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Impacts of DR and DER on DSO tariff structure development

D.Sc. (tech.) Samuli Honkapuro Associate professor LUT School of Energy Systems Lappeenranta University of Technology FINLAND

<u>Samuli.Honkapuro@lut.fi</u>

Total electricity prices for Finnish household customer



Electricity price of household customer (Source Energy Market Authority).

Cost structure in electricity distribution

- The dimensioning of the grid components (lines, transformers, etc.) is based on the <u>peak</u> <u>power</u> → Investments and financing costs are based on the power demand
- Operational costs (operation, maintenance, repair) are based on the size and type of the <u>network</u> → no direct dependency on the energy or power demand
- Losses are mainly based on the amount of the <u>delivered energy</u>
- Metering and billing (included in operational costs) are based on the <u>amount of the</u> <u>customers</u>
- Administration costs (included in operational costs) are mostly based on the size of the company
- Transmission network fees depend on the tariff structure of the TSO, e.g. in Finland, they are energy based. However, the costs of the TSO are mainly <u>power based.</u>

The majority of the DSOs' costs are based on power demand, while incomes at the moment are mostly based on energy demand.



Typical DSO tariffs in Finland

- Typical tariff structure of a Finnish DSO is energy based tariff combined with a fixed fee, which is typically dependent on the size of the main fuse (cents/kWh + €/month)
- The proportion of the fixed and energy based fees vary between the companies and customer types
- The revenue of the DSOs is regulated by the authority, but DSOs may decide their tariff structures freely



Fixed monthly fee [€/month]

DSO tariffs of Finnish distribution companies (90 companies, 138 tariffs) for typical residential customers (main fuse 3*25 A) in year 2012. *Source: Finnish Energy Market Authority*

Typical DSO tariffs in Finland

- In average, the proportion of the fixed fee varies between 25 % to 58 %, depending on the customer type (situation at year 2010)
- The proportion of the fixed fee has increased during the past years



Average proportion of energy based fee and fixed fee for different customer types in Finnish DSOs in year 2010. Source: Finnish Energy Market Authority

Changes in operational environment of the electricity distribution

- Operational environment in the electricity distribution is changing rapidly, due to
 - Increasing energy efficiency and energy savings
 - Smart grids, distributed generation, demand response, energy storages
- Significant influences on the demand of electrical energy and power
 - Impacts on electricity distribution networks and business
- => Needs for renewing DSOs' tariff structures
- AMR meters and Smart Grids provide new technical possibilities for load control and measurements of electricity consumption
- => Possibilities to develop new tariff structures

Changes on electrical energy and power transmitted through electricity distribution network



Impacts of DER for DSO

- Most challenging for a DSO are such actions, which decrease the amount of the delivered energy more than power demand
- In such case, the revenues of the DSO will decrease, while costs remain the same or even increase
- To ensure that incomes will cover the costs, more cost reflective tariff structures must be developed
- AMR meters are currently being installed widely and they provide functionality, which supports the development of the tariff structures

Interactions between stakeholders



Smart grids and interactive customer gateway



Present situation of DR in Finland

- Finland is a leading country in smart meter implementation, penetration level of smart meters is almost 100 %
- Balance settlement is based on measured hourly consumption of end users
- About 1.8 GW of ready-to-control heating loads exist (for comparison; nation level highest peak load 15 GW)
 - Heating loads in many cases controlled based on ToU (Time of Use) tariffs
- Existing market places for flexible resources (day-ahead, intraday, balance power, frequency controlled reserves)

DR market places in Finland

Market place	Type of contract	Min. size	Activation time	How many times activated	Price level 2014 *)
Frequency controlled normal operation reserve	Yearly and hourly markets	0.1 MW	3 min	Constantly	15.8 €/MW,h (yearly market) + price of electricity
Frequency controlled disturbance reserve	Yearly and hourly markets	1 MW	Immediately with frequency 30 s \leq 49,70 Hz or 5 s \leq 49,50 Hz	Quite rarely	4.03 €/MW,h (yearly market)
Frequency controlled disturbance reserve (on- off-model)	Long-term contract	10 MW	Instantly, when f under 49.5 Hz	About once a year	~0.5 €/MW,h + 580 €/MWh + activation fee 580 €/MW
FRR-A	Hourly market	5 MW	Must begin within 30 s of the signal's reception, fully activated in 2 min	Several times a day	Hourly market + energy price
Balancing power market	Hourly market	10 MW	15 min	Several times per day	Market price
Fast disturbance reserve	Long-term contract	10 MW	15 min	About once a year	~0.5 €/MW,h + 580 €/MWh
Elspot **)	Hourly market	0.1 MW	12 h	-	Market price
Elbas **)	Hourly market	0.1 MW	1 h	-	Market price
Strategic reserves ***)	Long-term contract	10 MW	15 min	Rarely	-

*) The prices are suggestive; more detailed terms and pricing principles are in agreements relating to each market place.

**) Nord Pool Spot

***) The Energy Authority

Source: Fingrid

Optimization of the usage of the flexible resources





–Market based demand response aims to shift loads from peak price hours to low price hours (i.e. demand is decreased when there is lack of available generation capacity and vice versa)

–Aim of the network operator is to decrease the peak demand of the network

⇒ In some cases, there may exist conflict of interests in demand response needs between different stakeholders

 \Rightarrow Both network and market impacts of the demand response has to be studied

 \Rightarrow Need for new tariff structures -> power (capacity) based tariff (ϵ /kW,a)

Conflict of interests in demand response



Figure 6.17. Effects of load control in different markets on the highest loads at the feeder level.

Tuunanen, J. *Modelling of changes in electricity end-use and their impacts on electricity distribution*. D.Sc. (tech.) Thesis (in review process)

Conflict of interests in demand response – impacts of market based load control to network loads



Orig = original loads

E = control based on spot prices only

PTx = control based on power based distribution tariff only (different variations of power based tariff) EPTx = control based on both spot price and power based distribution tariff

Source: Rautiainen, A. *"Aspects of Electric Vehicles and Demand Response in Electricity Grids"*. D.Sc. (tech.) thesis. Tampere University of Technology 2015.

Conflict of interests in demand response – impacts of market based load control to peak loads of transformers

Case network area

457 km MV network793 km LV network469 MV/LV transformers7 612 customers



Source: Rautiainen, A. *"Aspects of Electric Vehicles and Demand Response in Electricity Grids"*. D.Sc. (tech.) thesis. Tampere University of Technology 2015.

Power based tariff

- To overcome the problems related to energy based distribution tariff, power based tariff has been suggested
 - Billing is based on the subscribed capacity or metered peak power (kW)
- In the case of the capacity subscription, certain procedure for exceeding the capacity limit (e.g. penalty fee) is needed

Key properties of power based tariff

- Is inline with the general demands of DSO tariff structure
- For DSO, such tariff structure is cost reflective, and ensures predictable revenues
- For customers, incentives to decrease peak power
- In long run, increases capacity utilization rate in distribution network
 => increases efficiency and decreases the costs of the electricity distribution

Impacts of power based pricing on energy efficiency

If distribution tariff does not include energy based component, does that provide customers with incentives for increasing their energy consumption?

- Distribution tariff is only 20-30 % from the total electricity cost of the smallscale customer => energy based costs (sales and taxes) have still major role
 - => no incentives to increase energy usage, although it is not included in distribution fee
- Power based tariff provide incentives to decrease the peak-power demand
 - => encourage to cut of unnecessary electricity usage
 - => possibilities to achieve permanent energy savings
- Incentives for more efficient usage of the distribution network capacity (i.e. increasing the peak time)



Proportion of fixed and energy-based fees for household customers, if DSO tariff is considered as fixed.

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Thank you!

D.Sc. Samuli Honkapuro

LUT Energy Lappeenranta University of Technology Lappeenranta, Finland Samuli.Honkapuro@lut.fi