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***Abstract*—This paper discusses the development of distribution tariffs of small consumers in Finland. Changes in the electricity sector have created pressures for the Distribution System Operators (DSO) to develop their pricing practices in order to better reflect their cost structures. In this context, power-based distribution tariffs (PBDT) have been seen as a potential direction for development. This paper analyses the EU and Finnish legal framework for distribution tariffs with an aim to identify potential regulatory barriers and incentives for developing PBDTs in Finland. To support this analysis, the paper also provides results of a survey conducted in Finland in 2016 in the EL-TRAN project, reflecting the will of Finnish consumers to improve their ability to affect the distribution fees. The results indicate that the consumers are interested in having this opportunity.**

***Index Terms*—Electricity distribution pricing, Power-based distribution tariff, Energy efficiency, Legislation**

I. INTRODUCTION

The development of the electricity sector during the past years has been fast. More detailed consumption information is available due to smart metering infrastructure. On the European level, most states initiated smart meter rollouts and many have already reached the EU targets. [1] Detailed consumption information enables the development of pricing practices for both the energy retailers and Distribution System Operators (DSO) and opens new business possibilities, such as demand response services in various markets.

Traditionally, DSOs have been passive actors in the electricity market. Distribution network businesses are natural monopolies, so there has been no incentives for the DSOs to develop their pricing. The role of the DSOs has been restricted to providing a neutral market platform on which the competitive market activities can take place. [2] However, the present DSO tariff structures are inflexible and do not adequately respond to the needs imposed by the changing operational environment and the deployment of smart technologies. Power-based distribution tariffs (PBDT) are seen as a potential development direction for the pricing of the DSOs and there is ongoing international research regarding the reform of the small consumer distribution tariffs. [3] [4] [5]

This paper discusses the potential for developing the distribution tariffs for small consumers in Finland. We aim to answer the following four key research questions:

1. What are the key factors motivating the DSOs into developing the tariffs of small consumers?
2. What are the directions to which the tariffs of small consumers could be developed?
3. What is the legislative and regulatory framework for developing distribution tariff structures and in particular, power-based distribution tariffs?
4. Are Finnish households interested in reducing their distribution tariff payments by changing their own consumption habits?

To answer the first research question, we provide a description on some of the key upcoming challenges in the pricing of electricity distribution. Then, we discuss the alternatives of the DSOs in developing different pricing schemes by way of answering the second research question. To address the third research question, we provide a compact review of the EU and Finnish legislation regarding distribution tariffs and aim to recognize potential barriers and incentives for PBDTs for small consumers. Finally, to answer question four, we provide selected results of a larger survey conducted in Finland in 2016 in the ongoing EL-TRAN project, which aims to research what the resource efficient power system means, how it can be implemented, what kind of policy issues will be faced in the implementation and how these issues will ultimately be solved [6]. The results of the survey indicate the will of the consumers towards more flexible distribution tariffs. The primary focus of this paper is on the Finnish electricity market, but its output can be utilized in other electricity markets.

The paper is structured as follows. In the second section, the pricing of electricity distribution is reviewed. The third section analyses the EU and Finnish legal framework for developing electricity distribution pricing. Section four exam-

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ines, the future options for developing electricity distribution pricing. The fifth section discusses the alternative pricing schemes and, in particular, the PBDT. The last two sections provide the discussion and conclusion to the paper.

II. The Pricing of Electricity Distribution

The DSOs fund their operation mainly by the revenue generated with distribution fees (i.e. use of system charges). This section provides background information regarding the pricing of electricity distribution and a compact description of some of the central upcoming challenges faced by the DSOs.

A. Background

The DSOs apply distribution tariffs for their customers in order to collect the needed revenue to recover the costs and to gain a reasonable profit for the capital invested into the network. There are different kinds of tariff options for various customer types, but for the small consumer in Finland, the tariffs consist of two main components: a fixed base charge (€/month) and a volumetric consumption charge (c/kWh). The volumetric consumption charge in some tariff options include a Time-of-Use (TOU) feature, which offers the consumer a chance to use electricity with a cheaper rate during certain hours. The TOU tariffs have been in use in Finland for a long time dating back to time before the electricity market was unbundled and there was need to level the intra-day energy production and consumption.

Regarding the means of how the DSOs fund their operation, the changes cannot be too radical. For example, in Finland, the portion of the distribution tariffs from the electricity bill of a household consumer is roughly one third. The rest of the bill consists of the tariff of the energy retailer (i.e. one third) and related taxes cover the remaining third of the total electricity bill. Simply put, for the consumer, the distribution fee covers only roughly 30-40 % of the electricity bill, which is relatively small and if there are fundamental changes made into the tariff, the whole electricity bill of the customer will not change excessively. For the DSO, the effect of the distribution fee on the revenue is full 100 % and the changes made into the tariffs can have significant financial effects. For this reason, the DSOs have been quite cautious about making fundamental changes in their pricing practices.

B. Challenges and Change Drivers in the Electricity Sector

Although the energy sector is pursuing energy efficiency to fight the climate change, the change is not problem free. For example, from the DSO perspective, the distribution business will face new kinds of challenges to tackle. The costs of the DSO are mainly capacity related (i.e. power (kW)), but the present pricing scheme emphasizes the volumetric consumption charges (i.e. c/kWh). The increasing amount of small-scale distributed generation at the customer site can prove to be problematic since the amount of energy traveling through the electricity network decreases. In order to close the gap between the target and realized revenue, the DSOs would have to raise the price level of the tariffs. This would lead to higher distribution fees for consumers who do not have their own generation, meaning that the remaining costs would have to be recovered from them. Additionally, one interesting issue is that in Finland, the energy tax is gathered together with the distribution tariffs (i.e. the taxes are shown in the price list of the DSO). The energy tax is linked to the energy consumption (i.e. c/kWh) and if the consumption behavior changes (e.g. due to microgeneration), the amount of collected taxes change. However, although the aspect regarding the energy tax is an interesting question requiring research work, it falls outside the scope of this paper and it is not examined further.

The trend in the past years in Finland has been such that the DSOs have started to shift the emphasis from the volumetric consumption charges to the fixed charges of the tariffs [7]. However, if the trend would continue, the distribution tariffs would lose the incentives for the consumers to consider the effect of distribution tariffs on their electricity bills. Roughly put, the DSOs have three different approaches to react to the coming challenges:

1. When deficit in the revenue starts to form, raise the unit prices of the tariff components
2. Shift pressure from the volumetric consumption charges to the fixed charges
3. Develop the pricing through applying new pricing schemes (i.e. novel tariffs)

In the first two approaches, the DSOs apply more of a passive ways to react to the changes. In the third approach, the reaction is active. By developing the pricing, the DSOs could respond to the aforementioned problems regarding the cross-subsidies between different consumers, the appropriate recovery of the costs and the maintaining of incentives in the tariffs not to mention the possibility to improve the cost-reflectivity of the tariffs. Additionally, by developing the pricing, the DSOs could actively respond to the changes in the consumption due to increasing number of large electrical appliances in the future (e.g. electric vehicles and heat pumps).

III. Legal Framework For The Pricing of Electricity Distribution

The traditional objective of regulating electricity networks is to ensure the uninterrupted availability of affordable electricity. This legal framework also controls the parameters based on which DSOs can charge for the distribution of electricity. This section provides an analysis of the national and European legal framework, which affects the pricing of electricity distribution in Finland.

A. EU law

The underlying idea in the EU regulation of electricity networks is to prevent natural monopolies from abusing their market position and causing adverse effects on competition in the electricity market. This objective is pursued through general competition law and sector specific electricity legislation, both of which are relevant for the development of network tariff structures.

The Electricity Directive issued in 2009 establishes common rules for the distribution of electricity. It imposes an obligation on DSOs to ensure the long-term ability of the electricity system to meet reasonable demands and requires that the DSOs develop a secure, reliable and efficient electric-

ity distribution system that takes into account the environment and energy efficiency. The Electricity Directive also places an obligation on the national regulatory authorities to fix or approve national tariffs or their calculation methodologies. In doing so, the national regulatory authorities are to ensure that the tariffs are published prior to their entry into force and applied objectively and without discrimination between system users. The national regulatory authorities should ensure that DSOs are granted appropriate short- and long-term incentives that increase efficiencies, foster market integration and ensure security of supply. The tariffs should also allow the DSOs to make necessary investments in a way that ensures the long-term viability of the networks. [8]

The obligations imposed under the Electricity Directive should be interpreted together with the Energy Efficiency Directive issued in 2012 . The Energy Efficiency Directive obligates member states to ensure that the development of network tariffs provides incentives to implement energy efficiency measures in the context of the continuing deployment of smart grids. These measures, however, should not adversely impact the security of the system. [9]

From the point of view of developing distribution tariffs, the most concrete obligations are imposed through Annex XI to the Energy Efficiency Directive, which establishes the energy efficiency criteria for electricity network tariffs. [9]

First, Annex XI requires that network tariffs are cost-reflective of cost-savings achieved from demand-side measures, including savings from lowering the cost of delivery or of network investment and a more optimal operation of the network. In particular, the Annex states that national tariff structures should not prevent DSOs from shifting the load from peak to off-peak times by final customers. [9]

Secondly, Annex XI allows national tariff structures to support dynamic pricing for final customers. These pricing mechanisms include, but are not limited to, TOU tariffs, critical peak pricing, real time pricing and peak time rebates. [9]

These sector specific legislative instruments aim to provide incentives for the development of more dynamic pricing models and as such, do not place restrictive barriers for the development of PBDTs. However, the need to prevent natural monopolies, including DSOs, from abusing their dominant positions requires that the legal framework in force also ensures reasonable prices of electricity. The requirement for reasonable and affordable prices is one of the cornerstones of regulating European security of supply. It is clearly addressed in Article 3 of the Electricity Directive, according to which all household customers have the right to be supplied with electricity at reasonable, easily and clearly comparable, transparent and non-discriminatory prices. [9]

The incentives to develop dynamic prices on the one hand, and the requirement to maintain reasonable prices on the other, are discussed next in the context of Finnish law.

B. Finnish Law

The general framework for regulating network tariffs in Finland is directly derived from EU law. The EU obligations identified above are primarily implemented through the Electricity Market Act (588/2013), which sets the general principles for pricing network services. According to Sections 18 and 24 of the Electricity Market Act, a network operator is under an obligation to provide its services on equitable and non-discriminatory bases and without undue restrictions on competition. Further, network pricing should overall fulfill the requirement of reasonability while taking into account the reliability and the efficiency of the system. Section 24 a requires that the pricing of network services also consider the overall system performance. [10]

The Finnish Energy Authority oversees compliance with the provisions of the Electricity Market Act. The Energy Authority applies a common methodology for determining the reasonable levels of profits for DSOs. This methodology is revised every four years. The regulator in Finland is thus more interested in the pricing methods as whole rather than observing individual tariff solutions of the DSOs.

IV. FUTURE CHANGE DIRECTION

On the European level, the development direction of the tariffs is towards solutions that are more dynamic than present tariffs. There are different ways to consider what dynamism in the case of tariffs is. For example, regarding the distribution tariffs, the dynamism can be understood at least in two alternative ways:

- The price levels (i.e. unit prices) of the tariff components vary, creating a very strong dynamic effect on distribution fees combined with varying consumption.
- The price levels of the tariff (i.e. unit prices) are static, but the dynamism forms from the changes in the consumption when the consumer responds to the price signals of the tariffs.

From the Finnish electricity market perspective, the latter option would appear as a more attractive solution since the former option would result in a complex situation. For example, if the role of the DSO is to be the neutral participant in the electricity market who provides the needed infrastructure, it is at least questionable whether the DSO should apply as dynamic tariffs as possible (e.g. tariffs with different price for every hour). The price signals of the tariffs of the DSO could be in conflict with those of the energy retailer and they could interfere with the business of the retailer. Additionally, if the tariffs of the DSO would be very dynamic, it is also questionable if they reflect the actual costs of the DSO in a proper way since the costs are strongly linked to the power capacity of the network. These costs are typically quite fixed and dependent more on the power rather than on energy.

To reflect the will of the consumers, a survey (including one reminder round) was carried out in August–October 2016. Selected results of the survey are presented in Figs. 1 and 2. According to the EL-TRAN survey, Finns are interested in reducing their payments for electricity distribution if they had a better option for that than today. More than every fourth (26 %) of the respondents were very interested in this option and nearly seven out of ten (66 %) replied that they are at least fairly interested. Less than 8 % of the respondents were not at all interested. The question posed was as follows: Would you be interested in reducing your house-

hold payments for electricity distribution through your own activities if you had better opportunities for it than today? (Fig. 1.) Excluding gender ($p > 0.05$), the interest in reducing household payments through own activities was statistically dependent ($p < 0.05$) on age, basic education, the ownership type of housing, occupational position, and political affiliation.

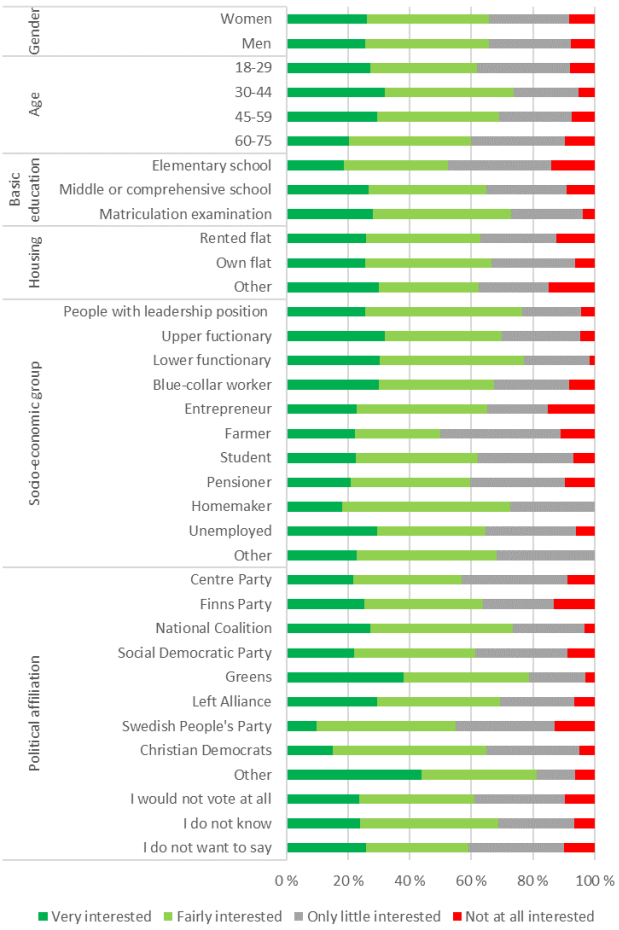

Figure 1. The results of the survey to the question "*Would you be interested in reducing your household payments for electricity distribution due to your own activities if you had better opportunities for it than today?*"

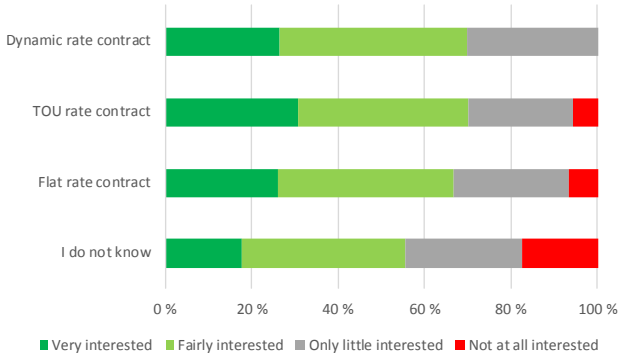

Figure 2. The results of the survey to the question regarding the interest of the consumers, based on their type of contract with the energy retailer, in reducing the payments for electricity distribution through their own activities (number of answers was 1 298).

In terms of age the respondents belonging to the age group from 30 to 44 years-old were most interested in reducing the payments; 74 % of this age group was very or fairly interested. Among the oldest age group, i.e. from 60 to 75 years-old, interest was the lowest (60 %).

Level of basic education was related to the interest. Those with the highest basic education, i.e. matriculation examination, were more interested in reducing their payments than those with the lowest basic education.

Housing was also related to the stand of respondents. Of those living in a flat/house of their own 67 % stated that they were very or fairly interested in reducing payments compared to 63 % of those living in a rented flat.

In terms of occupational position, people with leadership position (77 %) and lower functionaries (77 %) were the most interested in savings in electricity distribution costs whereas only 50 % of farmers replied that they are at least fairly interested. With respect to political affiliation, the supporters of the Greens were most eager in this option as 79 % of them stated that that they are at least fairly interested.

The interest in reducing household payments through own activities was also statistically dependent ($p < 0.000$) on the type of contract a household has with the energy retailer. In the questionnaire, the response options were as follows: (1) contract with a dynamic rate for electricity, which varies hourly, (2) flat rate contract, (3) TOU rate contract (i.e. daytime and nighttime) and (4) I do not know. (Fig. 2) Among the respondents who replied that they do not know what sort of a contract they have, the share of those "not at all interested" was the greatest (18 %). Yet more than half of them (56 %) were also at least fairly interested. The share of those at least fairly interested was also highest among those having a TOU rate contract (70 %) or those with a dynamic rate contract (70 %). The respondents having a dynamic rate contract were all at least only little interested.

The data was gathered on a postal survey (and Internet survey) conducted among a random sample representing 18-75-year old Finns. Even if the rate of response was rather low 33.6 %, the large size of the sample (N = 4 000) ensures that the data well enough represent the Finnish population at large. [11]

In order to achieve the ambitious EU goals for energy efficiency, renewable energy production and energy savings, the structure of the European electricity market has to be further developed. To address this challenge, the Commission proposed an extensive legislative package for energy in late 2016. This Clean Energy for All Europeans package includes proposals that further incentivize the activation of consumers and the demand-side in general. [12]

First, the proposals include provisions that directly address the development of distribution tariffs. Future tariffs should reflect the cost of use of the distribution network by system users, including active customers. The requirement of non-discriminatory tariffs does not prevent differentiating based on consumption or generation profiles of the system users. [12]

Secondly, the proposals establish tasks for DSOs, which member states are to implement in their national legislation. [12] The national legislation should allow and incentivize DSOs to improve efficiencies in the operation and development of the distribution system, including local congestion management. [13]

The proposed legislative package is not yet in force and will be subject to extensive negotiations before it can become binding law. Nevertheless, the proposals indicate the European efforts to engage electricity consumers to become active market participants.

V. Alternative Distribution Tariffs

The future focus in the energy sector is more and more on the energy and resource efficiency. According to the results presented in the previous section, there exists a genuine interest amongst the consumers to have better means to affect the magnitude of the distribution fee. The question here is "how this could be pursued through the network tariff pricing?" As stated before, the DSOs can develop their pricing practices and one form of this development is to apply novel tariff structures.

In the literature, various alternative tariffs have been discussed [3] [4] [5] [14] [15]. For example, certain dynamic tariffs, such as the critical peak pricing, would encourage the consumers to consume less energy during certain hours through price signals. Other similar tariffs have been discussed before and common for these kind of tariffs is that they consist mainly of two components, a fixed base charge and a consumption charge linked to energy consumption. Although the effect of the tariffs could be relatively good on the consumption through demand response, there are some downsides resulting from the volumetric tariff component. For example, the volumetric charge:

- Includes a revenue risk for the DSOs since a large portion of the revenue would be formed by a very variable mechanism (i.e. energy), which is further dependent on e.g. yearly weather conditions (i.e. temperature).
- Does not reflect the cost structure of the DSO that well.
- The consumers who are not able to invest e.g. into their own energy production will have to pay more (i.e. cross-subsidization occurs).
- Includes a possibility to interfere with the operation of other market participants through conflicts of interest (e.g. between the DSO and the energy retailer as discussed in [16]).
- To fill the gap in the revenue, the DSO would most probably raise the unit prices of the tariffs further strengthening the aforementioned viewpoints.

A. Power-based Distribution Tariffs

From the various alternative tariff structures, especially the tariffs that are linked more to the capacity are seen as a potential alternative for present tariffs. [3] [17] [18] PBDTs are a good example of these kind of tariffs. By PBDTs, we mean tariffs, which take into account the power demand of the consumer more detailed way compared to the present distribution tariffs of small consumers. To concretize this concept, we consider an example PBDT structure to consist of the following tariff components [19] [20] [21]:

- A fixed monthly base charge (€/month)
- A volumetric consumption charge (c/kWh)
- A monthly power charge (€/kW, month)

Compared to the present tariffs of small consumer, the PBDTs, and the presented example tariff structure, carry many benefits from different viewpoints. For example, compared to the present tariffs, the proposed PBDT:

- Reflects better the cost structure of the DSO because a large portion of the costs derives from the network capacity (i.e. power).
- Gives the consumers better control over their distribution fees through their own actions (i.e. consumption).
- Levels the cross-subsidies within and between the consumer and the prosumer (i.e. those who consume and produce electricity) groups.
- Encourages the consumer toward both the energy and resource efficient consumption.

Between different PBDTs, there are differences in their properties and effects, but on a general level, applying some kind of a mechanism to include the power aspect in the distribution tariff is seen to improve the situation from the present. The presented example PBDT has been applied in Finland for years for the larger commercial and industrial customers. This specific tariff could be applied quite easily for the smaller consumers and it is at present under active investigation in Finland [5] [19] [20] [21].

VI. Discussion

Based on the results of the survey presented in the fourth section, the consumers seem to be interested in affecting the magnitude of their distribution fees through their own actions. This finding is quite interesting, since the electricity distribution tariffs are not typically the most visible products to the customers compared e.g. to the products of the energy retailers. The initial expectation regarding this question was that there would be more of the answers stating "Not at all interested". However, in the Finnish media, the raising level of fixed charges of the DSO tariffs has been under discussion and the worry is that the consumers would not be able to do anything about their distribution fees if the present trend is to continue. One essential starting point in the development of novel distribution tariffs is that the possibilities for the consumers to affect the magnitude of their distribution fees would be better than today. The PBDT would offer this opportunity through both the energy charge and the power charge. Another interesting item in the results shown in Fig. 2 is that when the consumer already has a retailer tariff, which includes more variation in the price level, the consumer is also more interested in affecting the magnitude of the distribution fee. The questions presented for the consumers provide relevant information about the will of the people. However, when changes are made, it is not completely clear whether the consumers still favor the changes, and accept the outcomes, even when their distribution fees would increase.

Section three provided a review of the EU and Finnish legislative framework. Regarding the use of PBDTs for small consumers, we did not detect factors, which could prevent the tariff reform towards e.g. the suggested example PBDT structure. However, it should be noted that there are also many other PBDT structures, each possessing different properties. For example, there is difference if the tariff is linked to power via the volumetric consumption charge (i.e. instead of having a TOU feature, the price level of the volumetric charge could depend on the hourly power instead of time) than when there is a separate charge for power. Additionally, when tariffs are reformed, individual changes in the distribution fees of the customers cannot be too high. This means that a gradual change of tariff structure would seem like a more suitable approach instead of a change that would happen overnight to soften the customer impacts of the new tariff.

VII. Conclusion

This paper discussed the development of the electricity distribution pricing. From various alternative tariff structures, especially the power-based distribution tariffs are seen as one potential development direction. The paper provided results of a consumer survey conducted in Finland in the EL-TRAN project to reflect the will of the people regarding more flexible distribution tariff structures. Based on the results of a consumer survey and analysis presented in the paper, there is will among the consumers to have better possibilities to affect the distribution fees. Additionally, based on the analysis on EU and Finnish legislation, we did not recognize any barriers, which could prevent the DSOs from applying PBDTs, such as the example PBDT presented in the paper, for small consumers in Finland. Because the examination of the European legal framework in this paper is limited to Finland, it cannot be said how novel tariffs could be implemented in other member states as there exist differences in the national legislation between different member states. However, by taking into account the national legislation, the results of this paper can be utilized also outside Finland.

The example PBDT structure has been applied to larger customers widely in Europe for a long time, but, in the future, this same tariff structure, excluding possible separate charges for reactive power, could be applied also for smaller consumers. However, in order to successfully implement the PBDT for small consumers, more detailed information about the consumption should be available to the customers and the DSOs e.g. through smart metering.

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