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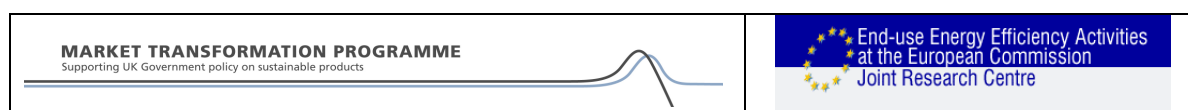
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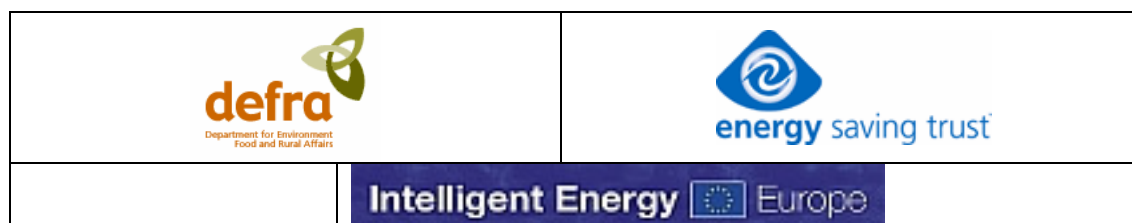
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Load demand pricing - Case studies in residential buildings

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Abstract

Since the liberalisation of the Swedish electricity market in 1996, the competition between utilities has increased, and the generation capacity has gradually been adjusted to suit the demand.

Consequently, the earlier excessive electricity production capacity has been reduced. However, if the gap between the generation capacity and demand will be too narrow, this may result in notable power shortages in the electricity market. In order to achieve lower load demand, to avoid load peaks and to reduce electricity cost, a Swedish electrical utility - Skånska Energi Nät AB (SENAB), is planning to include a load demand component in its electricity tariff to make customers more aware of their energy consumption pattern and (possible) load demand problems. This study investigates the impact of the new tariff from the viewpoint of the utility as well as its customers, compared to the existing tariff. The project was carried out by the Efficient Energy Use in Buildings Research Group at the Department of Energy Sciences, Lund University.

The results of the investigation show that if a load demand component were to be introduced into SENAB's network tariff, primarily customers with a 16-ampere fuse would incur higher network charges whereas customers with a higher fuse level would incur lower charges. With the existing network tariff, customers with high fuse levels pay relatively high standing charges in relation to their exploitation of the grid and as such they are subsidising customers with lower fuse levels. The study also shows that it is important that the new load demand pricing strategy (tariff) is communicated to customers in a comprehensive manner, so that they understand it and furthermore realise that they can save money by changing their energy consumption patterns without lowering their standard of living or comfort.

Introduction

Sweden has a relatively high electricity consumption per-capita, about 17 000 kWh per inhabitant annually, more than twice as high as the European Union average. In the year 2005, Sweden was in fourth place in the world, in terms of electricity consumption, after Norway, Iceland and Canada. The high electricity consumption in Sweden is due to electricity-intensive industries and the high demand for space heating caused by the cold climate. Over the past thirty years, the electricity consumption in Sweden has increased at the rate of almost 3 % annually [1].

The Swedish electricity market was reformed in 1996 and then again in 1999 for household users. As a result of the electricity market reforms, consumers may now choose their electricity supplier and all trading must be competitive. However, the grid operator can not be chosen by the consumer, and is still regulated. A corporation that pursues network operations may not pursue trading in or generation of electricity. Therefore, there must be a clear distinction between generation of and trading in electricity and network operations.

Electricity consumption varies between different hours of the day, between days of the week and between seasons of the year. The highest power demand occurs only during a few hours when the outdoor temperature drops. In recent years, the power demand has reached new peak levels but due to predominantly economic and political reasons the load reserves have dwindled. The reliability of supply criteria that determined the required peak load generation capacity before the market reform was abandoned in conjunction with the liberalisation. The problem of load capacity has become more and more obvious during the last years. According to the law (in force until March 2008) the Swedish national grid operator is obliged to ensure reliability of electricity supply by purchasing reserve capacity.

One possible solution to the load problem may be the introduction of a new pricing strategy with a load demand component, which means that consumers pay for load demand instead of electricity consumption only. In this way, the customers would be more aware of their energy consumption pattern and may be incited to lower the load demand, which could help the utility to avoid high load peaks.

The objective of this study was to investigate how such a tariff would affect one of the Swedish electricity utilities and its more than 16 000 electricity customers.

Electricity price at user level

The total electricity price charged to the Swedish customers consists today typically of three parts: electricity fee, network fee and taxes.

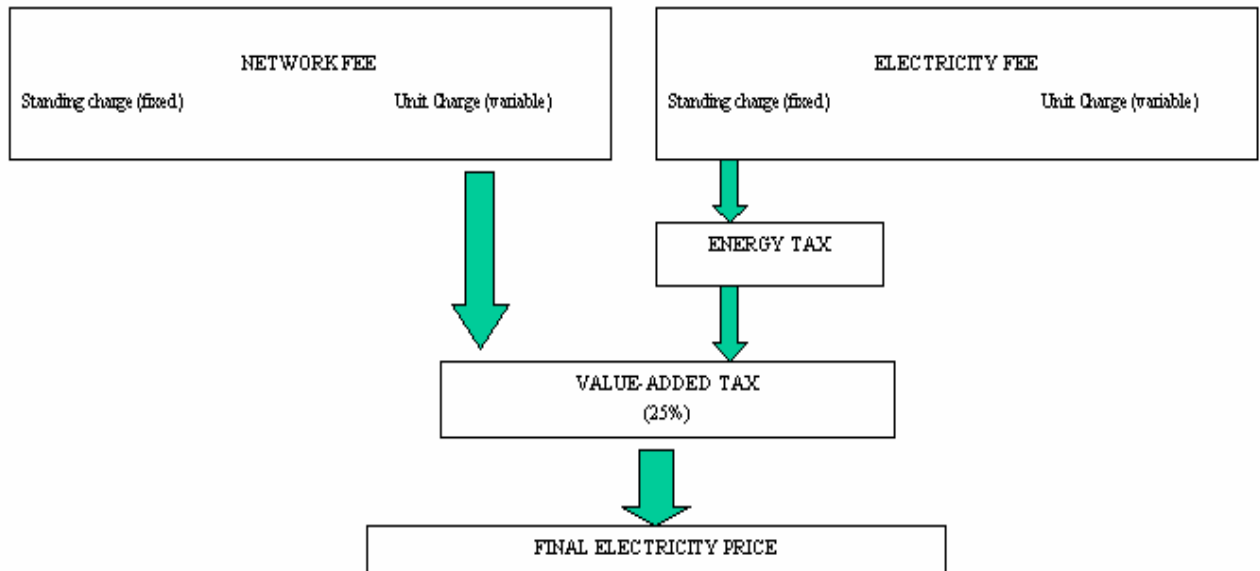


Figure 1: Residential electricity price structure [4].

The only part of the electricity bill that the customers themselves are able to influence is the electricity fee. All customers have the opportunity to switch their electricity supplier or renegotiate their existing contract, and, in this way, get a lower price.

The second part of the total electricity price, the network fee, is paid to the network owner in the area. The network owner provides the physical transmission of electricity from the generation plants to the end-user. Customers cannot choose their network provider so the network fee must be reasonable and non-discriminatory. Network tariffs are supervised and published by the Swedish Energy Agency. The third part of the electricity charge is taxes. In Sweden, like in all the other Nordic countries, the consumption of electricity is taxed. Swedish customers have to pay two different types of taxes, an energy tax and a value added tax (VAT). The energy tax for domestic customers depends on the region. Industries pay no taxes at all at user level. The VAT is applied to the total price of electricity, including the energy tax.

About 40 % of the total electricity price to a domestic customer is the price of electrical energy, 20 % is the share of the network tariff and taxes account for 40 % [2].

Residential electricity customers can often receive two bills: one from the electricity supplier and another one from the electricity grid company in the area. Both bills divide the fees into variable (depending on the amount of electricity used) and standing subscription fees (see Figure 1). The variable fee on the network bill is the charge for transmission and network services. The fixed part is based on the main fuse used in the household and includes also governmental charges (as green certificates etc) [3].

Previous experience from load demand tariffs

The main purpose of implementing a load demand component into electricity pricing is to draw the customer's attention to load demand (kW) rather than energy demand (kWh). In this way, customers will hopefully become more conscious of their energy consumption pattern and possible load demand problems.

As of January 1st 2001, Sollentuna Energi became the first Swedish energy utility to have incorporated a load component into their grid tariff. Their experience is therefore of great interest

when other utilities are investigating the possibility of implementing load based electricity pricing strategies.

Sollentuna Energi's load charge depends on the customer's average load value of three daily 1-hour load peaks during one month. This means that through achieving more even electricity use pattern, customers can lower their network bill. The utility introduced the new tariff in a broad campaign explaining "load demand" terms and giving many advices about different ways to lower load demand in residential buildings, with and without electrical heating.

Sollentuna Energi's new tariff showed that customers living in flats with a 16 ampere fuse level had paid, with the old tariff, a lower grid fee than other customers. Some customers in flats had a surprisingly high load demand and relatively large electricity use. Generally speaking, customers living in flats with a 16 ampere fuse level incurred small increase in their grid fee while customers with higher fuse levels (25 – 63 ampere) got a significant price reduction [5]. According to the evaluation made by the utility itself it was possible to lower load demand about 5 % thanks to this new load based tariff.

The experience from Sollentuna Energi also shows the importance of customers' understanding the difference between "power/load" and "energy" terms. In a study made on 1020 of Sollentuna Energi's customers in October 2002 [6], 78 % preferred the old tariff (where customers only paid for their electricity consumption) to the new one. Some argued that it was bothersome to have one more thing to think about concerning the electricity bills. Others argued that the new tariff created higher and unfair electricity costs.

Case study - Skånska Energi Nät AB

Skånska Energi AB (SEAB) is an electric utility that operates in the southern-most county of Sweden, Scania, supplying electricity to about 17 000 customers. The vast majority of these customers, about 75%, are residential customers, but there are also schools, agricultural properties and industrial companies in the customer base [7]. SEAB is divided into a retail company - Skånska Energi Marknad AB (SEMAB) and a grid company which owns the grid in the area - Skånska Energi Nät AB (SENAB). SENAB is buying electricity from the high voltage grid owner within this area - E.On. The contract states the highest hourly load demand, so called subscribed load, which was at the time of this investigation 78 MW. If this level is exceeded, the utility pays fine per each kW, depending on the terms of the contract with E.On. Over the past 5 years, the subscribed load capacity has been exceeded twice (by 2 MW) - once on the morning of January 21st, 2004 and once on New Years Eve, 2001. The morning peak on January 21st, 2004 cost the company about half a million SEK (54 000 EUR). In order to avoid penalty charges from the supplier and to reduce load demand, and in the long term decrease the subscribed load level, SENAB is interested in incorporating a load component into the grid tariff. In 1998, SEAB invested in an advanced remote metering/billing system, CustCom. This system, which is based on 1-hour measurements for all customers, makes it possible for the utility to introduce such a tariff.

A specialised Internet module makes it possible for SEAB's customers to enter a website and to monitor their electricity use statistics (in kWh/h) whenever they wish, which may help them to verify their network bill and to give more attention to their electricity use and load peaks.

Load demand tariff simulations

With a view to analyse how a grid tariff with a load demand charge could affect the utility and its customers, a new pricing strategy (tariff) was constructed and price simulations, with varying load tariff component values, were carried out [9].

The simulations were conducted as cost comparisons between the cost that the customers would have with the new load demand tariff and the cost that they have currently, with the existing tariff.

The structure of the load demand tariff can be seen in Equation (1).

$$\Phi = P_{av} a + s \quad (1)$$

P_{av} [kW] denotes the average value of the customer's three highest hourly load peaks from three separate days during each month. a [SEK/kW] is a constant load price that takes two different values - one from April to October and another from November to March. s [SEK] is the fuse level fee of the network tariff (standing charge). Taxes and governmental fees are excluded from the analysed pricing.

The structure of the existing tariff can be seen in Equation (2).

$$\Phi = 0,149 E + S \quad (2)$$

E [kWh] is the electricity consumption during one month. 0,149 [SEK/kWh] is the energy unit price of the network and **S** [SEK] is the standing charge of the network tariff. Taxes and governmental fees are not included.

The price simulations were run for all of SENAB's customers with fuse levels between 16A and 200A. Customers were divided into groups depending on their fuse level. Customers with a 16-ampere fuse were separated into three subgroups: customers living in flats 16L, electric heated houses 16V and houses with other heat source 16A.

In all four simulations, the condition that SENAB's total revenue would be close to zero, seen over the whole year, was applied. Component **a** was adjusted in order to achieve this.

In order to get a distinct difference between low and high demand periods, the component **a** in the load demand tariff was almost doubled during the high demand period November - March, compared to the low demand period April - October.

Simulation results

In the first price simulation the following premises were given: (1 SEK = 0.11 EUR)

$$s = S/2$$

a = 73 SEK/kW November-March

a = 35.5 SEK/kW April-October.

Figure 2 shows the difference in SENAB's income (load demand tariff – existing tariff) for each fuse group. Figure 3 shows the average cost increase for customers in each fuse group, when using the new load tariff compared to the existing tariff.

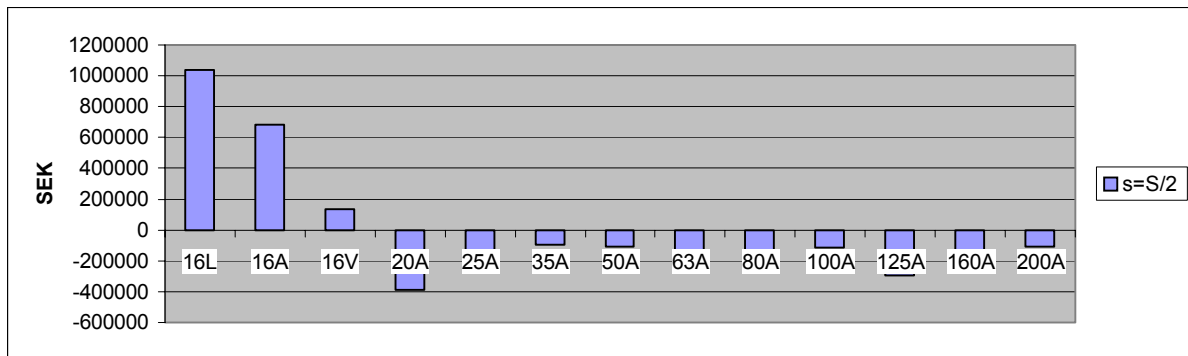


Figure 2 Difference in SENAB's income for each fuse level group (load tariff – existing tariff).

a = 73 SEK/kW November-March, **a** = 35.5 SEK/kW April-October, **s** = S/2.

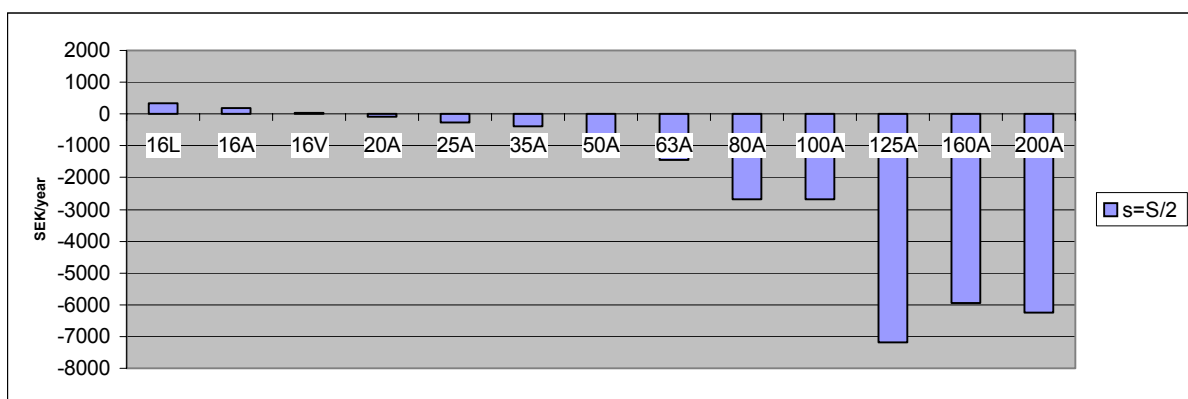


Figure 3 The average cost increase for customers in each fuse group with the new load tariff compared to the existing tariff.

a = 73 SEK/kW November-March, **a** = 35.5 SEK/kW April-October, **s** = S/2. (1 SEK = 0.11 EUR)

Negative values in Figure 3 imply that the average customer would be charged less with the new load tariff. The results show that customers with low fuse levels would generally be charged more, whereas customers with higher fuse levels would be charged less.

The second price simulation was performed for $s = S/3$, $a = 80$ SEK/kW November-March, and $a = 39.5$ SEK/kW April-October. The findings from the second simulation were similar to that of the first one. 16L, 16A and 16V customers would incur higher charges with the load tariff, whereas the other groups would be charged less (see Figure 4 and 5).

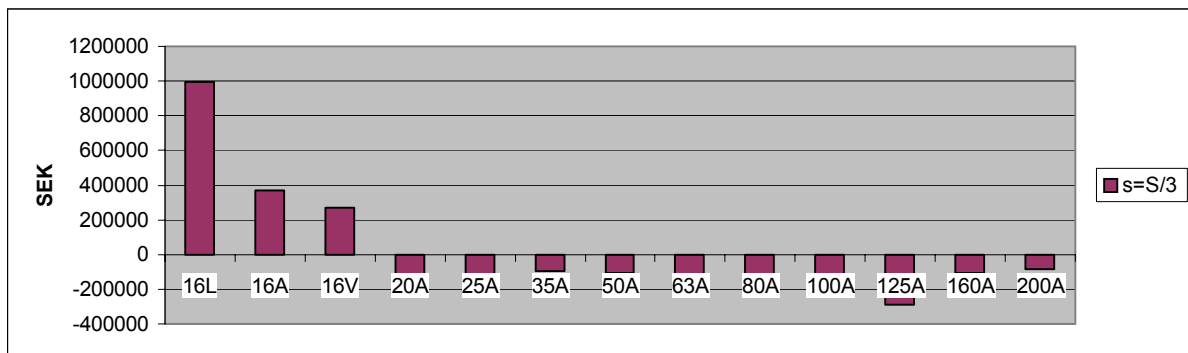


Figure 4 Difference in SENAB's income for each fuse level group (load tariff – existing tariff).

$a = 80$ SEK/kW November-March, $a = 39.5$ SEK/kW April-October, $s = S/3$. (1 SEK = 0.11 EUR)

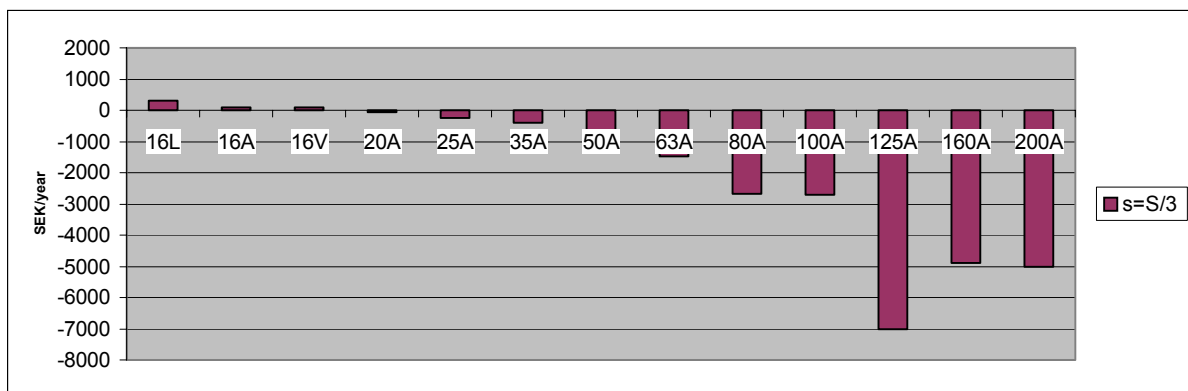


Figure 5 The average cost increase for customers in each fuse group with the new load tariff compared to the existing tariff.

$a = 80$ SEK/kW November-March, $a = 39.5$ SEK/kW April-October, $s = S/3$. (1 SEK = 0.11 EUR)
 In order to compare how a tariff based only on a load demand component would turn out, s was set to zero ($s = 0$) in the third simulation. $a = 95$ SEK/kW November-March, $a = 46.6$ SEK/kW April-October. In this case, 16A customers would be charged less with the load tariff and 20A-group would be charged more, thus achieving the opposite result to the previous two cases. The other fuse groups however were still following the trend achieved in the first two simulations (higher charges for 16L and 16V and lower charges for the others groups). The results can be seen in Figure 6 and 7.

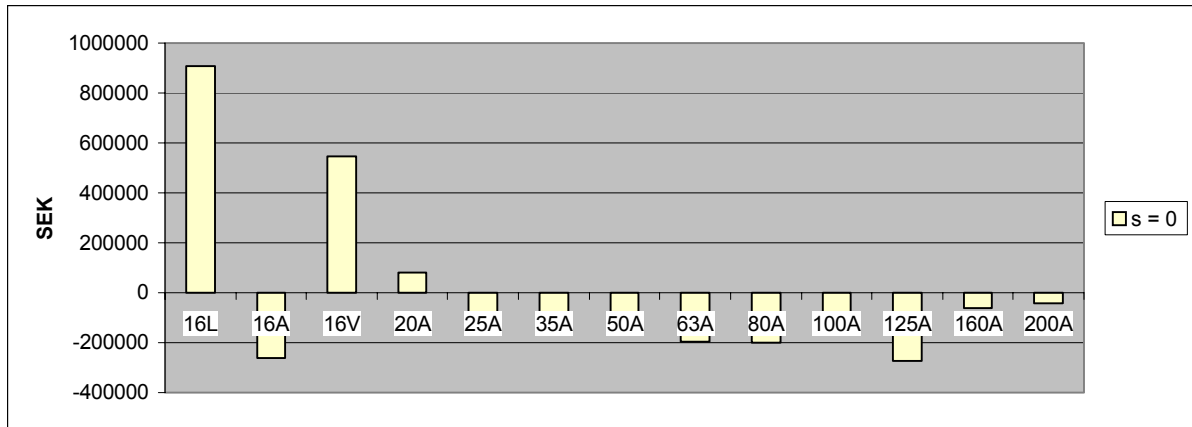


Figure 6 Difference in SENAB's income for each fuse level group (load tariff – existing tariff).

$a = 95$ SEK/kW November-March, $a = 46,6$ SEK/kW April-October, $s = 0$. (1 SEK = 0.11 EUR)

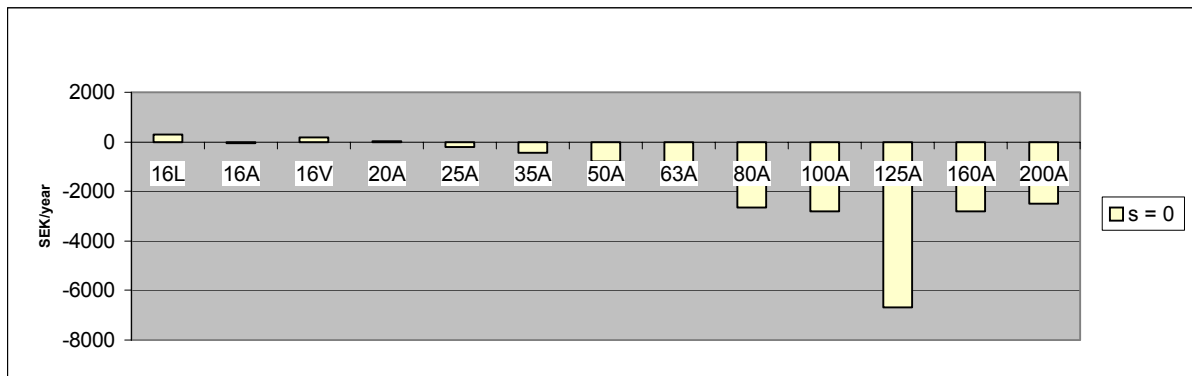


Figure 7 The average cost increase for customers in each fuse group with the new load tariff compared to the existing tariff.

$a = 95$ SEK/kW November-March, $a = 46.6$ SEK/kW April-October, $s = 0$. (1 SEK = 0.11 EUR)

In the fourth and final simulation, the aim was for SENAB's total revenue change, for each fuse level group, to be as close to zero as possible. In this case, s was the component that was adjusted. a was given the value of 70 SEK/kW from November to March and 35 SEK/kW during April-October. Table 1 shows the existing fuse fee and predicted fee for the new load tariff, if the goal was the one mentioned above. Customers with higher fuse levels would in general incur a higher fuse fee compared to customers with low fuse level. This means that with the existing tariff, customers with a higher fuse level pay a relatively high standing charge in relation to their load demand. It is worth noting that 125A customers would get a higher standing charge with the load tariff. This confirms the conclusion that with the existing tariff, higher fuse level customers are subsidising customers with lower fuse levels.

Table 1 Comparison between existing tariff's and load tariff's fuse fee

Fuse level (Ampere)	Existing tariff's fuse fee SEK/year (without VAT)	Load tariff's fuse fee SEK/year (without VAT)	Ratio: load tariff / existing tariff (%)
16L	696	50	7,2 %
16A	1462	606	41,5 %
16V	1800	966	53,7 %
20A	2238	1333	59,6 %
25A	2792	1820	65,2 %
35A	3861	2500	64,8 %
50A	5438	3804	70 %
63A	6758	5162	76,4 %

80A	8568	7415	86,5 %
100A	10700	8567	80,1 %
125A	13344	14570	109,2%
160A	17072	15670	91,8 %
200A	21007	18000	85,7 %

Conclusions and recommendations

Conclusions from this study and recommendations that can be relevant for energy utilities when planning load based pricing, have been gathered under some selected headings:

Existing tariff with load component

The main purpose of including load demand components into the network tariff is to achieve a lower load demand and avoid load peaks. The analysis has shown that:

- Load based tariff adjusts pricing between fuse groups,
- Totally, load based tariff together with remote meter reading is profitable for utilities,
- The difference between “energy” and “power” must be explained in a comprehensive manner,
- To reach tariff’s goals, it is very important that customers understand the structure of load tariff and its aim,
- Customers have to understand that they can save money by changing their energy consumption patterns without the deterioration of comfort or standard of living,
- According to the utility’s own evaluation, it was possible to lower load demand about 5 % thanks to the new load based tariff.

Tariff simulations

The results of this study show that:

- If a load demand component were to be introduced into SENAB’s network tariff, primarily customers with a 16-ampere fuse would incur higher network charges compared to customers with higher fuse levels, who would be charged less.
- With the existing network tariff, based on electricity use, customers with high fuse levels pay today relatively high standing charges in relation to their exploitation of the grid.
- Several households would lower their fuse level (and the costs),
- It is not clear what would the introduction of load based tariff mean for total load demand level within the simulated area.

Some important issues when introducing load based tariff

Electricity pricing should reflect real marginal costs of electricity production and the utilities’ costs. Load based price could achieve higher price elasticity and thus limit the needs for expensive peak load production. Many utilities have already invested in modern Automatic Meter Reading systems (AMR) which facilitate implementation of load based tariffs. Customers are in such a case both an exposed target and a vital potential - in many situations they really want to “help” society, and even “their” utility, to avoid problems and shortages. Therefore, promotion of a new tariff with load based price signal requires a solid and carefully prepared information campaign. It is of great importance for the result that the purpose of such a tariff is clearly introduced to the customers from the very beginning. The difference between “load demand” and “energy use” is not easy to understand and keep after for the majority of customers. They need help to gain a better insight into how their electricity costs will depend on their habits and usage of appliances and installations at home.

Load tariff structure

Load demand tariff should, as any tariff, be simple and easy to understand. The structure and price levels are of decisive importance when trying to influence and change the patterns of energy use. The tariff can always be adjusted afterwards but a comprehensive knowledge about consequences for both customers and utility will help to avoid unnecessary sources of irritation and complaints.

Construction of a new tariff should start with an analysis of load characteristics for a grid company in question - load curves for different customer groups, load factors and superposition factors as well as load aggregation on selected levels in the grid should be investigated.

It is also essential to update the customer register regarding heating system, load guards etc. The new tariff should be tested on some limited groups of customers.

A conceivable solution for a utility, when implementing a new load demand tariff, could also be to offer its customers installation of diverse electronic devices (displays, load guards, soft heating systems) helping them to "keep an eye" on load demand. Together with the new tariff, these investments should be paid back in a relatively short time, helping at the same time to lower load demand in the grid- a win-win solution for both partners.

Customer feed-back

Several investigations and studies have indicated that a continuous feed-back to energy customers is of great significance while different energy related measures and changes are in progress. Possibility to compare the results "before" and "after" or "own" with "others" can intensify and establish more long lasting behavioural changes. Introduction of load demand tariff should therefore be supported by continuous customer focused information. Market segmentation could give a hint how different customer groups should be reached and influenced, depending on their energy related behaviour, lifestyle, information sources and frame of reference.

Extra values

Introduction of load demand tariff needs, or is made possible by, a remote meter system (AMR) with hourly readings. This means that this new tariff should be seen as a part of a development of products and services connected to the AMR system. A number of applications can for example improve customer service and save needs of administration. Extra value-added services related to billing, energy statistics, monitoring, energy guidance, grid optimisation etc, can create new possibilities and values for the company and its customers.

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