Tariffs in Nordic countries – survey of load tariffs in DSO grids

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Table of contents

1 Introduction 7
1.1 Background – Why a survey of tariff design? 9
1.1.1 Technological change – smart grid and meters 9
1.1.2 Energy Efficiency Directive 9
1.2 Seminar with stakeholders 10
1.3 Outline of the report 11
2 The Nordic design of load tariffs 12
2.1 Implementation of the Energy Efficiency Directive in the Nordic countries 12
2.1.1 Implementation of the directive in Denmark 12
2.1.2 Implementation of the directive in Finland 12
2.1.3 Implementation of the directive in Iceland 12
2.1.4 Implementation of the directive in Norway 12
2.1.5 Implementation of the directive in Sweden 12
2.2 Tariffs in the Nordic countries 12
2.2.1 Tariffs for typical households 13
3 Conclusions regarding differences and similarities Fejl! Bogmærke er ikke defineret.
3.1 The current structure ....**Fejl! Bogmærke er ikke defineret.**
3.2 The trend for new design of tariffs**Fejl! Bogmærke er ikke defineret.**
3.3 Policy options for regulators on tariff design**Fejl! Bogmærke er ikke defineret.**
4 Summary of studies done on load tariffs in DSO grids 17
4.1 Load tariffs and demand response 17
4.1.1 Norway: 17
4.1.1 Sweden: 18
4.1.2 Finland: 20
4.1.3 Denmark: 21
4.2 What can be learnt about design of tariffs from the survey of studies done? 22

4.2.1 Cost-reflective tariffs ... 22
4.2.2 Demand response potential ... 22

Annexes ... 23

5 Tariff design in Denmark ... 24
5.1 Few restrictions in how to design grid tariffs in Electricity Act ... 24
5.2 Structure of grid tariffs for load in DSO-grids ... 25
5.3 Smart meters ... 27
5.4 Discussions on tariff design in industry ... 28
5.5 Conclusion ... 30

6 Tariff design in Finland ... 31
6.1 Electricity Market Act ... 31
6.2 Structure of grid tariffs in DSO-grids ... 32
6.3 Discussions on tariff design ... 36

7 Tariff design in Iceland ... 38
7.1 Electricity Act ... 38
7.2 Structure of grid tariffs in DSO- grids ... 38
7.3 Discussion on tariff design ... 39
7.4 Conclusion ... 39

8 Tariff design in Norway ... 40
8.1 Electricity Act ... 40
8.2 Structure of grid tariffs in DSO-grids ... 42
8.3 Discussions on tariff design ... 43
8.4 Conclusion ... 46

9 Tariff design in Sweden ... 47
9.1 Limited restrictions on grid tariff design in the Electricity Act ... 47
9.2 Structure of grid tariffs for load in DSO-grids ... 48
9.3 Discussions on tariff design in industry ... 50
9.4 Conclusion ... 52

Table over the report's figures

Figure 1 | Fixed part of the grid tariff for a typical household customer in the Nordic countries, 2015 14

Figure 2 | The price component for a typical household electricity customer in the Nordic countries, 2015 15

Figure 3 | Fixed part of a grid tariff for different levels of consumption, 2015 26

Figure 4 | Elements of the electricity price in 2015 27

Figure 5 | Implementation of smart meters in Denmark, 2013 28

Figure 6 | Daily load and limits for time differentiation, fictive example 29

Figure 7 | Timedifferentiation of tariffs, fictive examples 30

Figure 8 | Fixed part of the grid tariff for user type with 1×25 A, 2000 kWh/year in 2015 33

Figure 9 | Components of the retail electricity price, house with electric heating - 2.000 kWh/year 35

Figure 10 | Components of the retail electricity price, house with electric heating - 18.000 kWh/year 35

Figure 11 | Proportion of installed smart meters 36

Figure 12 | Components of electricity costs to a household, 2015 38

Figure 13 | Fixed part of grid tariff for household customer with 20 MWh per year in 2015 42

Figure 14 | Components of electricity costs to a household, 2015 43

Figure 15 | Fixed part of the grid tariff for user types with 16 and 25 A, 5.000 and 20.000 kWh/year respectively in 2015 49

Table over the report's tables

Table 1 | Average typical household tariffs in the Nordic countries, 2015 15

Table 2 | Smart meter implementation in the Nordic countries. 16

Table 3 | Mean tariffs for different customer groups, 2015 26

Table 4 | Average tariffs by user type (in year 2015 price level, not including taxes) 34

Table 5 | Proportion of fixed and variable parts of network tariff by user type 34

Table 6 | Mean tariff for different customer groups in 2015 42

Table 7 | Proportion fixed charge in grid tariff for different customer groups 43

Table 8 | Proportion fixed charge in grid tariff for different customer categories and proportion of Time-of-use tariffs 49

Table 9 | DSO grids using power based tariffs for households in 2015. 50

1 Summary and conclusions regarding differences and similarities

1.1 The current structure

In the Nordic countries there is some variation in electricity network tariff design. In Denmark, the fixed proportion of tariffs varies especially in the tariffs for the customer group with low consumption. The fixed part of the tariff is usually bigger in Finland on DSO's operating in rural areas. The proportion of the fixed part of the tariff has been increasing steadily in Finland. In Norway, the proportion of the fixed part of the tariff has slightly increased from 2011 to 2015, but the fixed part of the tariff still constitutes a smaller part of the total tariff. In Sweden, the variation in design is a typical feature of tariffs. Still the cost structure is in principle the same, but there is a rather wide variation in design in Sweden. The proportion of the fixed part of the tariff has over the years had a slow increasing trend for a larger fixed part in Sweden too.

A development towards a larger proportion of fixed part of tariff can be seen in all Nordic countries. There are though differences between the Nordic countries on the level of fixed part's proportion of the total tariff.

1.2 The trend for new design of tariffs

At the moment the design of tariffs has been left to the network companies to organise within their income cap for all Nordic countires except Norway. Norway has some regulations on allocating costs to fixed and variable parts of the network tariff, but even here the DSOs have quite some degrees of freedom in setting the tariff. For the other countires the network companies have their freedom to adjust tariffs according to their individual cost structures and customer demographics. Pricing must still meet the specific criteria of impartiality and non-discrimination, simplicity and transparency.

In Finland and Denmark, the industry has steered tariff design by guidance and tariffs are quite unilateral throughout the network companies. The industry guidance contains unambiguous guidance concerning all of these elements in the tariff methods. In general, the current guidance is to include all DSO-specific cost types that depend on consumption of electricity in the variable part of tariff and all cost types that do not vary with consumption in the fixed part of the tariff. The guidance leaves DSOs to adjust tariffs based on their individual cost structure. The trend on the other hand seems to be to explore whether more capacity based tariff can be more cost reflectve instead of or in addition to energy-based tariff.

1.3 Policy options for regulators on tariff design

In all the Nordic countries the role of national regulatory authority is to ensure that pricing of network services is reasonable as a whole, so in other words within the revenue cap. In Denmark, Finland, and Sweden there are no regulations on how the network operators should allocate costs on the fixed and variable parts of network tariff. These countries also share the following requirements concerning tariff setting:

- Tariffs must be cost-reflective,
- Tariffs must steer customers to efficient use of the power system and thus encourage customers to save energy.

Legislation gives DSOs relatively free hands on tariff design but the regulator has to ensure that these requirements are fulfilled in tariff setting. The role of the regulator is to be neutral. When there is no legislation on the issue, in order for the regulatory authority to take a position in favour on a certain type of tariff design, there should be clear benefits compared to the previous design.

In recent years, industry-led working groups in the Nordic countries have been studying the issue of tariff design. Norwegian national regulatory authority NVE has recently formed a work group of its own. The work continues in 2016.

2 Introduction

2.1 Background – Why a survey of tariff design?

The premises for network regulation and tariff design are undergoing a rapid transition. The implementation of the Energy Efficiency Directive in national legislation has lead to increased requirements on tariffs, such as incentivising efficient grid usage. In addition to new legislative conditions, the introduction of new technology opens up new opportunities. Real time metering enables new types of tariffs, and monitoring and steering equipment enables load steering and direct demand response. In parallel to these changes, there is an increasing discussion about the need for harmonization of tariffs between different countries.

Against this background, this report on tariff design produced by the NordREG Network Regulation Working Group intends to answer the following question:

What can the NRA do to incentivize more energy efficiency in distribution and use of energy through grid tariff design?

The report will provide a survey of the current DSO load tariffs in the Nordic countries, present the ongoing discussions on tariff design, and assess the implementation of the Energy Efficiency Directive in the countries as well as surveying the policy options for NRAs to incentivise DSOs to design tariffs which are compatible with the Energy Efficiency Directive.

2.1.1 Technological change – smart grid and meters

The development and introduction of new technologies provide new possibilities for tariff design and network operation. Automatic meter reading (AMR) makes hourly metering possible and enables a change from ordinary energy based charging to power based charging as well as time-differentiated tariffs.

2.1.2 Energy Efficiency Directive

The Energy Efficiency Directive was implemented in 2012 and establishes a set of binding measures to help the EU reach its 20 % energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages to the energy chain, from its production to its final consumption.

With regards to distribution operations and the topic of this report, the Energy Efficiency Directive puts a number of new requirements on tariffs. These mainly relate to tariffs which incentivise efficient use of the network. The Directive requires NRAs to provide incentives for grid operators to make available system services to their users permitting them to implement energy efficiency improvement measures. Specifically to tariff design, the Directive requires that network tariffs are *cost-reflective of cost-savings in the network achieved from demand-side or demand-response measures and distributed generation, including savings from lowering the cost of delivery or of network investment and a more optimal operation of the network*. In addition, the Directive specifies that network tariffs may support dynamic pricing, for example through time-of-use tariffs or critical peak pricing.

EU countries were required to transpose the Directive into national law by 5 June 2014. It has been transposed in all Nordic EU member states.

2.2 Seminar with stakeholders

NordREG arranged a seminar in Stockholm on 5th November 2015 to discuss tariff design with interested parties. The day consisted of presentations by 9 speakers and engaged discussions with an active audience of around 50 people from all Nordic countries. The speakers represented grid companies, industry associations, universities and consultant agencies and were from Denmark, Finland, Norway and Sweden. They presented the possibilities that can arise from new advanced meters and different alternatives for tariff design. Some designs were theoretical and exploratory in their nature whereas others were already implemented. Results from pilot projects with different tariff designs were also presented.

New technology gives opportunities for providing customers with improved price signals compared to traditional tariffs, with a fixed charge and a variable charge depending on energy consumed. Among the participants in the seminar, there was a rather broad consensus that price signals from tariffs are good in general. Numerous speakers raisedthat tariffs should have a capacity element (as a supplement), as this would better reflect the costs of the network. The network is dimensioned for peak capacity meaning that capital costs are to some extent capacity-driven. Tariffs reflecting customers use during the network's maximum load are therefore relevant. Various participants suggested making capacity-based tariffs time-dependent to better reflect the network costs for the DSO.

Some challenges to providing price signals through tariffs to household customers were raised. Designing a tariff model that sends price signals to customers that reflects when capacity is scarce and that is also transparent for the end-user, and fairly easy to respond to, is complicated. There may be a trade-off between sophisticated and cost-reflective tariff models and transparency for the end user. However, improved tariff design was also raised as a means to achieve better relations between the customers and the DSOs.

It was furthermore emphasized that the tariff is only one part of the end user's electricity cost. The electricity price is another important component and the price signals you want to send through this may differ from the price signals of the tariffs. Some participants agreed that the customer should only have to meet one price signal. Thus there may be a reason to somehow coordinate price signals from the tariff and the electricity price. Evidence was presented that suggested the customer needs a rather high saving potential in order to change their behavior. There was also a discussion of the role of tariffs and to what extent they should be designed with efficiency targets, climate goals and other political issues in mind. The efficiency of tariffs as a tool for this was questioned.

Tariffs were discussed from the perspective of a supplier centric model by various speakers. With suppliers being the main contact point for customers, the potential need for harmonization was raised. The supplier centric model is however being implemented differently in different countries, providing different starting points for DSOs when designing their tariffs.

Many participants were pleased that NordREG is addressing the issue of tariff design, and encouraged further work. Any changes in tariff design will redistribute costs between customers; if some pay less, some must ultimately pay more. This must be communicated to the customers, and it was seen as positive that NordREG and the NRAs would be part of this communication. Participants also encouraged NRAs to explore what the customers actually want. One conclusion from the seminar could be that the new technologies open up possibilities, but it may not be useful to exploit all of them. Price signals that consumers can respond to are good in principle, but their benefits must always be weighed against their costs.

2.3 Outline of the report

The report describes the general design of load tarffis in the Nordic countries in chapter 3, and chapter 4 summarizes studies done on load tariffs in the DSO grids in the different Nordic countries. In the annexes, i.e. chapter 5-9, the Nordic countries describe in more detail the different individual tariff setups in their respective countries, whithout drawing similarities as such.

3 The Nordic design of load tariffs

3.1 Implementation of the Energy Efficiency Directive in the Nordic countries

3.1.1 Implementation of the directive in Denmark

The Energy Efficiency Directive is implemented in the Danish electricity act – most of the directives content was already implemented in advance of the passing of the directive, and the directive has not caused any changes in the electricity act regarding tariff setting.

3.1.2 Implementation of the directive in Finland

The energy efficiency directive has been implemented in Finland by the Energy Efficiency Law. The Energy Efficiency Law entered into force 1 January 2015.

3.1.3 Implementation of the directive in Iceland

Iceland has not implemented the Energy Efficiency Directive since the Directive has not yet been made part of the Agreement on the European Economic Area. At the moment the government does not have any changes on the agenda as regards tariff design for the Icelandic DSOs. The implementation of the Directive may, however, have some impact on the legal framework that the DSOs currently work under in the future and indirectly effect tariff design in Iceland.

3.1.4 Implementation of the directive in Norway

The Energy Efficiency Directive has not been implemented in the Norwegian electricity act. There is an ongoing discussion about the Directive's relevance for EEA.

3.1.5 Implementation of the directive in Sweden

The Energy Efficiency Directive has been implemented in the Swedish Electricity Act by the parliament, among others through added provisions on efficient network operation. This is described in further detail in the section "*Tariff design in Sweden*" in the Annex to the report.

3.2 Tariffs in the Nordic countries

Overall the Nordic countries have different regulations on tariffs – cf. the annexes for more specific information on the different countries. However, the principles on how to regulate the tariffs are more or less the same. I.e. the pricing of electricity distribution must meet specific defined criterias. Hereamong the tariffs must be impartial and non-discriminatory for different customer groups, the tariffs must be simple and clear to understand (i.e. transparent).

The network companies are solely responsible for designing tariffs within their income cap (which is regulated by the regulatory authority) according to the regulation on tariff structures. In the Nordic countries (except for Norway) there exists no regulation on how the network operators should allocate costs on the fixed and variable parts of the network tariff. In Norway there is regulation on how to allocate the fixed and variable costs; the fixed component shall cover customer-specific costs and a share of the other fixed costs of the network, while the energy component (variable cost) shall cover the cost of marginal network losses and may in addition cover a share of the other costs not covered by the fixed component.

For all countires the DSOs have an obligation to provide information about their tariffs to the national regulatory authority.

In Denmark, Finland, Norway and Sweden the national regulatory authority does not have a confirmation process regarding tariff structures of DSOs. The national regulatory authority in Iceland has a confirmation process regarding tariff structures of DSOs.

In a case of disagreement on tariff structures between customer and DSO, National Regulatory Authority in every country makes a decision if the tariffs are set according to regulation.The regulatory approach is that price differentiation is in principle not allowed; the Nordic countries, however, do have exemptions to this principle. For example price differentiation for the sake of an effective use of the grid and security of supply is legal in Denmark (the latter one from April 2016). In general there can be reasons to make exemptions from this rule which would allow differentiated tariffs according to some objective and reasonable criterias. In Norway, tariffs can be differentiated according to objective and verifiable criteria based on relevant grid conditions.

For example there exists tariff differentiation on different customer groups in all the Nordic countries. The specific customer groups in the different Nordic countries vary, however, the general customer grouping can be grouped into the following three customer categories household, small industry and large industry customers.

3.2.1 Tariffs for typical households

The tariffs for household customers in each country vary in design even though the structure of the cost in principle is the same.

The following consumption types represent a typical household in the Nordic countries:

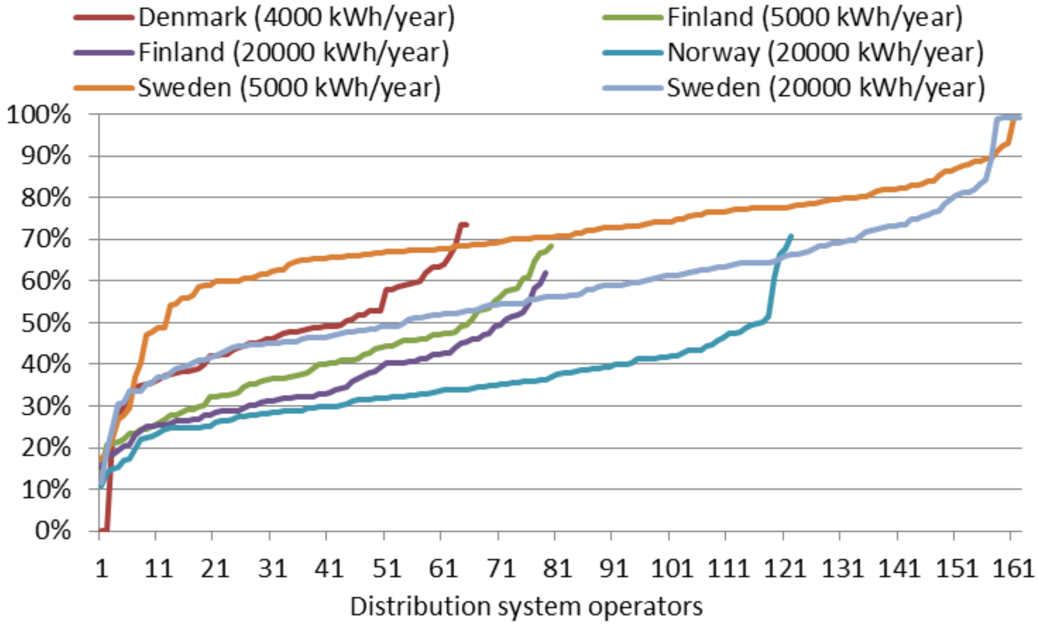
- Denmark: Annual consumption 4.000 kWh
- Finland: Annual consumption 5.000 kWh and 20.000 kWh
- Norway: Annual consumption 20.000 kWh
- Sweden: Annual consumption 5.000 kWh and 20.000 kWh

Several observations can be derived from Figure 1. First of all, Sweden has the highest number of DSOs. On average the fixed share of network tariff is higher in Sweden than it is in other countries. This is true with consumption types with lower annual consumption (4.000 – 5.000 kWh) and higher annual consumption (20.000 kWh). DSOs in Norway on average have lowest fixed part of the grid tariff. Denmark and Finland more or less follow the same pattern regarding fixed part's share of the total grid tariff, when the number of DSOs is increased although the share of fixed part is on average higher in

Denmark. Regarding fixed part's share of the network tariff on average, there is not so much difference in Finland between consumption types than there is in Sweden.

Average fixed and variable shares of network tariff for household customers in Denmark, Finland, Norway and Sweden are listed in Table 1.

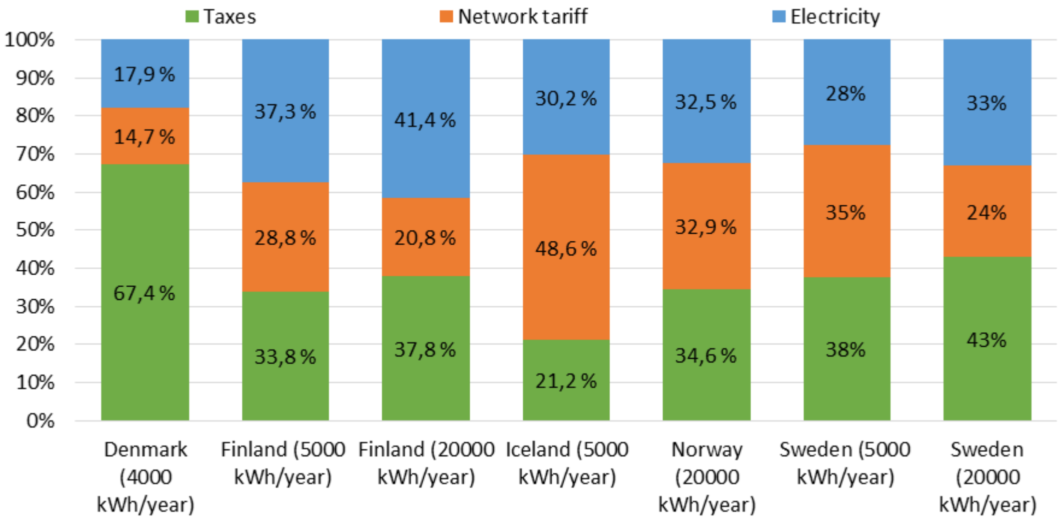
Figure 1 | Fixed part of the grid tariff for a typical household customer in the Nordic countries, 2015



Source: DERA, Energiavirasto, NVE & Swedish Energi Market Inspectorate

The amount which tariffs account for in the total electricity bill varies between the Nordic countries, cf. Figure 2. However, in general the tariffs account for maximum of one third of the electricity bill with the exception of Iceland where network tariff account for approximately half of the electricity bill. The cost of electricity power is more or less one third of the total electricity price with the exception of Denmark, where it is 18 percent. In Finland the electricity power's share of the total electricity bill is highest in the Nordic countries. Fx. in Denmark the network tariff only account for around 15 percent of the electricity bill, but this is due to high electricity taxes in Denmark (67 percent). The share of electricity taxes is lowest in Iceland.

Figure 2 | The price component for a typical household electricity customer in the Nordic countries, 2015



Source: DERA, Energiavirasto, Orkustofnun, Statistisk Sentralbyrå & Sveriges el- och naturgasmarknader 2014

The average network tariff for a typical household in the Nordic countries is shown in Table 1. The average annual network tariff is highest in Sweden. Also, the fixed part of the network tariff on average is highest in Sweden. This is the case for both consumption types. Denmark, Finland and Norway are closer to each other regarding the average annual cost of network tariff when differences in consumption types are taken into account. Regarding the variable part of tariff, the cost per kWh seems to decrease when annual consumption increases. The cost per kWh in the variable proportion of tariff is lowest in Denmark when we look on the consumption type with low annual consumption. When we look on the consumption type with high annual consumption, the cost per kWh in the variable component of the tariff is lowest in Norway.

Table 1 | Average typical household tariffs in the Nordic countries, 2015

	Denmark € (DKK)	Finland, €		Norway € (NOK)	Sweden, € (SEK)	
Consumption type (kWh/year)	4.000	5.000	20.000	20.000	5.000	20.000
Average annual network tariff	178 € (1.327)	224 €	505 €	583 € (5.247)	314 € (2.924)	680 € (6.326)
Variable component of tariff on average, €/kWh	0,027 € (0,2)	0,045 €	0,025 €	0,020 € (0,18)	0,063 € (0,58)	0,034 € (0,32)
Fixed part of annual network tariff on average €	70 € (525)	99 €	188 €	181 € (1.627)	228 € (2.122)	348 € (3.242)
Fixed part on average %	40 %	44 %	37 %	31 %	73 %	51 %
Variable part on average %	60 %	56 %	63 %	69 %	27 %	49 %

Source: DERA, Energiavirasto, NVE & Swedish Energi Market Inspectorate

Smart meter implementation is more or less fully implemented in Finland and Sweden, while Denmark has implemented smart meters for roughly half of its electricity customers. Norway has 10 percent while Iceland has not yet implemented any smart meters. So the diversity of smart meter implementation is high across the Nordic countries, cf. Table 2.

Table 2 | Smart meter implementation in the Nordic countries.

Denmark	Finland	Iceland	Norway	Sweden
57 %	95 %	0 %	10 %	100 %

Source: Danish Energy Association, Energiavirasto, NVE & Swedish Energi Market Inspectorate
Note: Time of date for the smart meter implementation was in respective order 2013, 2014, 2015, 2014 and 2009.

4 Summary of studies done on load tariffs in DSO grids

The ongoing developments in tariff design and network regulation are receiving substantial attention both from commercial parties and academia. To provide a background to the survey and analysis of current tariff design in the Nordic countries, this chapter presents a survey of research and previous studies performed on the topic in the respective countries.

4.1 Load tariffs and demand response

4.1.1 Norway:

- "Optimal network tariffs and allocation of cost" (Report 2008-129) by Econ.

http://www.nve.no/Global/Kraftmarked/Tariffer/Optimal%20network%20tariffs%20and%20allocation%20of%20costs.pdf?epslanguage=en

"*Pricing of transmission and distribution of electricity should be done according to economic criteria, that is reflect the marginal short-term costs of losses and congestion in the grid. Long-term price signals beyond these short-term signals should reflect the cost of customer-specific investments. As the grid constitutes a natural monopoly, these tariffs will however not be sufficient to cover the total need for income in the grid. Hence, there will be a need for tariffs that provide recovery of residual costs. The allocation of residual costs between network customers should be done in a manner which distorts use of the grid and investments as little as possible. In practice, this means relatively low tariffs for generation and large industrial users, while households, the public sector and small businesses should cover the bulk of the residual costs, although there are many variations within these groups and over time. The Norwegian tariff system incorporates many of the economically correct principles, but it is practically impossible to implement a theoretically perfect system.*"

- Future design of loadtariffs ("Framtidig utforming av nett-tariffer") (Report from EC-Group, 2014).

"*The report aims for a cost-reflective design for load tariffs. Based on the cost structure for the Norwegian network, the allocation of income between the different tariff components should be: Approximately 20% from energy component, approximately 10% from the part of the fixed component that covers customer-specific costs, approximately 20% from the part of the fixed component that covers costs mainly in the low-voltage network and approximately 50% from the part of the fixed component that covers administrative costs and costs in the overall parts of the network (mainly high-voltage distribution and transmission network). The fixed part of the tariff is recommended to be differentiated with customers fuse size.*"

- Capacity pricing with AMS meters ("Prising av overføringskapasitet med AMS") (Report from THEMA, 2013).

http://www.thema.no/wp-content/uploads/2015/04/THEMA-rapport-2013-23-Prising_av_overf%C3%B8ringskapasitet_med_AMS1.pdf

"*The report analyzes the impact of AMS metering on the design of the distribution tariff and to what extent prices should be used to signal operation costs and capacity shortages in distribution networks. The report concludes that tariffs reflecting the hourly cost of grid losses should be implemented, taking into account hourly electricity prices and estimated loss ratios. Such grid pricing would enhance the precision of hourly spot price signals and yield improved data on price response for end-users. The public good characteristics of the grid (particularly that investments happen in leaps) make it challenging to design precise capacity pricing without risking significant deadweight losses. In addition, there are a number of practical obstacles to capacity pricing, including lead times, security constraints and CENS (Cost of energy not supplied) regulations.*"

- Recovery of residual costs with AMS meters ("Innkreving av residual nettkostnader med AMS") (Report from THEMA 2013).

http://www.thema.no/wp-content/uploads/2015/04/THEMA-rapport-2013-22-Innkreving_av_residuale_nettkostnader_med_AMS.pdf

"*The introduction of smart meters in the Norwegian distribution grid gives new opportunities for network cost recovery through residual tariffs. Ideally, such tariffs should be neutral both in the short and long run and not affect end-users demand for electricity. The report finds that increased fixed charges and lower energy charges are more efficient than the current high energy charges for households and other small end-users, and may be introduced independently of smart meters. Introducing residual tariffs based on maximum consumption for smaller end-users, which is made possible by hourly metering, will also increase efficiency compared to the current model. However, there are many administrative issues which must be sorted out before choosing a specific model.*"

4.1.1 Sweden:

There have been some studies on the impacts of load tariffs on customer behaviour. Among others, they have focused on how electricity use is impacted with new tariffs based on capacity instead of energy consumed. This section presents some of the recent Swedish research on the topic.

- Bartush C, Wallin F, Odlare M, Vassileva I and Wester L, "Introducing a demand-based electricity distribution tariff in the residential sector: Demand response and customer perception", Energy Policy 39, 2011.

"Increased demand response is essential to fully exploit the Swedish power system, which in turn is an absolute prerequisite for meeting political goals related to energy efficiency and climate change. Demand response programs are, nonetheless, still exceptional in the residential sector of the Swedish electricity market, one contributory factor being lack of knowledge about the extent of the potential gains. In light of these circumstances, this empirical study set out with the intention of estimating the scope of households' response to, and assessing customers' perception of, a demand-based time-of-use electricity distribution tariff. The results show that households as a whole have a fairly high opinion of the demand-based tariff and act on its intrinsic price signals by decreasing peak demand in peak periods and shifting electricity use from peak to off-peak periods."

- C. Bartusch, P. Juslin, U. Persson-Fischier och J. Stenberg, ”Elkonsumenters drivkrafter för en ökad förbrukningsflexibilitet. Hushållsattityder och anpassningar till en tidsdifferentierad och effektbaserad elnätstariff”, Elforsk rapport 14:41, 2014.

http://www.elforsk.se/Rapporter/?rid=14_41_

“In terms of changes in the pattern of electricity use, the estimated effects of a demand-based, time-of-use electricity distribution tariff are fairly marginal and limited to households living in single-family houses. The results suggest that this category of homeowners in Sollentuna, as part of adjusting their electricity consumption to the demand-based tariff, has decreased their demand by 2.3 and 1.2 per cent during the summer and winter months respectively as compared to the reference group in Saltsjö-Boo…

The results further indicate that demand-based tariffs have an evident effect on households' attitudes and intentions to shift electricity use from peak- to off-peak hours, but also that these are not reflected in their actual behavior. There is consequently only a weak relation between the occurrence of a demand-based tariff and the share of electricity that is consumed in peak- and off-peak hours respectively among the households that the study covered. The psychological factors that have the most influence on whether or not, and in that case to what extent, households adapt their electricity use to a demand-based tariff in this sense are the expected consequences of, and so their attitude towards, the behavioral change at hand as well as the degree to which they perceive to have control over it. In more concrete terms, this means that economic savings and positive effects on the environment, climate change and a sustainable development for younger and future generations are the most important driving forces, while the circumstance of considering ones electricity consumption to be basically non-existing, or that one uses most of the electricity during off-peak hours as it is are the greatest barriers, for adapting ones electricity consumption to the demand-based tariff.”

- Einar Persson, Björn Berg, Fredrik Fernlund, Olle Lindbom, 12:48 Pilotstudie i Vallentuna - Reflektioner rörande affärsmodeller för förbrukarflexibilitet och självlärande prognosstyrning för kundanpassad effektreglering, Elforsk rapport 12:48, 2012.

http://www.elforsk.se/Rapporter/?rid=12_48_

”It is today possible to implement Demand Response in a large scale in Sweden through smart services which automatically optimizes heating. For a homeowner with a ground source heat pump this implies yearly savings of 2200-2600 SEK (electric boiler 2800-4000 SEK), based on simulations of price and temperature data from the years 2010 and 2011. This is made possible through a combination of increased energy efficiency (10-15 %) due to effects such as smoother indoor temperatures, and shifting of consumption from expensive to cheaper hours (approx. 15 kWh heat per day). The reward of load shifting varies heavily between seasons, since it depends on an intricate relation between price volatility and heating needs (e.g. 1720 SEK and 590 SEK for 2010 respectively 2011, simulated on ground source heat pump). It is also clear that the effect of time dependent grid tariffs dominate the savings in times of low price volatility (e.g. of 1090 SEK “load shift savings” for an electric boiler during 2011 770 SEK was due to grid tariffs). The benefits can be reached without demanding active participation or compromising the comfort level.”

- SWECO, ”Syntes av elnätstariffer”, Energiforsk rapport 2015:170.

"For some time, several parallel discussions regarding the use of the local distribution-grids and necessary changes in the DSO-tariffs for low-voltage customers, have been taking place…

Most likely, the optimal tariff-structure differs from grid to grid and between types of customers. It is obvious that different customer types have varying preferences (and potential to alter their consumption-pattern). So instead of ending in a discussion of which tariff is most suitable for which customer, the cost-reflectiveness should be the aim. Rather that speaking of "favouring" tariff-structures, the scope of discussion should instead be to which extent the consumption-pattern is increasing the costs for the DSO.

This project have taken on the challenge in a novel fashion and started from real hourly consumption data from almost 200 000 customers during a period of three years. The project have "recalculated" the economic history and by this created new understanding of how alternate tariff-models can affect costs/revenues, partly on an aggregated level and partly for different types of customers. Both from the perspectives "ceteris paribus" (everything else alike), that the change in the energy-system will accelerate with increasing influx of electric cars and PV-systems, as well as that the technical development facilitates automatic load control for a larger share of the customers."

4.1.2 Finland:

- Lassi Similä, Göran Koreneff, Veikko Kekkonen "*Network tariff structures in Smart Grid environment*." RESEARCH REPORT VTT-R-03173-11, 2011.

http://www.vtt.fi/inf/julkaisut/muut/2011/VTT-R-03173-11.pdf

"*The report examines the emerging options and requirements for electricity transmission and distribution network tariffs in the evolving Smart Grid (SG) environment. Smart Grids mean more sophisticated metering and communication technologies, which enhance possibilities to make tariffs more transparent, more economically efficient and cost-reflective, and more just*."

- Jarmo Partanen, Samuli Honkapuro, Jussi Tuunanen, and Hanna Niemelä: "*Tariff scheme options for distribution system operators*" Lappeenranta University of Technology,4.5.2012.

http://www.lut.fi/documents/10633/138922/Tariff+scheme+options+for+distribution+system+operators/d2c7a66f-4033-42ff-a581-dc4ef8586592

"*The research report provides the results of the research project "Tariff scheme options for distribution system operators*".

- Kimmo Lummi; Antti Mäkinen, Antti Mutanen, Pertti Järventausta - Tampere University of Technology "*Electricity Distribution Pricing Methodology In Finnish Regulation Framework - A Case Study of Matching Principle"* Conference/Compilation NORDAC 2014, The 11th Nordic Electricity Distribution and Management Conference, 8-9 September 2014, Stockholm, Sweden.

"*In the paper, the practical theory of electricity distribution pricing in Finnish regulation framework and electricity market environment is discussed. A methodology to produce* *distribution tariffs, that realize the matching principle, is introduced. One goal of the paper is to demonstrate the effects of different load profiles in tariff design*."

- Energiavirasto (Energy Authority) "*Sähkön siirtohintatariffien kehitys 2000-2013 (Development of electricity network tariffs in 2000 – 2013)",* in Finnish.

http://www.energiavirasto.fi/documents/10179/0/Sahkon_siirtohintatariffienkehitys2013.pdf/49f73b2d-f227-473f-b510-fb77a76f18e4

"*The report examines development of fixed and variable components of electricity network tariffs in Finland during period of 2000 – 2013*."

4.1.3 Denmark:

- SEAS-NVE NET A/S og DONG Energy Eldistribution A/S "*Flyt dig! Forsøg med variable nettariffer 2015 (Move! Experiment with variable tariffs)".*

http://www.seas-nve.dk/~/media/2-0-seas-nve/pdfer/om%20seas-nve/15895%20rapport%20flyt%20dig_web.ashx

"*The purpose of Move! was to find out to what extent ordinary households without electric heating would change their behaviour as regards their consumption of electricity when time-differentiated tariffs were used instead of fixed grid tariffs. The time-differentiated grid tariffs were divided into three periods of the day on all days of the week.*

An analysis of the test data shows that the test customers reduced their consumption during the peak load (red interval) by a little more than 2.0% in comparison with the customers in the control group (equivalent to a change by 0.4 percentage points, measured in relation to the total consumption). Furthermore, a test shows that this is a statistically significant effect, and therefore the difference in the peak load share of the electricity consumption between the test and the control groups can be attributed to the Move!

An elasticity for the change in the peak load price compared to the total average electricity price has been calculated at approximately - 0.19. This means that a change in the relative price between peak load and the total average price of 10% will reduce the consumption during peak load by 1.9%.

The effect with a reduction of the peak load share by 2% is relatively constant over time and largely the same on weekdays as in the weekend.

The Move! test period was limited to one year. Thus, the effect uncovered by the experiment must be described as a short-term effect. It is an open question whether the effect will be of the same size in the long term."

4.2 What can be learnt about design of tariffs from the survey of studies done?

The studies mentioned in chapter 4.1 have a wide range of suggestions for the future implementation of tariffs. Overall the results from the studies can be arranged into the following two groups:

4.2.1 Cost-reflective tariffs

A view from the studies is that tariffs should be cost-reflective in a way which reflects the hourly cost of grid losses while taking into account electricity prices and estimated loss ratios. Such grid pricing would enhance the precision of hourly spot price signals and yield improved data on price response for end-users. One suggestion for a cost-reflective design for load tariffs (based on the Norwegian network cost-structure) is to approximately allocate the income from the different tariff components in the following way: 20 percent from energy component, 10 percent from the part of the fixed component that covers customer-specific costs, 20 percent from from the part of the fixed component that covers costs mainly in the low-voltage network and 50 percent from from the part of the fixed component that covers administrative costs and costs in the overall parts of the network.

4.2.2 Demand response potential

Demand response has also been studied thouroughly and one of the studies shows that households react fairly strongly to price signals by decreasing peak demand in the peak periods and shifting electricity use from peak to off-peak periods. A study of time-of-use electricity distribution tariff shows that the tariff has a fairly marginal and limited change in the pattern of electricity use for households, the result is that homeowners (in Sollentuna) have decreased their electricity demand by 2,3 and 1,2 percent during the summer and winter months respectively. Antoher study found a similar result that time-differentiated tariffs made customers decrease their consumption during peak loads with a significantly 2 percent (in comparison with a control group).

Demand response can according to a study provide homeowners with a profit (2200-2600 SEK) by having their heating automatically optimized.

Annexes

Annex 1. Danmark (Denmark)

Annex 2. Finland (Finland)

Annex 3. Island (Iceland)

Annex 4. Norge (Norway)

Annex 5: Sverige (Sweden)

5 Tariff design in Denmark

The appendix is composed of four parts. The first part shows how the grid tariffs are treated in the Danish Electricity Act and how the Energy efficiency directive is implemented in the Act. The second path gives an overview of the tariff design in Denmark and an actual picture of the structure of load tariffs for the DSO-grids. The third part is a status for smart meters in Denmark. Finally, the fourth part is a short survey over the discussions of tariff design.

Analysing design of grid tariffs is important for two reasons:

- New technologies such as interval metering and two-way communication provide new opportunities for tariff structures.

- Different tariff structures give consumers different incentives and can therefore impact the use of the grid

New technologies like metering and communication gives opportunities for a more flexible use of electricity over the hours during a year. New technologies can therefore make the customers more price sensitive in the future.[1] The new metering device can change the design for household customers and small firms from traditionally energy based to power based charging.

5.1 Few restrictions in how to design grid tariffs in Electricity Act

Grid tariffs are treated in Chapter 10 of the Danish Electricity Act, which places the following requirements on grid tariffs:

§ 70: Prices for grid companies's services must be set in accordance with the revenue cap, which are set to cover cost for an efficiently operated grid.

§ 73: Grid tariffs must be set in a fair, objective and non-discriminatory way, according to the costs that the respective consumer groups apply. Price differentiation for the sake of an effective use of the grid and security of supply are legal (this last part apply from 1. of April 2016).

§ 73 a: The (tariff) methods used by the grid companies must be approved by the Danish Energy Regulatory Authority (DERA) before use.

§ 73 b: The industry organisations can make standardized guidances for methods of tariff setting etc., which DERA supervise.

On top of it is stated in the first paragraph of the act that the overall purpose of the electricity act amongst others are to secure an effective use of the economic resources, and in § 6 it is stated, that the grid companies must offer their services to the consumers in an transparent, objective, fair and non-discriminatory way.

[1] Most studies of customers price elasticity reports rather low levels of elasticities.

Summarizing, the Electricity Act only puts few requirements on grid tariffs: be transparent, fair, objective and non-discriminatory. As long as these requirements are met, grid companies are free to set grid tariffs as they see fit. DERA sets the size of the total allowed revenue (revenue cap), but does not decide how grid tariffs are structured – DERA, however, approves the methods used by the DSO for setting tariffs.

The Energy efficiency directive is implemented in the Danish electricity act – most of the directives content was already implemented in advance of the passing of the directive, and the directive has not caused any changes in the electricity act regarding tariff setting.

5.2 Structure of grid tariffs for load in DSO-grids

DERA collects the tariffs from each DSO in Denmark. In Denmark it is required that the methods used by the DSO for setting tariffs are approved by DERA, and the DSOs are obliged to report to DERA in case of a change in tariffs.

The methods for tariff calculation must comply with the Danish electricity Act, that states that the methods must ensure that the tariff are set in a fair, objective and non-discriminatory manor according to the cost that a customer group apply. This also means that there must be no cross subsidization amongst customer groups.

The DSO can set their methods for tariff calculation based on an industry guidance, which DERA supervise. The industry guidance are devised by the Danish Energy Agency (DEA) and supervised by DERA. Most of the DSOs use the industry guidance with minor deviations.

The cost structure in net distribution are related to tariffs by principles of cost allocation. The cost allocation has the purpose of fulfilling the goals for objective (cost-reflective) tariffs. The different type of costs are allocated to the different customer groups, which are set by their connection point (voltage level) to the grid, and thereafter it is decided whether the different types of costs should be tariffed as a part of the fixed tariff or the variable tariff, and whether it should be tariffed as a downward running tariff and should be time diffentiated.

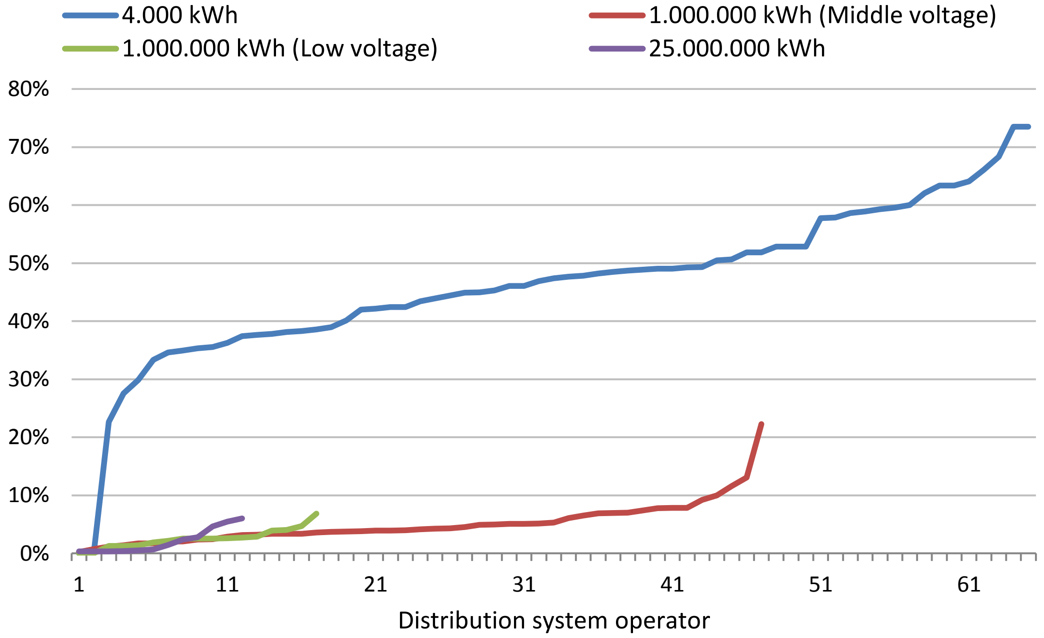
The industry guidance contains unambiguous guidance concerning all of these elements in the tariff methods. The overall guideline is, that all cost types for the DSO that depend on the consumption of electricity are tariffed as a part of the variable tariff and all cost types that do not vary with consumption (i.e. costs concerning administration and costs concerning meters and metering) are tariffed as a part of the fixed tariff. On top of that most of the variable costs are in the just supervised industry guidance recommended to be time differentiated. This industry guidance is expected to be used by most of the DSOs by April 2016.

This means, that there are no or very little variation in the design of the tariff structure amongst the Danish DSOs. However, this does not mean that the fixed and the variable part of the tariffs constitute the same part of the total tariffs amongst the DSO, since this is determined by the cost structure of the respective DSO.

In Figure 3the proportion of the fixed part in the tariff for the following customers: A customer connected on the low voltage level with a consumption of 4000 kWh electricity; a customer on the middle voltage level (or in the lower side of a transformer) with a consumption of 1 mio. kWh; a customer on low voltage level with a consumption of 1 mio. kWh and finally a customer on the high voltage level with a consumption of 25 mio. kWh.

For the small customers the fixed part varies from 0 to 74 % with far most between 34 and 54 %. For the larger customers the fixed part is below 10 % for most grid companies.

Figure 3 | Fixed part of a grid tariff for different levels of consumption, 2015



Source: DERA

As can be seen in Figure 3, the fixed part of the tariffs varies quite much especially between the DSOs for the small costumers – for larger costumers the variations are smaller. For the small customers the fixed part varies from 0 to 74 %, but with far most of the DSOs with fixed parts between 34 and 54 %. For the larger customers the fixed part is below 10 % for far most of the DSOs.

Table 3 shows the average variable tariffs and average fixed part for year 2015.

Table 3 | Mean tariffs for different customer groups, 2015

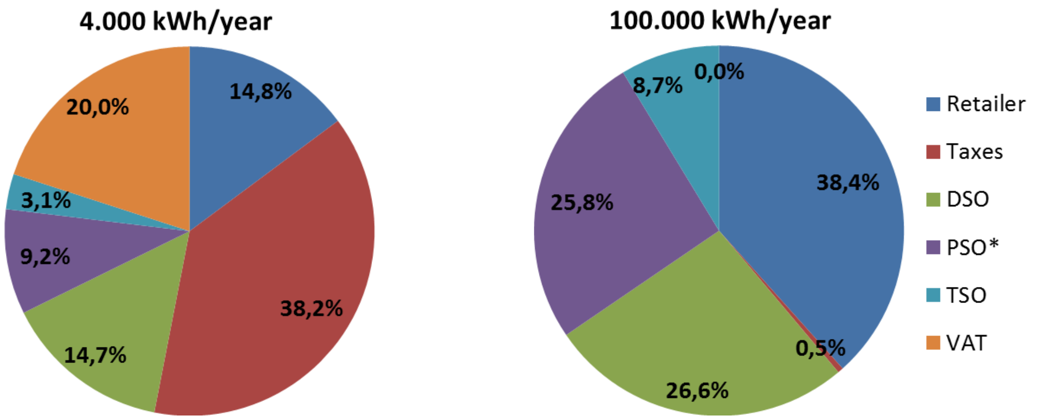
	Variable tariff (øre/kWh)	Fixed tariff (DKK/year)
Household consumer (C-customer on low voltage)	20,05	525
Industry consumer (low voltage)	12,95	2.800
Industry consumer (B-customer on middle voltage)	9,70	5.400
Large industry consumer (A-customer on high voltage)	4,01	17.500

Source: DERA

Table 3 shows that the higher voltage level that a costumer is connected to the grid, the lower variable tariff (caused by the structure with downward running tariffs), but the higher fixed tariff, caused by higher administrations costs, but due to the high consumptions of the costumers on higher voltage levels, the share of the fixed tariff in the overall tariff payments are still lower, than for small costumers.

In Denmark tariffs only account for a minor share of the total electricity price, cf. Figure 4 for an overview of the different shares of the electricity price.

Figure 4 | Elements of the electricity price in 2015



Source: DERA
Note: *Public Service Obligation

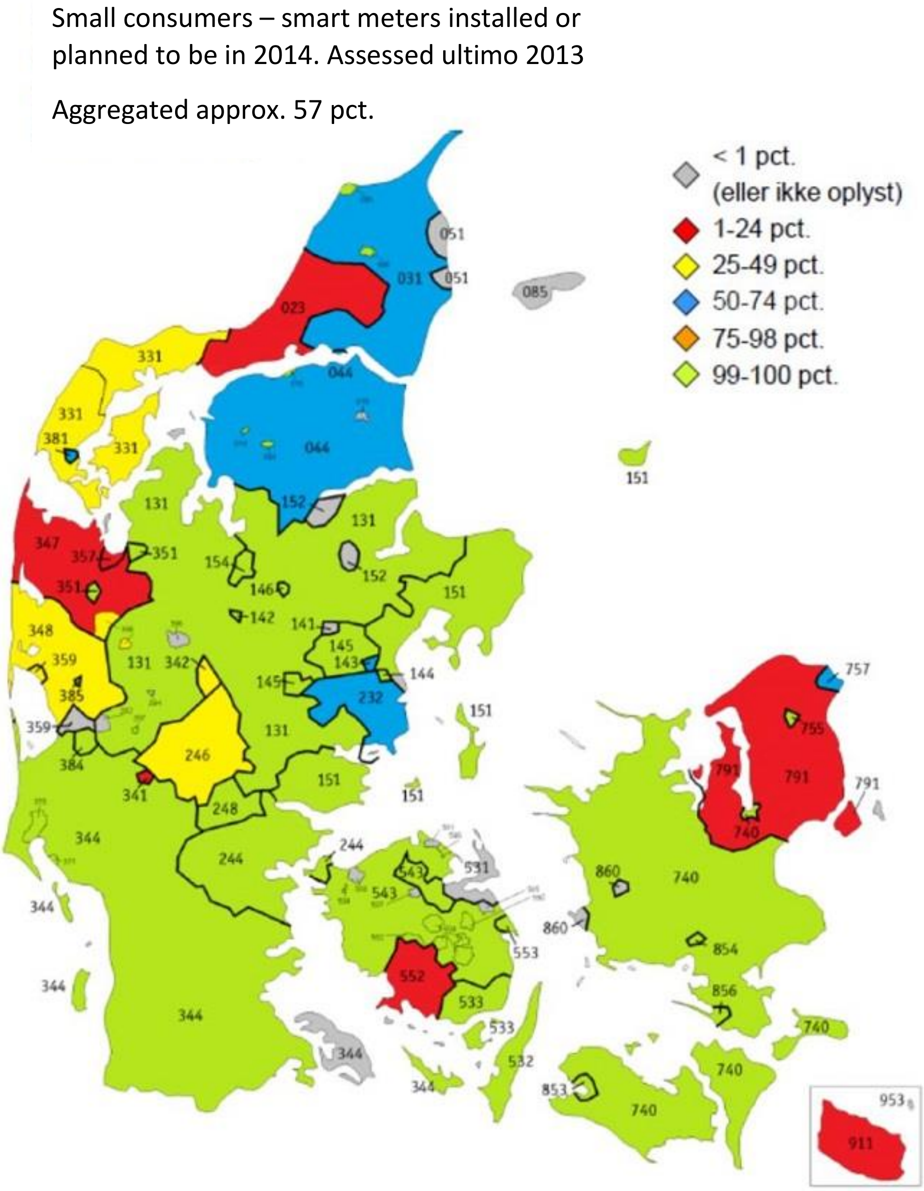
Figure 4 shows that tariff only accounts for a minor part of the total electricity price – in particular for small costumers, for whom the tariffs accounts for only about 15 pct. of the total price. This is due to the high electricity taxes in Denmark. For larger scale costumers (business/industry consumers) the tariffs account for a larger share (about 27 pct) due to the fact that Industry consumers do not pay VAT and only pay a very small energy tax.

5.3 Smart meters

By the end of 2013 it was decided to implement AMR-systems (smart meters) to all consumers in Denmark. At the time only around 60 percent of the consumers had a smart meter, including industrial consumers with a consumption of more than 100.000 kWh/year, whom are obliged to be billed by the hour, and thereby had to have a smart meter. This means that the new rules mainly apply to template customers whom has a consumption of less than 100.000 kWh/year.

The AMR-systems shall be fully implemented by 2020. Figure 5 below shows the status for the rolling out of smart meters for small consumers by the end of 2014, illustrated by the already installed and planed installations in 2014 by the end of 2013. As shown, the status by the end of 2014 was, that 57 pct. of the small consumers should have a smart meter. Figure 5 also shows, that it is mainly in the Copenhagen area, that the implementation is in the starting phase.

Figure 5 | Implementation of smart meters in Denmark, 2013



Source: Danish Energy Agency

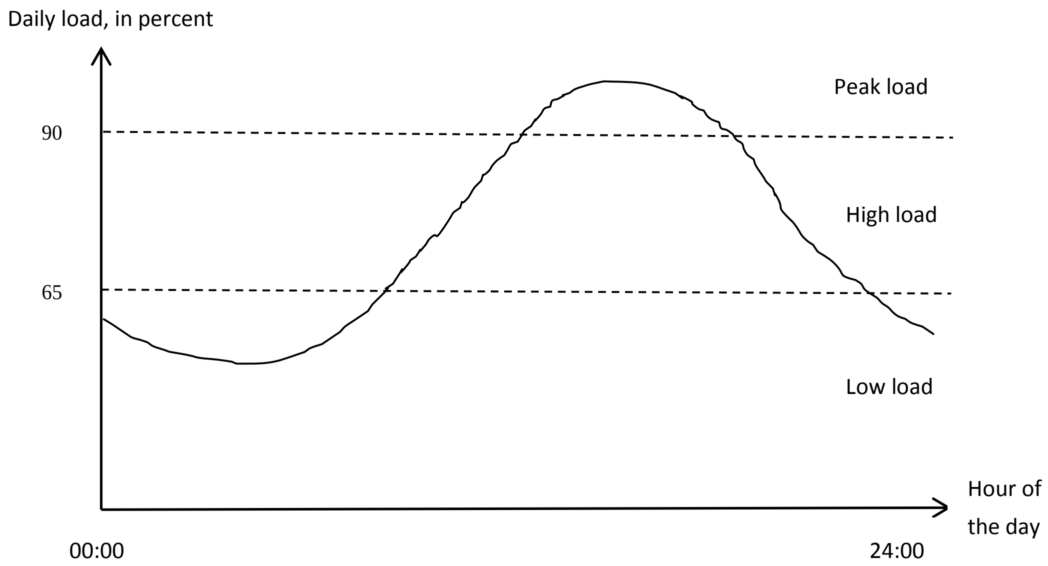
5.4 Discussions on tariff design in industry

With the continuous implementation of AMR systems for reading the customers use of electricity it is now possible to use power based charging hourly for household and other small users of electricity. Therefore this has been an issue in the industry regarding the design of grid tariffs.

The industry Association, Danish Energy Association, has in the new industry guidance, just approved by DERA, developed a model for time-of-use tariffs. The model is a simplified model with the purpose to give the DSOs the opportunities to test time-of-use tariffs and collect experiences rarther than a theoretical correct cost reflective model. The simplified model is also ment to be a precursor for this correct cost reflective model.

The time differentiation is based on standardized load curves on daily basis on aggregated level for all DSOs, and separated between the higher voltage levels and the lower voltage level and between summer and winter. Load curves are calculated as the average load in the grid hour by hour. The idea is that extra costs due to high load in the grid are paid by consumption during these high load periods. This simplified model is developed to minimize the respective DSOs need to get further information for tariffing. In Figure 6 a fictive daily curve is illustrated with the limits for time differentiation.

Figure 6 | Daily load and limits for time differentiation, fictive example



Source: The DERA Secretariat.
Note: The figure is an illustration of a fictive daily load curve.

In Figure 7 the time differentiation of the tariffs in the simplified model are shown. A green dot means low load, a yellow dot means high load and a red dot means peak load.

In the calculation of the tariffs the idea is, that consumption in high load periods shall contribute to the share of costs allocated to low load. In periods with low load you only pay the cost for this low load. In periods with high load you pay the cost of low load and an additional charge for the cost of consumption in the high load period, and in periods with peak low you pay the cost for low load, plus additional charge to high load and again an additional charge for peak load consumption.

According to Dansk Energi the starting point is that by exploiting demand response flexibility it is possible to postpone or avoid development of the network (increase in the grid volume). Therefore it is more costs over time and not specific marginalcosts at a high consumption for a given hour. The time differentiated tariffs sends the right pricesignals in a long term perspective, because it reflects the costs of consumption under the maximal peak load. By using time differentiated tariffs the consumers are incentivized to utilize the grids capacity in an appropriate manner.

Figure 7 | Timedifferentiation of tariffs, fictive examples

0,4 kV- niveau

	Hverdage og weekend*	
Time	Vinter	Sommer
0-1	🟢	🟢
1-2	🟢	🟢
2-3	🟢	🟢
3-4	🟢	🟢
4-5	🟢	🟢
5-6	🟢	🟢
6-7	🟢	🟢
7-8	🟢	🟢
8-9	🟢	🟢
9-10	🟢	🟢
10-11	🟢	🟢
11-12	🟢	🟢
12-13	🟢	🟢
13-14	🟢	🟢
14-15	🟢	🟢
15-16	🟢	🟢
16-17	🟢	🟢
17-18	🔴	🟢
18-19	🔴	🟢
19-20	🔴	🟢
20-21	🟢	🟢
21-22	🟢	🟢
22-23	🟢	🟢
23-24	🟢	🟢

50 og 10 kV-niveau

	Hverdage	
Time	Vinter	Sommer
0-1	🟢	🟢
1-2	🟢	🟢
2-3	🟢	🟢
3-4	🟢	🟢
4-5	🟢	🟢
5-6	🟢	🟢
6-7	🟡	🟢
7-8	🔴	🟡
8-9	🔴	🟡
9-10	🔴	🟡
10-11	🔴	🟡
11-12	🔴	🟡
12-13	🔴	🟡
13-14	🔴	🟡
14-15	🔴	🟡
15-16	🔴	🟡
16-17	🔴	🟡
17-18	🔴	🟡
18-19	🔴	🟡
19-20	🔴	🟡
20-21	🟡	🟡
21-22	🟡	🟡
22-23	🟡	🟡
23-24	🟡	🟢

Source: Dansk Energi.
Note: Green means low, yellow high and red peak.

5.5 Conclusion

The efficiency directive has been implemented in the Danish electricity act, and the tariffs must be set in a transperant, fair, objective and non-discriminatory manner. The tariff structure in Denmark contains a fixed part covering all non-comsumption dependend cost, and a variable part covering the cost that depends on the consumption. The fixed part of the tariff payment varies between the DSOs, from zero to more than 70 percent.

The industry has recommended a simplified model for time-of-use tariffs which are expected to be implemented in the DSOs from April 2016, but not for all consumers from that point, since AMR-systems will not be fully implemented until 2020.

6 Tariff design in Finland

6.1 Electricity Market Act

The new Electricity Market Act (588/2013) defines certain standards and principles that pricing of electricity distribution services must meet. These are covered mainly by § 24 and § 25 of the Electricity Market Act.

According to § 24 subsection 1, the sale prices and terms of network services and the criteria according to which they are determined shall be equitable and non-discriminatory to all network users. Exceptions to them may only be made on special grounds.

This provision means that the network operator must provide network services by same uniform terms for all the network operator's customers. Distribution pricing must not depend on the customer's supplier of electricity. Pricing must not change unfoundedly when the electricity supplier changes. Pricing must be uniform within same customer type group. Pricing can vary between different size and type of customers.

According to § 24 subsection 2, pricing of network services has to be reasonable.

This provision means that network tariffs have to reflect costs that the network operator has possibility to achieve. Energy Authority regulates network operator's total revenue from the network services. Regulatory methods ensure reasonable return for capital committed to network operations and incentivize cost efficiency.

The Electricity Market Act 24 § subsection 3 requires that the pricing of network services shall not contain any conditions or limitations that would be unfounded or that would obviously restrict competition within electricity trade.

The aim of this provision is to ensure that the terms of network services are reasonable and do not unfoundedly restrict the customers' ability to utilize the network.

According to Electricity Market Act, § 25 subsection 2, so-called spot pricing is applied in pricing of electricity distribution services.

The network operator shall, for its own part, create preconditions permitting the customer to conclude a contract on all network services with the network operator to whose network he is connected as subscriber. The network operator shall, for its part, create preconditions permitting the customer to be granted the rights, in return for payment of the appropriate fees, to use from its connection point the electricity system of the entire country, foreign connections excluded.

Within a distribution system, the price of system services must not depend on where within the network operator's area of responsibility the customer is located geographically.

According to Electricity Market Act 54§ distribution network operator must offer different network services needed by users of its network.

The network operator must provide end users time-based electricity distribution services. This includes time-based metering service. Time-based electricity distribution services include: distribution based on hourly metering, distribution based on one time electricity, distribution based on two-time electricity (day- and night time) and distribution based on seasonal electricity (winter day time and other).

The Electricity Market Act was amended in 2014 (1430/2014). According to § 24 a pricing and terms of sale of network services shall not contain criteria that are harmful for overall efficiency and energy efficiency of production, transmission, distribution and delivery of electricity.

In addition to obligations imposed directly by the law tariffs must meet the following more general principles:

Principles:

- Tariffs must be cost-reflective
- Tariffs must be impartial and non-discriminatory for different customer groups. In addition, customer can choose any tariff product offered at the voltage level in question.
- Tariffs must be simple and clear to understand for customers.
- Tariffs must also steer customers to efficient use of the power system and thus encourage customers to save energy.

The objectives imposed to tariffs are partly contradictory. It is necessary to seek a balance between different objectives when determining the tariffs. Cost reflectivity of tariffs will actualize on average when the cost reflectivity of tariff products provided by the network operator is optimized. Large fixed part in tariff may not encourage consumers to save energy, but it may be more equal when allocating costs.

There are no regulations on how the network operators should allocate costs on the fixed and variable parts of network tariff. More detailed definition has been left to consideration of the electricity network operator.

6.2 Structure of grid tariffs in DSO-grids

Distribution system operators (DSO) have obligation to report electricity distribution grid tariffs in effect to Energy Authority. Based on reported tariffs Energy Authority has calculated average tariffs for different user types[2]. The user types represent typical households, with and without electric heating. There is also a user type for small industrial user.

User types are:

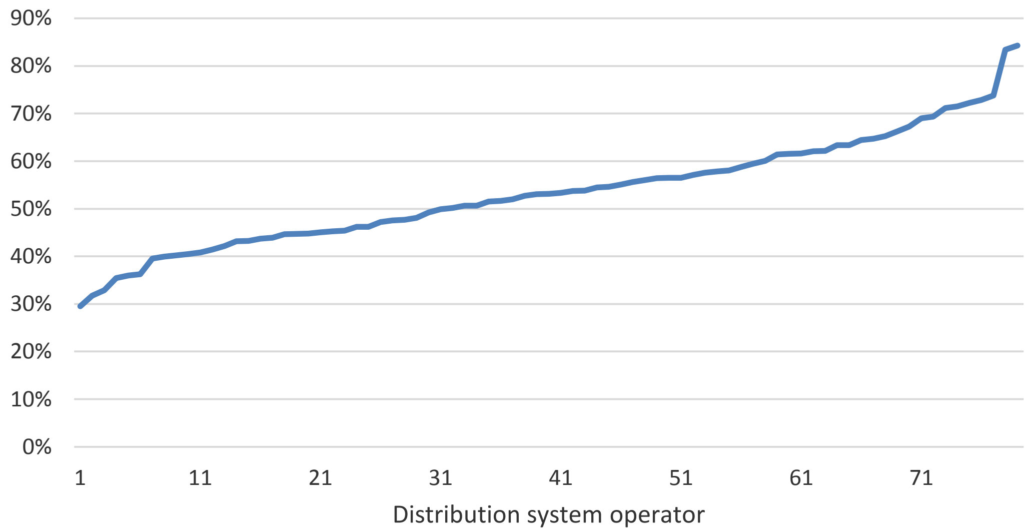
[2] For more information, see: Energiavirasto (Energy Authority) ” *Sähkön siirtohintatariffien kehitys 2000-2013 (Development of electricity network tariffs in 2000 – 2013)”,* in Finnish http://www.energiavirasto.fi/documents/10179/0/Sahkon_siirtohintatariffienkehitys2013.pdf/49f73b2d-f227-473f-b510-fb77a76f18e4

- Apartment, no electric sauna heater, main fuse 1×25 A, consumption 2000 kWh / year
- House, no electric heating, electric sauna heater, main fuse 3×25 A, consumption 5000 kWh / year
- House, electric heating, main fuse 3×25 A, consumption 18000 kWh / year
- House, electric heating, main fuse 3×25 A, consumption 20000 kWh / year
- Small industry, power requirement 75 kW, consumption 150000 kWh / year

Fixed component of grid tariff consist of fixed standing charge, usually depending on the fuse size, and with the industrial users, possibly additional power fee. Possible metering equipment fee is included in the fixed component of the tariff. Variable component of tariff is based on consumption of electricity.

Fixed component of grid tariff varies a lot among DSOs. Figure 8 shows that for a user type with consumption of 2000 kWh/year, fixed component of tariff varies from 30% to over 80% depending on which DSOs area consumer is located. Fixed component's share of grid tariff is usually higher on DSOs operating in rural areas than DSOs operating in suburban or urban areas.

Figure 8 | Fixed part of the grid tariff for user type with 1×25 A, 2000 kWh/year in 2015



Source: DERA, Energiavirasto, NVE & Swedish Energi Market Inspectorate

Table 4 shows the average fixed part, variable part and total grid tariff of above mentioned user types, not including taxes. From January 2010 to January 2015 the average grid tariff seems to have decreased in all consumer type categories except apartments consuming 2000 kWh/year.

Table 4 | Average tariffs by user type (in year 2015 price level, not including taxes)

	kWh/year	Fixed part €			Variable part €			Total €		
		2010	2013	2015	2010	2013	2015	2010	2013	2015
Apartment	2.000 (1×25 A)	49	61	63	52	54	50	101	115	112
House	5.000 (3×25 A)	94	97	99	144	135	125	238	232	224
House (electric heating)	18.000 (3×25 A)	181	187	188	378	358	337	559	545	525
House (electric heating)	20.000 (3×25 A)	180	187	188	353	336	317	533	523	505
Small industry	150.000 (75 kW)	1.372	1.669	1.700	3.819	2.828	2.520	5.191	4.497	4.221

Source: Energiavirasto

Table 5 illustrates how relative share of fixed and variable tariff components has developed over the years. The share of fixed component has increased in all consumer type categories.

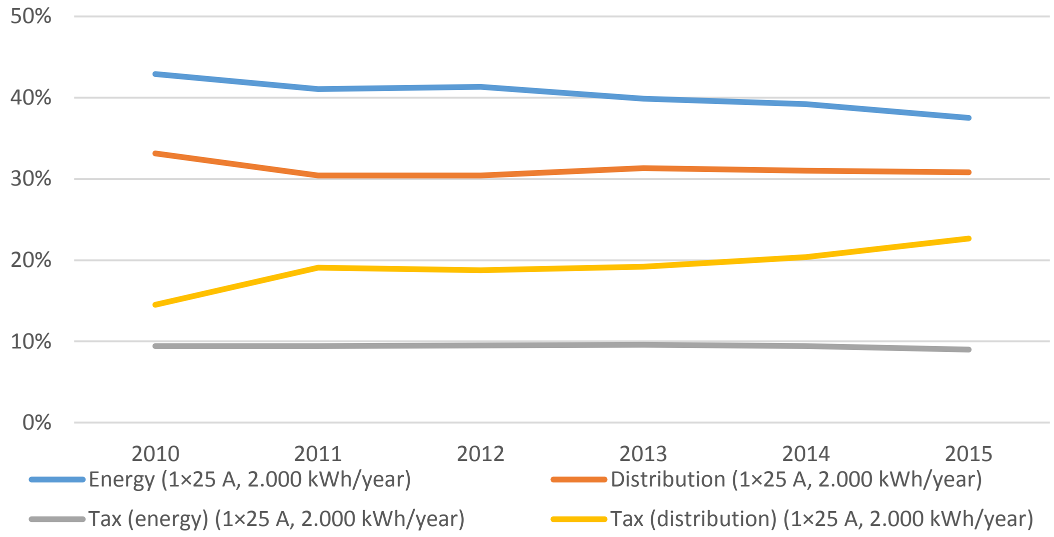
Table 5 | Proportion of fixed and variable parts of network tariff by user type

	kWh/year	Fixed part %			Variable part %		
		1/2010	1/2013	1/2015	1/2010	1/2013	1/2015
Apartment	2000 (1×25 A)	49 %	53 %	56 %	51 %	47 %	44 %
House	5000 (3×25 A)	40 %	42 %	44 %	60 %	58 %	56 %
House (electric heating)	18000 (3×25 A)	32 %	34 %	36 %	68 %	66 %	64 %
House (electric heating)	20000 (3×25 A)	34 %	36 %	37 %	66 %	64 %	63 %
Small industry	150000 (75 kW)	26 %	37 %	40 %	74 %	63 %	60 %

Source: Energiavirasto

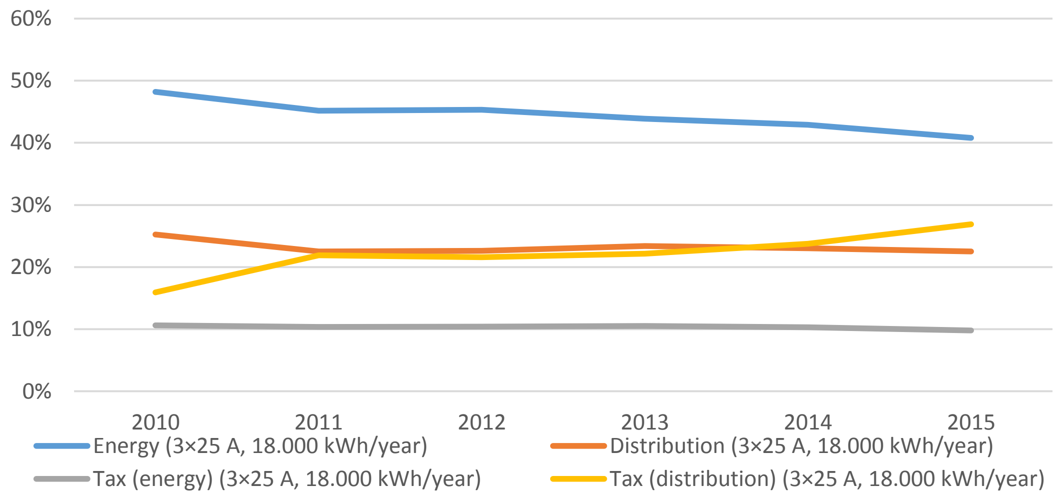
Figure 9 and Figure 10 show the development of components forming price of electricity. Share of energy component has decreased over the years in consumer type categories of apartment and house. There has been significant increase in the share of distribution tax component from January 2010 to January 2015.

Figure 9 | Components of the retail electricity price, house with electric heating - 2.000 kWh/year



Source: Energiavirasto

Figure 10 | Components of the retail electricity price, house with electric heating - 18.000 kWh/year

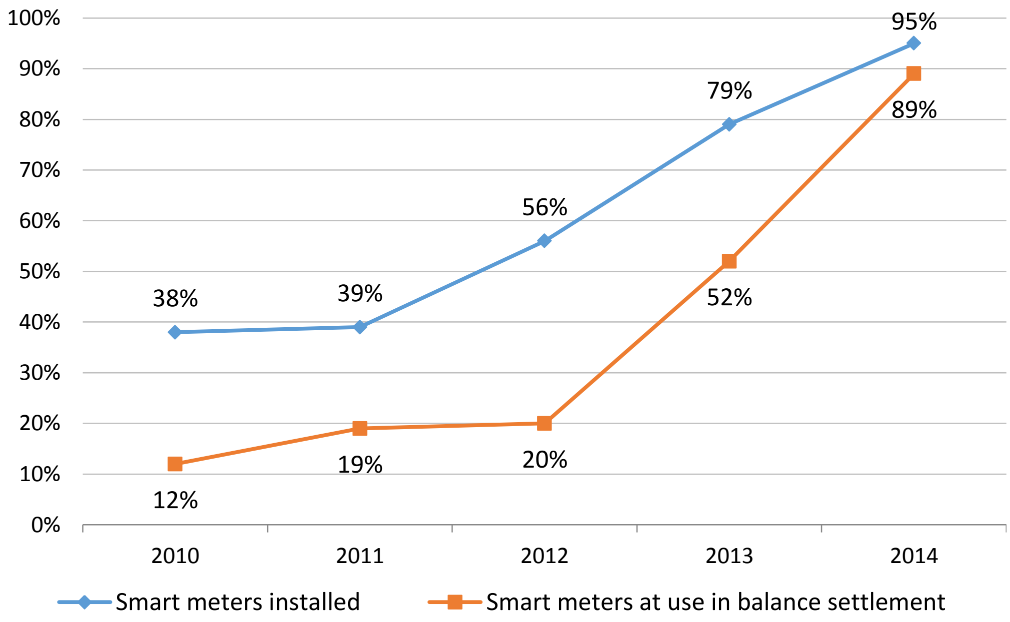


Source: Energiavirasto

According to the government decree on determination of electricity supply and metering (Vna 66/2009)[3], the metering of electricity consumption and small-scale electricity generation must be based on hourly metering and remote reading of the metering equipment (hourly metering obligation). Hourly metering must cover at least 80 % of the DSO's electricity metering points by the end of 2013. Figure 11 shows that by the end of 2014 89% of installed smart meters were at use of balance settlement.

[3] Valtioneuvoston asetus sähköntoimitusten selvityksestä ja mittauksesta (Government decree on determination of electricity supply and metering), (VNa 66/2009)

Figure 11 | Proportion of installed smart meters



Source: Energiavirasto

6.3 Discussions on tariff design

In 2012 a research group of LUT Energy conducted a research project "Tariff scheme options for distribution system operators". The project steering group comprised the LUT Energy researchers and representatives from The Finnish Energy Industries, electrcity network operators, Energy Authority and Ministry of Employment and the Economy.

The project report concluded that new pricing schemes are needed to encourage the customers in energy efficiency and demand response. According to the report the target is to establish a pricing scheme for DSOs that encourages the end-users to behave so that the energy efficiency of the whole energy system, including generation, transmission and distribution, is maximised and the total costs to the national economy are minimised. Furthermore, the pricing scheme has to be cost reflective, equitable and intelligible to all parties involved. Report studies the following alternative pricing schemes; fixed monthly charge, energy rate, dynamic energy tariff, power-based tariff and takes a closer look on power band pricing scheme.

In 2013 Energy Authority sent to selected DSOs a questionnaire about objectives of their tariff policy and pricing. In the answers, DSOs give reasons for their selection of tariffs, which are: fulfilling authorities' recommendations on means of metering, taking into account different customer needs and providing enough choices for consumers of different size. Most common objectives of tariff policy are steering and different objectives related to customers. The aim is to steer customers to efficient and stable use of electricity, and to save energy.

Customer related tariff policy objectives are for example clarity of tariff structure, selection of tariff products and ease of changing the product. Ensuring continuity of DSO's operations, predictability of revenue and stable income for owners is seen important.

Cost structure and the cost of network operations are mentioned as the basis of tariff setting. Also, Energy Authority's regulation methods and financing needs of replacement investments are mentioned. In practice, the network is designed and measured based on peak load capacity. According to some answers this has direct cost effect on construction and maintenance of network. According to some DSOs, current structure of their distribution tariffs do not reflect their true cost structure. In this case, fixed costs are allocated to some extent also to energy consumption based (variable) tariff components. The fixed standing charge (fixed tariff component) would increase significantly if all the fixed costs would be allocated on them. According to the DSOs, the actual share of fixed costs is 75% – 90%.

7 Tariff design in Iceland

7.1 Electricity Act

In Iceland each DSO shall establish a tariff for its services in accordance with the income possibility curve decided every five years by the National Energy Authority Orkustofnun (NEA).

The main provisions on tariffs in DSOs grids are to be found in Article 17 a. of the Electricity Act no 65/2003.

The same tariff shall apply in the distribution zone of each DSO for the consumption of low voltage electricity, i.e. 230-240 V. If the energy from the distribution system is delivered at a different voltage the tariff may be adjusted accordingly. In the same way, account may be taken of other differences in service in the tariff.

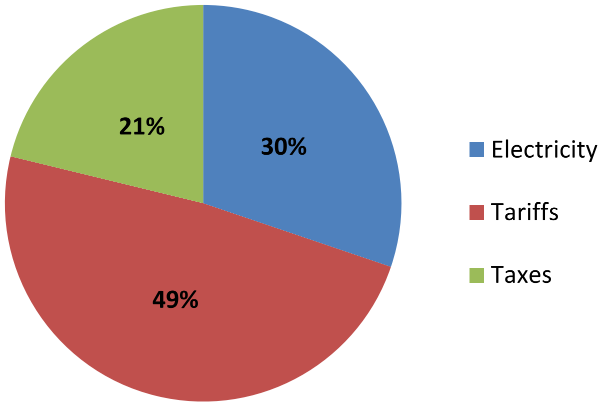
DSOs are permitted to apply to NEA for permission to maintain a separate tariff for rural areas where the cost of distribution is demonstrably higher than in urban areas. The condition for permission to maintain a separate rural tariff is that the use in the rural area in question must amount to a minimum of 5% of the total use in the distribution zone of the distribution system operator.

Each DSO shall send the tariff to NEA two months before taking effect. If NEA is of the opinion that the submitted tariff is in violation of law, NEA shall submit its comments to the distribution system operator in question within two weeks of the submission. A tariff shall not take effect until rectifications have been made to the satisfaction of NEA. The DSO is then obliged to publish the tariff.

7.2 Structure of grid tariffs in DSO- grids

The tariff for households consists mainly of two components, a fixed component and component based on the household´s use of electricity, c.f. Figure 12. Furthermore the customer pays an energy tax on the distribution cost and VAT. The tariff is the same during all hours of the year.

Figure 12 | Components of electricity costs to a household, 2015



Source: Orkustofnun

The rules on tariffs in Iceland grant the DSO a wide margin of discretion to decide the tariffs given that they treat their customers equally and establish their tariffs within the limits of their revenue caps. Therefore the tariffs for the six operating DSOs in Iceland are different.

Due to geographical limitations the cost of distribution to users in some areas of the country can be higher than in other areas. As mentioned above, DSOs can apply to NEA for a permission to maintain a separate tariff for rural areas if the cost of distribution is demonstrably higher than in urban areas. Currently, two DSOs have been granted such a permission.

7.3 Discussion on tariff design

The Icelandic DSOs have not implemented smart meters for their customers and NVE has not made any recommendations to the DSOs on that issue. Since the tariffs for DSOs in Iceland are the same during all hours there is a lack of incentive in implementing smart meters.

7.4 Conclusion

Iceland has not implemented the Energy Efficiency Directive since the Directive has not yet been made part of the Agreement on the European Economic Area. At the moment the government does not have any changes on the agenda as regards tariff design for the Icelandic DSOs. The implementation of the Directive may, however, have some impact on the legal framework that the DSOs currently work under in the future and indirectly effect tariff design in Iceland.

8 Tariff design in Norway

In the Norwegian regulations all tariffs are based on the costs referring to the consumer's point of connection. An agreement with the network company in the point of connection shall provide access to the entire network system and the power market.

All network companies are responsible for framing tariffs within their revenue cap pursuant to the regulation on tariff structure.

8.1 Electricity Act

Grid tariffs are treated in The Energy Act Regulations chapter 4, which states that tariffs are set by the network companies. Tariffs are used as the common term for all prices and financial remuneration for connection and use of network installations. Tariffs shall be designed so that they give signals whenever possible about efficient utilisation and efficient development of the grid. Tariffs can be differentiated according to objective and verifiable criteria based on relevant grid conditions.

Additional requirements are given in Regulations governing financial and technical reporting, income caps for network operators and tariffs (Reg. No. 302 of 11 March 1999), part V:

Chapter 13. General provision on tariffs

Section 13-1. *Principles of point-based tariffing*

All network companies are responsible for working out point-based tariffs that are in accordance with the following principles:

a) the tariffs shall refer to the points of connection.

b) an agreement with the network company in the point of connection shall provide access to the entire network system and the power market.

c) the network company is obliged to offer all customers who want network services non-discriminatory and objective point-of-connection tariffs and conditions.

d) the tariffs shall be designed so as to as far as possible give signals about efficient utilisation and efficient development of the network.

e) the tariffs can be differentiated according to objective and verifiable criteria based on relevant network conditions.

f) the tariffs shall be determined independently of power purchase agreements.

g) the tariffs shall provide the network company with income to cover costs under its revenue cap, tariff costs for access to higher voltage network (superjacent network), property tax paid and statutory payments to the energy fund.

h) all houses, apartments or vacation homes shall be metered and settled individually.

Section 13-2. *General rules on tariffing*

The tariffs for drawing and feeding power shall be worked out in accordance with the following basic structure:

a) usage-dependant tariff components that vary with the customer's ongoing drawing or feeding of energy.

b) other tariff components.

Section 13-3. *Usage-dependent tariff components*

The usage-dependent tariff components consist of an energy component and a capacity component.

As a main rule, the energy component shall be set on the basis of the cost of marginal network losses.

The network companies may set a capacity component to create balance between transmission needs and network capacity. The capacity component may be used when transmission needs exceed the capacity in the network.

Section 13-4. *Other tariff components*

Other tariff components shall cover network costs that are not covered by usage dependent tariff components.

Chapter 14. Practical design of tariffs for the ordinary drawing of power

Section 14-2. *Design of tariffs for the ordinary drawing of power from the distribution*

network

On the distribution network, customers without maximum demand metering shall be charged a fixed component and an energy component such that:

a) the fixed component covers customer-specific costs and a share of the other fixed costs on the network.

b) the energy component covers the cost of marginal network losses and may in addition cover a share of the other costs not covered by the fixed component.

Customers with maximum demand (load) metering on the distribution network shall be charged a fixed component, energy component and a load component. The fixed component shall as a minimum cover customer-specific costs. The energy component shall as a minimum cover the cost of marginal network losses. The load component shall be based on the customer's power consumption during defined periods.

Separate tariffs shall be prepared for high-voltage and low-voltage drawing.

For low-voltage drawing, the load component shall be volume-differentiated. These tariffs shall be designed such that all customers pay the same price for drawing up to the first stage and lower rates at subsequent stages. Tariffs may also be determined by other means that yield the same result.

The network owner shall offer tariffs with a time differentiated energy component to all customers in the distribution network who by regulation are subject to mandatory meter readings several times per year.

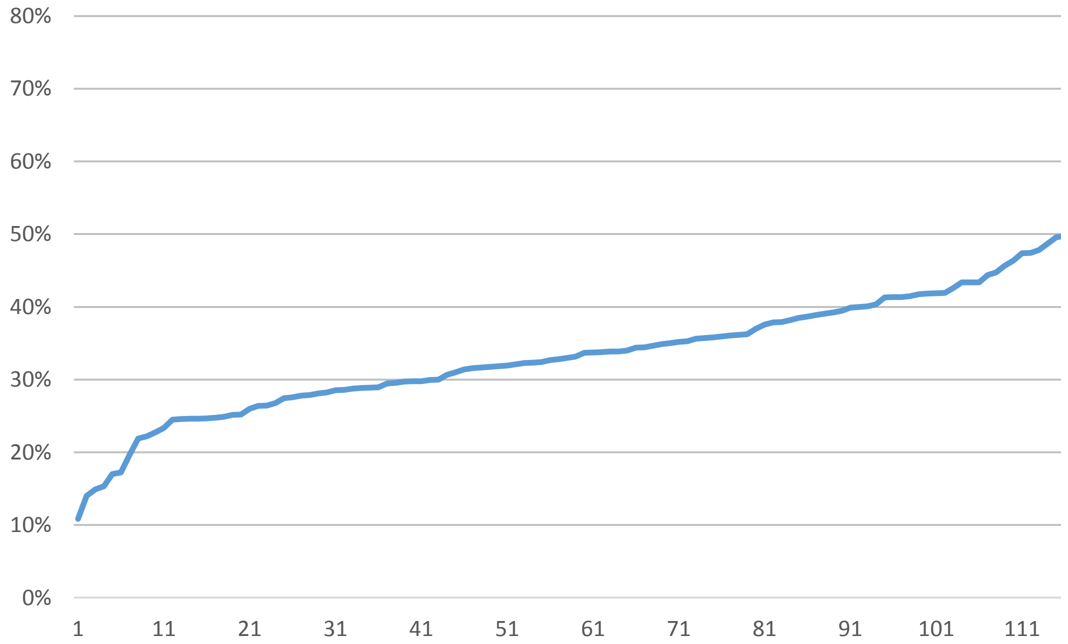
8.2 Structure of grid tariffs in DSO-grids

Current regulation provide network companies large degree of freedom regarding how to design tariffs. Tariffs for households, vacation homes and small commercial customers mainly consists of a fixed component and an energy component. Customers with master fuse exceeding a set limit, for example over 80 Ampéres or 125 Ampéres at 230 Volt, or customers with expected annual consumption exceeding 100 000 kWh usually have a load component in addition to the fixed component and the energy component.

Network companies part their customers into groups offered different tariffs, based on relevant network conditions. It is not irregular for households, vacation homes and small commercial customers to have different level of the fixed part within the same network company.

In Figure 13the proportion of the fixed part in the tariff for a household customer with 20 MWh per year is shown for 2015. The fixed part varies from 11% to 71% with mean value of 35%.

Figure 13 | Fixed part of grid tariff for household customer with 20 MWh per year in 2015



Source: NVE

In Table 6 mean tariffs for year 2015 in different customer groups is shown:

Table 6 | Mean tariff for different customer groups in 2015

	Power	Energy kWh/year	Tariff øre/kWh (EUR/Mwh)
Vacation homes	-	4000	82,5 (74,2)
Households (weighted average	-	20 000	26,3 (23,6)
Households	-	20 000	33,2 (29,9)

Small industy	-	30 000	35,6 (29,3)
Industry	40 kW	160 000	27,2 (24,4)
Industry	400 kW	1,6 GWh	11,9 (10,7)

Source: NVE

In Table 7 tariffs for year 2011 and 2015 are shown regarding the proportion of fixed part of total tariff.

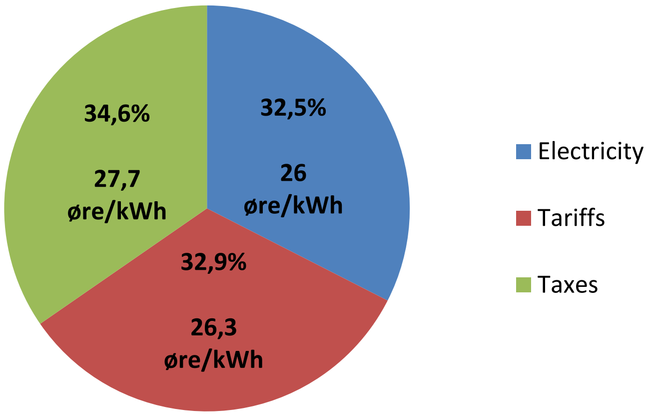
Table 7 | Proportion fixed charge in grid tariff for different customer groups

	Power	Energy kWh/year	Fixed part of tariff	
			2011	2015
Vacation homes	-	4000	71 %	72 %
Households (weighted average)	-	20 000	30 %	31 %
Households	-	20 000	32 %	34 %
Small industy	-	30 000	27 %	34 %
Industry	40 kW	160 000	17 %	19 %
Industry	400 kW	1,6 GWh	1 %	1 %

Source: NVE

Roughly, network tariffs constitute about 1/3 of electricity costs to a household, while about 1/3 is payment for the electricity to the supplier and about 1/3 is fees to the state[4], cf. Figure 14. Fees consist of consumption tax, statutory payments to Energy Fund and costs for electricity certificates.[5].

Figure 14 | Components of electricity costs to a household, 2015



Source: Statistisk Sentralbyrå

8.3 Discussions on tariff design

Within 1 January 2019, all Norwegian electricity consumers should have new advanced metering systems (AMS). AMS-meters will measure the customers electricity

[4] There are special arrangements in the three most northern counties, Finmark, Troms and Nordland. Households in these areas pay no VAT, there is also no consumtion tax in Finmarks and some of the minucipals in Troms. These areas will have a different mix, naturally.

[5] Consumption tax was 0,1365 NOK/kWh in the first half-year of 2015. From 1.7.2015 consumption tax is 0,1415 NOK/kWh. Payment to Energy Fund is 0,01 NOK/kWh and expected costs in 2015 for Electricity Certificates are 0,017- 0,021 NOK/kWh.

consumption on an hourly basis, and provide far better information about actual customer usage. This was a decision made by NVE in 2011 and NVE defined features of these meters.

NVE has collected information from most of the DSOs about how many customers have advanced metering systems installed. By the end of 2014, 10 % of all customers had advanced metering system with two way communication. (The majority of these are installed before 2011 and do not satisfy all demands for AMS, but the companies must not change these before 2019. In a setting where we compare the Nordic countries, 10 % will be the reasonable share).

In addition to more accurate settlement of electricity and network tariffs, AMS enables customers that adapt their consumption to price signals from the electricity market and from network tariffs to reduce their costs relating to energy consumption. By measuring the energy consumption not only in volume, but also over time, consumers may contribute not only to more efficient utilisation of the grid, but also with flexibility (demand-response) that may delay or reduce the need for grid investments. This will benefit all customers through lower tariffs than in the case with grid investments.

Costs arising in the grid by consumer use are mainly related to losses, provided sufficient grid capacity. The energy component of the tariff is far higher than the value of marginal losses[6]. This affects the not only the cost allocation among customers, but also the relative ratio between electricity from the grid and other options, without regard to the power system. For example:

- The prices between electricity and other energy carriers. The level of the energy component affects the relative profitability of electricity versus fuel oil, gas or other options in the choice of heating solution.
- Profitability of energy efficiency measures, and profitability for electricity production behind own meter (prosumer). For prosumers the energy component of the tariff is netted out in the point of connection. This means that investment in energy efficiency measures and production behind own meter can save contribution to cover capital and operating costs.

The ongoing discussion regarding tariff design suggests less energy-based and more power based tariffs for customers in DSO grids. NVE has had of a hearing on the issue, and the industry organization “Energi Norge” has a working group concerning tariff design. See also chapter 4 for some of the reports that have been written on the subject. An introduction of power tariffs to all customers could be justified by the following:

- better utilization of the grid, less grid investments and lower tariffs
- more cost-reflective and fair allocation of grid costs among users of the grid since network costs are far more capacity driven than energy driven.

NVE have heard the concept about the following tariff design for all load customers in DSO grids:

[6] Based on average historical costs, marginal losses will be about 0,05 NOK/kWh, while mean value of the energy component in 2015 is 0,181 NOK/kWh.

- An energy component reflecting the cost of marginal losses
- A fixed component covering customer-specific costs
- A power-based component, following one of the three options:

  1. Customers are settled according to metered load (kWh/h) in a given hour e.g. highest monthly hourly load or customers load during peak hour. One hour, or mean value of several hours.
  2. The customer pay a certain amount according to the main fuse size of the electrical installation, as a measure of the customers potential power use from the grid.
  3. The customer subscribes to a certain amount of maximal hourly power, and pays according to this. For consumption above this amount, there is a higher price, or it might be possible to limit the hourly power consumption to the subscribed amount using technology in the AMS meter.

Power tariffs can be designed to affect consumption (capacity tariff) or to cover the total need for income in the grid. The ideal way to cover residual costs, is a fully independent neutral tariff which does not affect the use of the grid. A fixed fee that is equal for all customers is the closest we get to such a residual tariff. When discussing tariff design, it is therefore crucial to be clear about whether we want the tariff to give signals about the load situation in the grid or not.

Shortage of grid capacity in the distribution grids is often solved by new grid investments, although there are only few hours during the year where the demand for grid capacity exceed the capacity in the grid.

NVE have heard the concept about handling shortage of grid capacity by utilizing consumer flexibility.

End user flexibility can be understood in two different ways:

- On the one hand, it may on the one hand be understood as price response, as end users voluntary adaptation of own energy consumption to the current price signals from the electricity market and grid costs.
- On the other hand, end user flexibility may be understood as interruption of consumption. Interruption is remote controlled and can in principle be carried out by a grid company, an aggregator or another actor that the customer has an agreement with. The end user must be compensated to accept that his consumption may be interrupted. If one or more participants are willing to pay, and end users are willing to sell there may occur a market for interruption, or a market for flexibility.

Purchase of end user flexibility in a market solution will provide proper valuation of flexibility and visualize the opportunity cost of an investment. This is in contrast to the current alternatives to grid investments as capacity pricing through tariff does not appear as a cost to the network company, but only a redistribution of income.

NVE has received 57 letters commenting on the hearing, mostly positive to introducing a power-based component in the tariff design. NVE will evaluate the comments and consider whether there is need to change the regulations of the tariff design. This work will continue in 2016.

8.4 Conclusion

The Norwegian acts states that tariffs shall be designed so that they give signals whenever possible about efficient utilisation and efficient development of the grid. Tariffs can be differentiated according to objective and verifiable criteria based on relevant grid conditions.

Current regulation provide network companies large degree of freedom regarding how to design tariffs. Tariffs for households, vacation homes and small commercial customers mainly consists of a fixed component and an energy component.

The ongoing discussion regarding tariff design suggests less energy-based and more power based tariffs for customers in DSO grids. NVE has had a hearing on introducing a power-based component in the tariff. This work continues in 2016.

9 Tariff design in Sweden

This appendix is composed of four parts. An overview of the design of tariffs in Sweden is followed by an actual picture of the structure of load tariffs for the DSO-grids. The third part consists of a description of how the Energy efficiency directive is implemented in the Swedish electricity act. The fourth part is a short survey over the discussions of tariff design Sweden.

Section 9.2 gives an overview of the various grid tariffs that are offered by Swedish grid companies. The structure of the tariff provides different incentives for consumers to modify their consumption patterns. A change in design can have impacts on both the load profile and the energy use.

Analysing design of grid tariffs is important for two reasons:

- New technologies such as interval metering and two-way communication provide new opportunities for tariff structures.

- Different tariff structures give consumers different incentives and can therefore impact how they use the grid.

New technologies (metering and communication) gives opportunities for a more flexible use of electricity over the hours during a year. The new technology can therefore make the customers more price sensitive in the future.[7] New metering devices can change the design for household customers and small firms from traditionally energy based to power based charging.

9.1 Limited restrictions on grid tariff design in the Electricity Act

Grid tariffs are treated in Chapter 4 of the Electricity Act, which places the following requirements on grid tariffs:

1 §: Grid tariffs should be objective and non-discriminatory. They should be designed in a manner compatible with the efficient use of the power grid and an efficient electricity generation and electricity use.

2 §: Grid tariffs for the transport of electricity shall be structured so, that a paid connection charge gives the right to use the national electricity grid, with the exception of interconnectors to neighbouring countries

3 §: On distribution level, grid tariffs for the transport of electricity cannot be structured taking into account the location of the connection point within the DSO region.

9a §: Grid tariffs for connection to a line or a grid shall be structured so that justifiable costs incurred by the holder of the concession are covered. On transmission level, the geographical location of the connection point and contracted power at the connection point can be taken into account.

[7] Most studies of customers price elasticity reports rather low levels of elasticities.

5 Chap. 7 a §: The revenue frame should be determined with consideration to in what extent the network is operated in a way that is consistent with an efficient use of the network. This evaluation may imply a decrease or increase of the reasonable return on the capital base.

Summarizing, the Electricity Act only puts two requirements on grid tariffs since the deregulation decision of parliament in 1995: it should be objective and non-discriminatory. As long as these two requirements are met, grid companies are free to set grid tariffs as they see fit. The Inspectorate sets the size of the total allowed revenue, but does not decide how grid tariffs are structured. Since 2014, the Act also includes the following provision on grid tariffs: "They should be designed in a manner compatible with the efficient use of the power grid and an efficient electricity generation and electricity use". This change is also supplemented with the formulation in 5 Chap. 7 a § which gives the regulator a possibility (a measure) to implement incentives in the revenue frame for a higher capacity utilization. The change in the act regarding tariff design depends on the requirements in the energy efficiency directive.[8] [9] Resulting from this change, the Energy Market Inspectorate has published a provision on how efficient grid use is determined and how it influences the income caps of the DSOs[10]. The provisions are valid for the regulatory period 2016-2019 and grant higher incomes for DSOs which reduce network losses and achieve a more even consumption profile.

9.2 Structure of grid tariffs for load in DSO-grids

Energy markets inspectorate (Ei) collects the tariffs from each DSO in Sweden on a yearly basis. In the beginning of each year a survey sends out to all DSO-grids. They have to report the structure for a number of customer categories. From the tariff for apartments (with defined use of electricity of 2000 kWh/year and fuse of 16 A) to an industry with subscribes power of 20 MW and electricity use of 140 GWh/year.

The structure of tariffs can be downloaded from Ei's website.[11]

A description and analysis of tariff structure and the design of tariffs was commissioned by Ei and done in 2011 by SWECO.[12] The report considers the relations of the cost structure in distribution to tariffs with principles of cost allocation. The cost allocation has the purpose of fulfilling the goals for objective, cost-reflective tariffs.

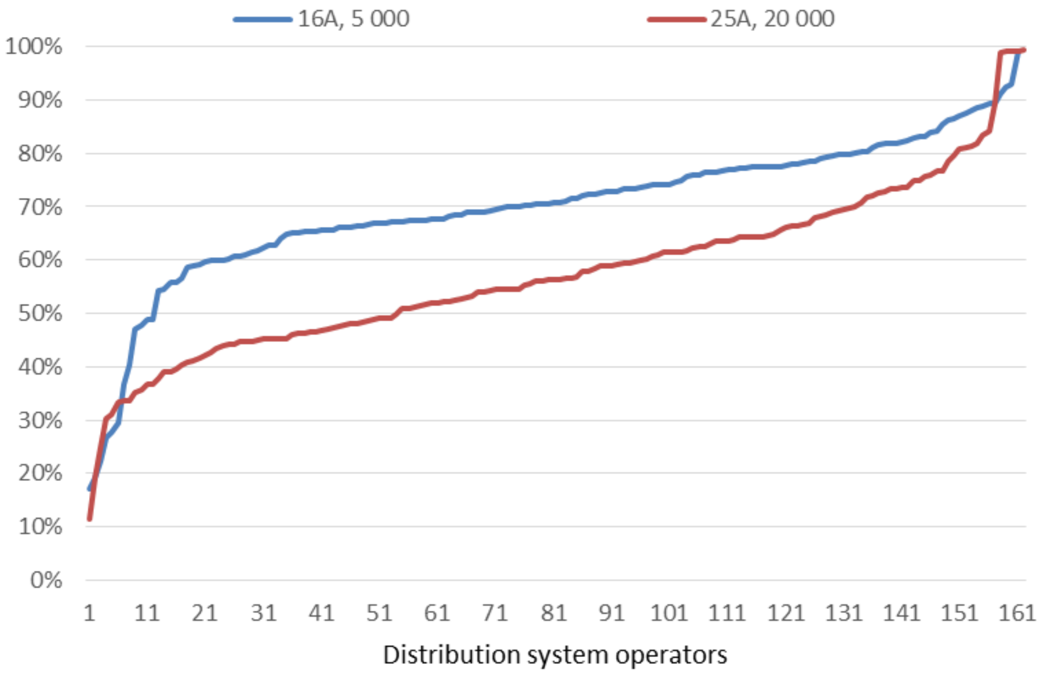
In a report to the government in 2012, Ei analysed the design of tariffs in the perspective of the Electricity Act and the proposal for the Energy Efficiency Directive.[13]

A typical feature of the structure of tariffs is the variation in design. The structure of cost is in principle the same, but still there is a rather wide variation in design. In Figure 15,

[8] Betänkande 2013/14:NU18 Genomförande av energieffektiviseringsdirektivet.
[9] http://www.regeringen.se/sb/d/18263/a/233650
[10] http://www.energimarknadsinspektionen.se/Documents/Publikationer/foreskrifter/El/EIFS_2015_6.pdf
[11] http://www.ei.se/sv/Publikationer/Arsrapporter/elnatsforetag-arsrapporter/
[12] http://www.ei.se/sv/Publikationer/Rapporter-och-PM/rapporter-2011/lokalnatstariffer-struktur-och-utformning/
[13] http://www.ei.se/sv/Publikationer/Rapporter-och-PM/rapporter-2012/

the proportion of the fixed part in the tariff for two typical household customers are shown (with 16 and 25 Ampere and 5 000 and 20 000 kWh electricity). The fixed part makes up a larger share of the total for the smaller user.

Figure 15 | Fixed part of the grid tariff for user types with 16 and 25 A, 5.000 and 20.000 kWh/year respectively in 2015



Source: Swedish Energi Market Inspectorate

Over the years, there is a slow increasing trend for more fixed part. In 2011, the mean value of the fixed part was 50 %.

In Table 8, tariffs for years 2011 and 2015 are shown regarding the proportion of fixed part and the proportion of time-of-use tariffs. As can be seen, there is a variation of the fixed part from only 1 % for category 20 MW/140 GWh to 73 % for apartments. The fixed part has grown somewhat since 2011. This trend has been going on slowly since the deregulation in 1996.

Table 8 | Proportion fixed charge in grid tariff for different customer categories and proportion of Time-of-use tariffs

	Level of fuse	Energy use	Proportion fixed charge		Proportion of Time-of-use
	Ampere	kWh/year	2011	2015	År 2015
Apartments	16	2 000	72 %	72 %	0 %
	16	5 000	67 %	71 %	0 %
	20	10 000	64 %	68 %	6 %
Small houses	20	20 000	50 %	53 %	5 %
	25	20 000	55 %	59 %	5 %
	25	30 000	46 %	49 %	8 %
	35	30 000	56 %		
	35	30 000	55 %	58 %	5 %
	50	100 000	38 %		

	63	25 000	72 %	61 %	5 %
	80	80 000	54 %	57 %	13 %
>35A	100	100 000	54 %	56 %	11 %
	125	125 000	54 %	56 %	17 %
	160	350 000	38 %	53 %	19 %
	200	240 000	50 %		
Power	100 kW	350 MWh		13 %	64 %
	1 MW	5 GWh		3 %	64 %
	20 MW	140 GWh		1 %	58 %

Source: Swedish Energi Market Inspectorate

Table 9 | DSO grids using power based tariffs for households in 2015[14].

DSO grids using power based charging for households customers Excl. VAT and governmental fee (54 SEK)					
20 A 20 MWh per year	Falbygden	Malung	Partille	Sala-Heby	Sollentuna
Fixed charge SEK/year	1.000	2.214	710	1.200	1.200
Power charge SEK/kW and month					
Peak-load winter	26,5	72	19,5	79,04	69,6
Off-peak winter	26,5	72	19,5	0	0
Peak-load summer	26,5	22	19,5	32	34,8
Off-peak summer	26,5	22	19,5	0	0
Energy charge öre/kWh					
Peak-load winter	17,5	0	17,2	0	0
Off-peak winter	17,5	0	17,2	0	0
Peak-load summer	17,5	0	17,2	0	0
Off-peak summer	17,5	0	17,2	0	0
Number of hourly values in monthly charging					
	1	5		5	3

Source: Swedish Energy Markets Inspectorate

9.3 Discussions on tariff design in industry

With the rolling out of AMR systems for reading the customers' use of electricity, it is now possible to use power based charging for household and other small users of electricity. Therefore there is a discussion in the industry regarding the design of grid tariffs.

The industry association for grid owners has a working group for tariffs and the group has written a paper on the issue called "Ny tariffstruktur". The purpose of the report is to suggest a structure for cost reflective tariffs. Inputs for the paper are governmental studies on tariff design with special focus on renewable generation, electrical vehicles and a more efficient energy[15], as well as the Energy Efficiency Directive from EU. The discussion regarding a common Nordic retail market (with proposal of a supplier centric model) is also an input to the work.

[14] SOU 2005:51 "Bilen, biffen, bostaden. Hållbara laster – smartare konsumenter", 2005
SOU 2008:110, "Vägen till ett energieffektivare Sverige", 2008.

[15] Ei 2012:14, "Tariffutformning - behövs mer detaljerade krav", 2012.

The focus has been to discuss how a power based tariff can be designed. In short, the group presents the following suggestion for a future structure:

A fixed part and two variable parts with charging both on use of electricity and the maximum load during each month. The billing is on monthly basis on actual use and load.

The fixed part will cover customer specific costs such as metering and billing and customer service. The power part is metered as the highest monthly hourly load (kWh/h) - that is the highest hourly mean value of load. The charge will cover capacity costs in the local grid but also the local grid's costs for upstream grid (sub-TSO). The third part is a distribution charge[16] based on the monthly use of electricity (kWh). This part will cover the costs for grid losses both in the own grid and upstream grid. Some capacity cost for central parts of the local grid will also be incorporated in the distribution charge. The reason for that is that some customer groups have collective evening out of the loads. This is the case for small users with low utilization time like apartments.

The reason for the proposal is threefold:

- All customer groups shall participate in paying for the ground costs (cost which is not depending on power or energy)
- All customer shall have the same definition of power value
- To use the mean value of several hourly values for charging is not recommended (which is the case for some grids in Sweden)

The group also suggest that the power charge shall be the same during all hours during the year – that is a uniform tariff and no time-of-use tariff. If a time-of-use charging will be used, it should be based on energy use (kWh).

Tariffs for apartments with good power simultaneity has in some cases a completely fixed part or a fixed and energy based part as the only customer group. All other customer groups have power based charging. The group is of the opinion that in the future, even the apartment customers shall have a power based charging. The reason for that is greater variation in the load profile between customers in apartments.

In a report from a tariff group, eight local DSO'a in the north of Sweden give a proposal for a new tariff.[17] They call it a "market monitored tariff" meaning that the grid tariff depends on the demand for capacity (kW). This tariff is adjusted each year with changes in demand for capacity. The charge for power will be different for each month depending on the load (capacity utilization), so there will be twelve different prices for power (SEK/kW). The load profile is calculated from the collective load – that is – all customers have a responsibility for the collective load. The tariff can therefore be characterized as a seasonal tariff because the load is much higher in the winter due to electricity heating. For some of the grids, there are customers visiting the mountains for skiing, further increasing the demand for capacity during these times.

The calculation of the tariff is based on the maximal load each month for the last two years. The load profile is used for the allocation of costs.

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[16] Överföringsavgift (öre/kWh).

[17] Elinorr – tariffutredning – delprojekt 1, 2014.

There are several objectives for tariff setting:

- Cost reflectivity
- Simplicity
- Giving incentives for efficient use of capacity. The customers shall have incentives to even out their load over the day.
- Stable revenues
- Less administration

The proposal gives a different price/kW load each month, but not a different price over the day or weekends. They propose a seasonal time differentiations, but not within the month. An explanation for that position is that these local grids have a special high load during the winter months and a time-of-use tariff over the day will probably give high loads during the night – that is – shifting the loads from day do night, but still high loads.

9.4 Conclusion

The Energy Efficiency Directive has been implemented in the Swedish Electricity Act. The supplement adds a wording that the tariff must give incentives for efficient use of the grids, but also incentives for efficient production and use of electricity.

The grid industry has the opinion that a change from fuse tariffs to power based tariffs is good. A possible exemption can be apartments, but several DSOs think that even apartments ought to have power based tariffs, possibly with another pricing structure between fixed and power based charging compared to other customer groups.

The industry is more hesitant to implement time-of-use tariffs over the day and weekends. If there shall be a time differentiation, they think that the differentiation shall be on the energy part (öre/kWh). Some grids think that a change to a power based tariff can be done in two steps. First a uniform power based tariff (no differentiation) and then after some years a second step with time differentiation. Today, there are only three local grids using a complete time-of-use tariff for household customers (like electricity heated houses). Two other local grids have power based charging with uniform price over the year.

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