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Impacts of DR and DER on DSO tariff structure development

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Total electricity prices for Finnish household customer

Electric supply 27%
Electricity sale 10%
Distribution network 27%
Transmission network 2%
Electricity tax 15%
Value added tax 19%

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

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Cost structure in electricity distribution

- The dimensioning of the grid components (lines, transformers, etc.) is based on the peak power → Investments and financing costs are based on the power demand
- Operational costs (operation, maintenance, repair) are based on the size and type of the network → no direct dependency on the energy or power demand
- Losses are mainly based on the amount of the delivered energy
- Metering and billing (included in operational costs) are based on the amount of the customers
- 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 power based.

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

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

Challenges from the perspective of the present distribution tariff structure

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

**TRANSMISSION SYSTEM OPERATOR (TSO)**
- TSO tariff
  - DSO business model
    - DSO’s revenue demand
      - Capital expenses
      - Investment needs
    - Operational expenses
      - Network losses
      - Peak demand
  - DSO’s revenue stream

**DISTRIBUTION SYSTEM OPERATOR (DSO)**
- Monopoly regulation
- Taxes
- Small-scale generation
- DSO tariffs
  - Incentives for customer to optimize energy usage
  - Total demand of energy and power
    - Accuracy of load forecast
  - TSO tariff
    - Retail tariffs
      - Retailer’s business model
        - Retailer’s revenue stream
          - Retailer’s electricity purchase costs
          - Accuracy of load forecast
          - Electricity wholesale price
          - Retailer’s revenue demand
            - Retailer’s business model
              - Retailer’s revenue stream
                - Retailer’s electricity purchase costs

**STATE**
- Capital expenses
- Operational expenses
- Metering and billing
- Total demand of energy and power

**CUSTOMER / PROSUMER**
- DSO’s revenue stream

**RETAILER / AGGREGATOR**
- DSO’s revenue stream

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In Finland, every customer has an AMR-meter and communication channel.
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

<table>
<thead>
<tr>
<th>Market place</th>
<th>Type of contract</th>
<th>Min. size</th>
<th>Activation time</th>
<th>How many times activated</th>
<th>Price level 2014 *)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency controlled normal operation reserve</td>
<td>Yearly and hourly markets</td>
<td>0.1 MW</td>
<td>3 min</td>
<td>Constantly</td>
<td>15.8 €/MW,h (yearly market) + price of electricity</td>
</tr>
<tr>
<td>Frequency controlled disturbance reserve</td>
<td>Yearly and hourly markets</td>
<td>1 MW</td>
<td>Immediately with frequency 30 s ≤ 49.70 Hz or 5 s ≤ 49.50 Hz</td>
<td>Quite rarely</td>
<td>4.03 €/MW,h (yearly market)</td>
</tr>
<tr>
<td>Frequency controlled disturbance reserve (on-off-model)</td>
<td>Long-term contract</td>
<td>10 MW</td>
<td>Instantly, when f under 49.5 Hz</td>
<td>About once a year</td>
<td>~0.5 €/MW,h + 580 €/MWh + activation fee 580 €/MW</td>
</tr>
<tr>
<td>FRR-A</td>
<td>Hourly market</td>
<td>5 MW</td>
<td>Must begin within 30 s of the signal’s reception, fully activated in 2 min</td>
<td>Several times a day</td>
<td>Hourly market + energy price</td>
</tr>
<tr>
<td>Balancing power market</td>
<td>Hourly market</td>
<td>10 MW</td>
<td>15 min</td>
<td>Several times per day</td>
<td>Market price</td>
</tr>
<tr>
<td>Fast disturbance reserve</td>
<td>Long-term contract</td>
<td>10 MW</td>
<td>15 min</td>
<td>About once a year</td>
<td>~0.5 €/MW,h + 580 €/MWh</td>
</tr>
<tr>
<td>Elspot **</td>
<td>Hourly market</td>
<td>0.1 MW</td>
<td>12 h</td>
<td>-</td>
<td>Market price</td>
</tr>
<tr>
<td>Elbas **</td>
<td>Hourly market</td>
<td>0.1 MW</td>
<td>1 h</td>
<td>-</td>
<td>Market price</td>
</tr>
<tr>
<td>Strategic reserves ***</td>
<td>Long-term contract</td>
<td>10 MW</td>
<td>15 min</td>
<td>Rarely</td>
<td>-</td>
</tr>
</tbody>
</table>

*) 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

- Forecasts (loads, generation, storages)
- Measurement & control
- Optimization of DER usage
- Decision of market places, bidding process

Conflicting interests or beneficial co-operation between stakeholders? Local or global optimum?

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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

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

Need for new tariff structures -> power (capacity) based tariff (€/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

Case network area
- 457 km MV network
- 793 km LV network
- 469 MV/LV transformers
- 7,612 customers

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

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

Case network area
457 km MV network
793 km LV network
469 MV/LV transformers
7 612 customers

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 small-scale 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!

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