff is on different levels and can be structured in a hierarchy as proposed in Fig. 2. The superior objectives are on the top, and subordinate objectives should be adapted to the superior objectives.

Some "vertical" requirements (on the left and right side of the figure) concerning the different levels in the hierarchy are also included in the figure. The different objectives and requirements are described below the figure.

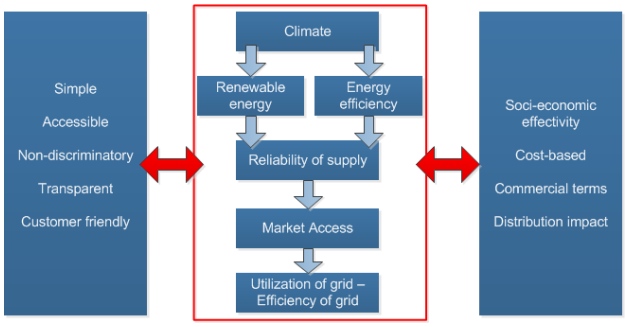

Fig. 2 Objective hierarchy for tariffs

Climate
The main superior objective relates to that tariffs should give incentives to mitigate climate change.

Renewable energy/Energy efficiency
Replacing fossil energy generation with renewable sources and reducing the energy consumption is a natural consequence of the objective to mitigate climate change. This objective is not only focusing on the power system, but also other areas - such as transport, etc.

Reliability of supply
A climate friendly, energy efficient and renewable power system has to fulfil the requirements for security of supply, which imply that the access to electricity is balanced with the actual need.

Market access
For the users in the power system to be able to meet the overall objective of the power system, all users should have access to the power system (market and grid access) on transparent and non-discriminatory conditions. The overall objective will facilitate social efficient adjustments for the users.

Utilization of grid – Efficiency of grid
The power grid is the hub connecting all the energy system actors. Since the grid represents 30% of the costs for the residential customers it is important that the grid is economical efficient, has a high degree of utilization and has a sufficient quality of supply.

Vertical requirements (left):
Simple, Accessible, Non-discriminatory, Transparent, Customer friendly
The requirements related to these aspects are probably the most difficult to satisfy, at the same time as the tariffs should be cost-efficient. It is difficult for the customers to understand the correlation between cost driving aspects (i.e. peak load) and the tariffs. The customers usually think they are buying kWhs and that is what they should pay for. The tariffs are a tool to affect customer behaviour, and if the customers do not understand the tariff it is difficult for them to respond correctly on the tariff.

The requirements for transparent and non-discriminatory tariffs are logical based on the sense of justice, but there is also communication challenges related to explaining why for example two customers with the same yearly energy consumption (but with large difference in peak load) should pay a different price.

As indicated in Fig. 2 these requirements are relevant for several levels in the objective hierarchy.

Vertical requirements (right):
Socio-economic efficiency, Cost-based, Commercial terms, Distribution impact
There is always a requirement to meet the overall objectives in a cost efficient way, and in Norway socio-economic efficiency is a central concept in the Energy law. An instrument for socio-economic efficiency is to expose the actors for cost-based price signals. Demand Response will be achieved if the customers see private benefit from the tariffs.

When developing tariffs it is also relevant to focus on the distributive impact for different groups: customers consuming electricity vs. customers generating electricity, industrial vs. residential customers, affluent groups vs. socially deprived groups, etc.

As indicated in Fig. 2 these requirements are relevant for several levels in the objective hierarchy.

CONVENTIONAL TARIFF REPRESENTING THE WHOLE POWER SYSTEM

In this paper a conventional tariff is used to elaborate the practical consequences from the suggested objective hierarchy illustrating that the different objectives might be incompatible.

The conventional tariff structure seeks to cover the whole power system and at the same time be relevant for both consumption and generation customers.

$$\begin{aligned} K = T + K_{system}(t) + k_{pcentral} \cdot P_{max0} \\ + k_{plocal} \cdot P_{maxl} + k_w(t) \cdot W(t) \\ + (S_{kmin} - S_{kref}) \cdot k_{sk} \end{aligned} \quad (1)$$

Where:

K	-	Total costs for the customer (electricity, grid, taxes)
T	-	Yearly connection fee – reflecting costs independent of consumption (grid, metering, ...)
$K_{system}(t)$	-	The costs for system services (balancing service, power of frequency characteristic)
$k_{pcentral}$	-	Capacity costs for grid on a higher voltage level (production and grid)
P_{maxo}	-	Dimensioning peak load or max feed-in to grid on a higher voltage level
k_{plocal}	-	Capacity costs in local grid
P_{maxl}	-	Dimension peak load or max feed-in to local grid
$k_W(t)$		Hourly energy price (Spot) – energy costs
W(t)	-	Electricity consumption/feed-in on an hourly basis
S_{kmin}	-	Min. short circuit capacity required by the load/feed-in (mainly due to voltage quality requirements)
S_{kref}	-	Min. standard short circuit capacity delivered to all customers via connection fee
k_{sk}	-	Specific cost for short circuit capacity

The conventional tariff consists of many parts, but this is important to discuss the coherence between the most important cost-driving parts, to get correct cost-based tariffs. Principally, several parts can be combined before introducing the tariff to the customers, but when discussing the objective hierarchy it is most appropriate to keep this detailing level.

CONCLUSIONS AND FURTHER WORK

The SmartTariff project has started up focusing on the alternative purposes of the tariff, requirements affecting the structure of the tariffs and a possible structure of a tariff representing the relevant objectives.

Further the SmartTariff project will perform several field trials, focusing i.e. on tariffs to solve capacity problems in the distribution system, which at the same time are cost-based and easy to understand for the customers.

Different capacity based network tariffs are under development and the testing activities will involve automatic demand response as well as manual demand response. Suitable appliances will be selected for load control and the performance of special designed control equipment will be analysed. The customer use of equipment will be monitored and feedback from the involved customers will be base for adjustment throughout the project.

The further development of tariffs will address the following challenges:

- Need for differentiation of tariff within the DSO area in order to incentivise customers located behind local bottlenecks
- Cost base for tariffs referred to local bottlenecks
- Regulatory aspects related to the location specific pricing
- Demand response incentives from energy price on hourly basis (Day Ahead)

Acknowledgments

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REFERENCES

[1] "Directive 2009/72/EC - Internal electricity Market, https://www.energy-community.org/pls/portal/docs/1164180.PDF ".

[2] "Directive 2012/27/EC - Energy efficiency, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF ".