DEVEPLOMENT OF POWER-BASED TARIFF STRUCTURE FOR SMALL CUSTOMERS AND PATHWAY FOR THIS CHANGE

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ABSTRACT

This paper discusses the development of alternative power-based tariff structures for small customers and presents a pathway for adapting one new structure. Development of new tariff structures are needed when actively responding to the future changes in the operating environment of the electricity distribution. In this paper, the studied tariff structures were a power-based tariff structure based on a cost-causation principle and a power-based tariff structure with power and time limits. The customer specific relative and absolute changes in the annual electricity distribution fees were analysed and by emphasizing the customer acceptance an acceptable pathway was created.

INTRODUCTION

In Finland, the electricity market is unbundled which means that the electricity retailers collect their revenues with retail tariffs and the Distribution System Operators (DSO) collect their revenues with distribution tariffs. Distribution costs for the small customers have traditionally been gathered with a tariff structure that is composed of a monthly fixed charge and a consumption based energy charge and the emphasis has been on the variable part of the charge (i.e. energy charge). This energy based tariff structure does not reflect the actual cost structure of the DSO because most of the costs result from the network infrastructure, which is rated by customer peak demands.

Future challenges, such as a decreasing amount of energy transferred via the distribution network and the growing simultaneous power demand of the grid, have raised conversation whether the DSOs should tackle the cost matching problem passively by raising the fixed charges of the present tariffs or actively by developing a tariff structure which has some kind of a power demand component. Due to the new act in 2009 set by the Finnish Government almost all customers (in Helsinki 99,98 %) are now provided by a new smart meter that features hourly energy measurements as well as registrations of quality of supply and demand response functionality [1]. Remote readable hourly measurements of smart meters enable e.g. new kind of dynamic tariffs of the energy retailers (e.g. spot-price based prices) and of the DSOs (e.g. hourly power demand based pricing).

The purpose of this paper is to demonstrate how a possible future tariff structures would affect a single customer and to show what kind of steps are needed when developing the structure of pricing. This paper is structured as follows. In the second section, bases of the electricity distribution prices are discussed. After that, the customer group and the surrounding environment is presented. After presenting the customer group, the studied structures are explained and the effects on customers are illustrated. The last section discusses which kind of steps are needed for proceeding from the present pricing practices to new ones.

ELECTRICITY DISTRIBUTION PRICING AND TARIFFS

DSOs have natural monopoly in the electricity distribution in Finland which means that they have no competition in their operation area. This means that there are no natural limiting factors for the DSOs to lower prices or to develop their pricing. Therefore, the electricity distribution business has to be controlled by legislation and regulation. [2]

The distribution pricing has to meet the limitations of Electricity Market Act (EMA) which states that the electricity pricing has to be reasonable and non-discriminative. The Energy Authority controls the reasonability of pricing by controlling the profit gained by DSOs by a certain calculation methodology. The regulation methodology is given beforehand to the DSOs and the reasonability of the pricing is calculated after the four years regulation period is ended. [4] The non-discriminative pricing is secured by following the point tariff principle which means that the customers of the same tariff group within the same DSO's area pay according to the same tariff regardless of the customer's location. [3] In addition to legislative pricing guidelines, there is a general set of principles, such as matching, simplicity and market price principle which can be used to guide the forming of distribution tariffs. Within legislation and these guiding principles DSOs can price their services freely, but the bases of the used practice have to be informed to the regulator (Energy Authority).

Different tariffs are used for various customer groups. The present practice is that there is a one-time tariff (general tariff) for small household customers. The general tariff consists of a fixed monthly base charge and a volumetric

energy charge. For larger household customers there are the time-of-day (TOU) and controlled night–time (CNT) tariffs. Both structures consist of a fixed charge and an energy charge having different price for the day and night time. In addition CNT has a power charge, which is based on the highest measured hourly peak power of the last 12 months. For the largest industrial customers, there are tariffs that consists of a fixed base charge, an energy charge and a power charge. [4]

CUSTOMER STRUCTURE AND OPERATIONAL ENVIRONMENT

Helen Electricity Network Ltd. serves almost 375,000 customers in the capital region of Finland, most of them being small customers in apartment houses and connected to the low-voltage network. In terms of the number of customers, the company is the third largest company in Finland focusing on electricity distribution. In the present pricing practice of Helen Electricity Network Ltd., the general tariff and the time-of-day tariff are the only distribution tariffs left that do not have a charge for power. The general tariff is the most common distribution tariff in Helsinki while the TOU tariff is the second most common tariff structure (Fig. 1). The majority of customers having the general tariff live in district heated apartment houses.

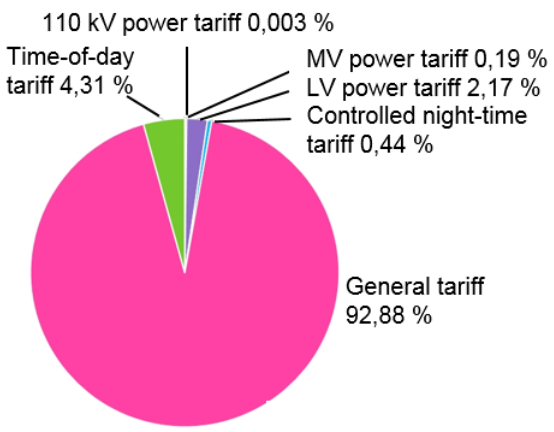

Figure 1: The relative shares of the number of customers in different tariff groups.

When present tariff structures are sorted by the amount of transferred energy, it can be seen from Fig. 2 that the two most common tariff structures (in the number of customers), general tariff and time-of-day tariff, covers only third of the whole amount of transferred energy.

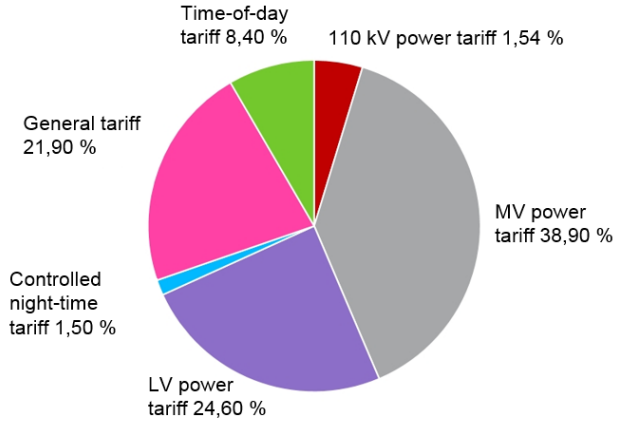

Figure 2: The relative shares of the transferred annual energy of the present tariff groups.

Also when present tariff structures are sorted by the amount of the collected distribution revenue, it can be seen from Fig. 3 that even with the present pricing practice slightly over half of the revenue is collected with structures which include some kind of a power component in it. Therefore, it is natural to study how the percentage of the power based tariff structures could be increased in Helen Electricity Network.

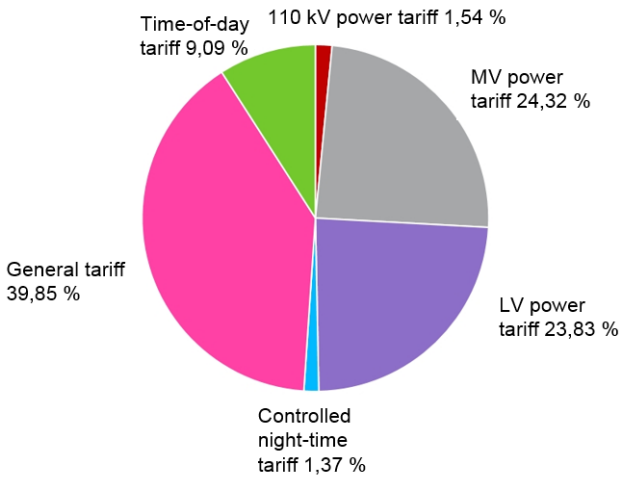

Figure 3: The relative shares of the total revenue of tariff groups collected with present distribution tariffs.

ALTERNATIVE DISTRIBUTION TARIFFS

Power-based tariff structures have been seen as promising alternatives to present energy based tariff structures for small customers. With the proposed new tariff structures, the negative effects of future challenges could be mitigated (e.g. the decreasing amount of energy transferred via distribution network and the growing simultaneous power demand of the grid). [4] The proposed tariffs would also reflect the cost structure of the DSO better than the present tariffs, because most of the costs of the DSO result from the capacity of the grid. [5] Additionally, the separate power charge could offer signals to the customer to avoid

consumption peaks and it would open opportunities for customers to lower their distribution fees when compared to present situation where the capital costs are included in the fixed charges. [6]

Power-based tariff structures and their customer impacts were studied with roughly 23,000 customers (general tariff, time-of-day tariff and controlled night-time tariff) from Helen Electricity Network, most of them being small or mid-sized living in electricity heated detached houses in an urban area. This group was selected assuming that these customers have the best possibilities to affect the level and the timing of their peak demand from the small customers. Different tariff structures were investigated and demonstrated in more detail in [7]. In this paper, the studied tariff structures are

- A power-based tariff structure based on a cost-causation principle
- A power-based tariff structure with power and time limits.

The studied tariff structures were analyzed against the target revenue which was calculated with the present tariffs from the 23,000 customers. The results presented in the following sections are not final distribution tariffs which would be implemented for the customers.

Power-based tariff structure based on cost-causation principle

The cost-causation in this paper means that the customers who cause the costs should pay for them. When using this approach in practice it means that almost 80 % of the total costs were allocated to fixed or power charges. The studied structure was developed in [8] by applying and analyzing areas fed by two substations with the corresponding customer, consumption and network data for 32,000 customers. The idea in this paper is to investigate how the formed tariff structure would suit when directly applied to a differently selected group of customers.

In this structure presented in [8], the tariff is considered to consist of three components: a fixed monthly charge, a volumetric energy charge and a monthly power charge based on the highest measured hourly peak power of the month. The tariff structure is presented in Table I (excluding taxes).

Table I: The tariff structure for the power-based tariff structure based on a cost-causation principle [ISGT]

Fixed charge (€/month)	Power charge (€/kW, month)	Energy Charge (c/kWh)
4.03	2.95	0.53

The revenue collected with the tariff structure presented in Table I is shown in Table II. The idea was to maintain the revenue collected same as collected with the old one so the customer specific changes would remain in the proper level. The revenue collected with the new structure is only somehow higher than the revenue collected with the present tariffs.

Table II: The revenue collected with the alternative structure

Target revenue (€)	10 013 970
Realized revenue (€)	10 064 013

The customer specific relative and absolute changes in the annual electricity distribution fees is presented in Fig. 4 if the tariff structure shown in Table I would have been applied without taking into account that customers might change their consumption profiles. The variation of the distribution fee that the changes for the most of the customers of the general, time-of-day tariff and controlled night-time tariff would fall between the range from -200 to + 600 €. The power charge, which is based on the highest peak hourly power of the month, is the major reason for the higher distribution fees, especially for the controlled night-time users where most of them are large consumers who has high peak power during the night time due to e.g. electrical heating.

On a more general level, the tariff structure would reflect well with the cost-structure of the DSO and the costs could be inflicted to them who are responsible of them. Also the tariff structure would encourage customers to take notice of how they consume electricity and it would signal the customers to lower their peak demand. The tariff structure could be launched quite easily because it is quite similar to the present power tariffs of the larger customers.

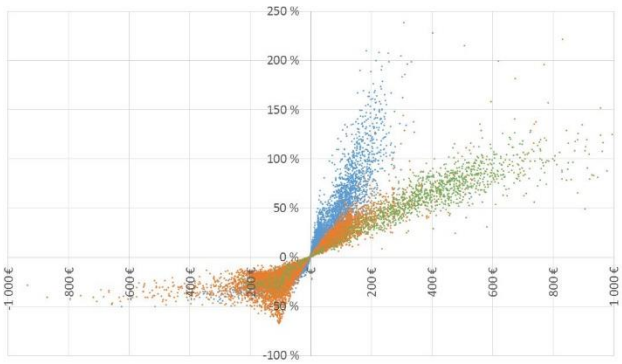

Figure 4: Changes in distribution fees when the tariff from Table I is applied. The dots represent the customers of the general tariff customers (blue), time-of-day tariff (orange) and controlled night-time tariff (green).

Power-based tariff structure with power and time limits

Another studied tariff structure consists of a monthly fixed charge, a volumetric energy consumption charge and a monthly power charge (Table III). A power of 5 kW is assumed to be included in the fixed charge and the power charge is in effect when the 5 kW level is exceeded. Additionally, the power charge during the night-time is

determined to be 38 % of the day-time charge when only the secondary substation and low voltage network costs are taken into account. The idea of this tariff is to encourage customers to transfer some of the load from day-time to night-time and also make pricing more reasonable for the largest customers of the controlled night-time tariff.

Table III: The tariff structure were a power of 5 kW is assumed to be included in the fixed charge and a power charge is determined when the 5 kW limit is exceeded.

Fixed charge (€/month)	Power charge (€/kW, month)	Energy Charge (c/kWh)
18.50	2.28	0.94

The idea was to collect the same revenue that was already collected from the customers with their present structures (Table IV). Therefore the changes in the distribution fees of the customers are basically arisen from dividing the costs in a new way inside the customer group.

Table IV: The revenue collected with the alternative structure.

Target revenue (€)	10 013 970
Realized revenue (€)	10 010 873

The customer specific relative and absolute changes in the yearly electricity distribution fees are shown in Fig. 5 when the tariff structure shown in Table III would have been used (excluding the potential effects of the tariff on consumption behavior). For most of the studied customers the absolute changes are between ± 200 euro in their annual distribution fee. Relative changes for the customers of the general tariff are high because of the considerable raise in the monthly fixed charge when compared to the present tariff structures. Also when compared to the tariff structure presented in Table I (Fig. 4) it can be noticed that the increase in distribution fees for customers of the controlled night-time tariff are more reasonable.

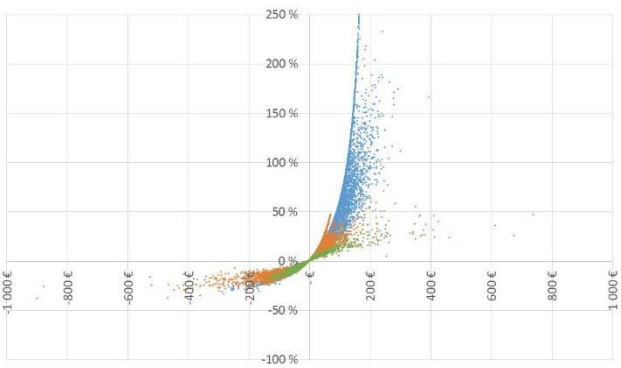

Figure 5: Changes in distribution fees when the tariff from Table II is used. The dots represent the customers of the general tariff customers (blue), time-of-day tariff (orange) and controlled night-time tariff (green)

On more general level, the presented tariff structure would also reflect well the cost-structure of the DSO, especially with the customers who exceed the power verge of 5 kW. The tariff structure would encourage the customers to take notice of how they consume electricity and to invest in different energy solutions, such as energy storages and distributed generation. The tariff structure could be taken into use with the present technology and it might mitigate negative customer reactions.

PATHWAY TOWARDS THE CHANGE

The power-based tariff structure with power and time limits was selected to clarify further what kind of steps are needed when applying a new tariff structure. The pathway was done only for the customers of the time-of-day tariff and the controlled night-time tariff. The reason for this is that these structures have been developed in a way that TOU and CNT tariffs could be combined together in the near future. Another reason for leaving the customers of the general tariff out of the examination was that they should have their own pathway because the present structure differs vastly from the two other present structures that were under examination.

In Finland, it has been proposed to EMA there should be a yearly limit for raising distribution fees. [9] According to the new proposal, the limit for the yearly raise of distribution fees for a customer group could be 15 % including taxes which means that the DSOs could raise fees without taxes approximately 20-25 %. However, the possible new addition to EMA does not take into account the situation where the DSO changes the whole pricing scheme. In addition to the possible limitation of EMA, the Finnish Consumer Disputes Board has lined that yearly customer specific 150 € (including taxes) raise is not immoderate even if the customer specific relative change is over 15 %. The pathway for the development of pricing was done in a way that the both aforementioned limitations were taken into account (Table IV). The pathway consists of six different steps and it was noticed that there are several reasons which might add the number of steps needed (such as the Transmission System Operator (TSO) modifying their pricing and the customers alter their consumption pattern). Basically it would be possible to transition to the new tariff structure by using just one step if only the limiting factor of EMA would have been taken into consideration. The pricing for the selected tariff structure (Table V, step six) has changed slightly because of the customer group was narrowed down to time-of-day and controlled night-time customers.

Table V: The pathway for the change of pricing. Prices do not include taxes.

Step	Change	Fixed charge (€/month)	Energy charge (c/kWh)	Power charge (€/kW)
1.	Merging of the time-of-day and controlled night-time tariffs	14.20	Day 1.90 Night 0.93	0.70
2.	Single energy charge and the power charge during the night-time is determined to be 63 % from the day charge	15.10	1.16	0.91
3.	Including 2 kW to fixed charge and the power charge during the night time is determined to be 38 % from the day charge	16.10	1.12	1.43*
4.	Including 3 kW to fixed charge	17.91	0.98	1.93*
5.	Including 4 kW to fixed charge	18.91	0.98	2.10*
6.	Including 5 kW to fixed charge	19.96	0.96	2.38*

* Power charge is charged when exceeding the power included to fixed charge.

Steps 1 to 3 are the main steps where the most remarkable development steps are applied. In the first step, the idea is to merge the two different tariff groups into one. The most prominent changes arise from presenting the power component to the customers of the time-of-day tariff. Otherwise the tariff structure would be the same as the present one. In the second step, the target is to maintain the image of cheaper night-time energy by giving up the two-time energy charge and launching sort of two-time pricing scheme for the power charge. This could mitigate the negative effects of raising the monthly fixed fee and the image of the cheaper night-time electricity could be stored. Also it would give proper signals for the customers to keep transferring their load from day-time to night-time. In the third significant step, 2 kW of power is included into the fixed charge and the power charge during the night-time is determined to be 38 % of the day charge.

The pathway was done in a way that the aforementioned boundaries were met. Afterwards it might be more reasonable to include 5 kW of power to fixed charge straight in step 3. If 5 kW seems to be too vast it could be narrowed down. Also this kind of approach might help people to adapt the new tariff structure.

CONCLUSION

In this paper, new power based tariff structures of electricity distribution for small customers were discussed and developed. The structure that was chosen for further analysis included a fixed charge, a single energy charge and a time of use power charge including a certain amount of free power. Finally, a pathway was created commissioning this kind of new tariff structure for the notable amount of customers. Further studies will be needed to analyze how, in the new situation, the customers might change their electricity consumption and what potential extra steps might be needed in the pathway of applying new tariff structures.

REFERENCES

[1] Regulation of electricity measurement 66/2009. Ministry of employment and the economy, Finland.

[2] Nordreg, “Economic regulation of electricity grids in Nordic Countries”, Nordic Energy Regulators, 2011.

[3] Electricity Market Act 2013/588. Ministry of employment and the economy, Finland.

[4] Lummi, K., Mäkinen, A., Mutanen, A. & Järventausta, P., “Electricity Distribution Pricing Methodology In Finnish Regulation Framework – A Case Study of Matching Principle”, *The 11th Nordic Electricity Distribution and Management Conference (NORDAC 2014)*, 8-9 September, 2014, Stockholm.

[5] Eurelectric, “Network tariffs for a smart energy system”, A Eurelectric paper, May, 2013.

[6] Lummi, K., Rautiainen, A., Järventausta, P., Heine, P., Lehtinen, J., Hyvärinen, M,, ”Cost-causation based approach in forming power-based distribution network tariff for small customers”, *13th International Conference on the European Energy Market (EEM 2016)*, 6-9 June, 2016, Porto.

[7] Apponen, R., “Deveploment of power-based tariff structure and pathway for this change”, Master’s thesis, 2016.

[8] Lummi, K., Rautiainen, A., Järventausta, P., Heine, P., Lehtinen, J., Apponen, R., Hyvärinen, M., ”Variations of Power Charge Basis of Power-based Distribution Tariff of Small Customers”, *The IEEE PES Innovative Smart Grid Technologies Asia Conference (ISGT Asia 2016)*, 28 November-1 December, 2016, Melbourne.

[9] Draft of government proposal for limiting the raise of electricity and natural gas distribution fees, version 3.6.2016.