Heat pumps and other DER technologies in Finland

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Final energy consumption by sector in Finland in year 2009

Industry: 47%
Space heating: 23%
Transport: 17%
Others: 13%

Source: Statistics Finland
Heating energy consumption in Finland by building types and heating methods in year 2009

- Detached houses: 35%
- Semi-detached houses: 6%
- Apartments: 17%
- Summer cottages: 3%
- Commercial and public buildings: 21%
- Industrial buildings: 13%
- Agricultural buildings: 5%

- District heat: 49%
- Light fuel oil: 12%
- Wood: 14%
- Heat pump: 5%
- Electricity: 18%
- Natural gas: 1%
- Heavy fuel oil: 1%

Source: Statistics Finland, Finnish Energy Association
Heating and cooling demand in Finland

Annual average outdoor temperature (between 1981-2000)

More demand for heating than cooling

Source: Ecoheatcool
Impacts of heat pumps in Finland

- Typical SPF (seasonal performance factor) in Finnish climate (source: Finnish heat pump association)
  - Air-to-air heat-pump 1.8…2.2
  - Air-to-water heat pump 1.5…2.0
  - Exhaust-air heat pump 1.5…2.2
  - Ground source heat pumps 2.6…3.6

- Economical saving potential in heating based on the analysis of the AMR data and questionnaire to customers (source: Aalto-university, ENETE-project, 2010)
  - Installing the ground source heat pump in electricity heated detached house resulted in savings of 27 – 47 % in annual heating electricity consumption
  - Air-source heat pump, as supportive heating source, resulted in 8 – 25 % savings in annual heating electricity consumption
  - Based on these analysis, savings in practice seem to be lower than in theory. However, results are influenced by external factors such as use of secondary heating sources, geographical biased location, usage for cooling, etc.

- Due to the climatic conditions, air-source heat pumps can be used only as supportive heating source
### Penetration of heat pumps in Finland – total amount

<table>
<thead>
<tr>
<th>Year</th>
<th>Air source heat pumps *</th>
<th>Ground source heat pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>4 427</td>
<td>17</td>
</tr>
<tr>
<td>1989</td>
<td>5 228</td>
<td>20</td>
</tr>
<tr>
<td>1999</td>
<td>5 725</td>
<td>22</td>
</tr>
<tr>
<td>2000</td>
<td>6 525</td>
<td>26</td>
</tr>
<tr>
<td>2001</td>
<td>7 566</td>
<td>31</td>
</tr>
<tr>
<td>2002</td>
<td>9 696</td>
<td>41</td>
</tr>
<tr>
<td>2003</td>
<td>15 560</td>
<td>67</td>
</tr>
<tr>
<td>2004</td>
<td>24 710</td>
<td>109</td>
</tr>
<tr>
<td>2005</td>
<td>43 170</td>
<td>194</td>
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<tr>
<td>2006</td>
<td>75 272</td>
<td>348</td>
</tr>
<tr>
<td>2007</td>
<td>104 818</td>
<td>489</td>
</tr>
<tr>
<td>2008</td>
<td>156 721</td>
<td>750</td>
</tr>
<tr>
<td>2009</td>
<td>198 235</td>
<td>958</td>
</tr>
</tbody>
</table>

* Air source heat pumps include air/air, air/water and exhaust air heat pumps.
Source: Statistics Finland.
Penetration of heat pumps – annually installed pumps

Source: Finnish heat pump association (Sulpu ry.)
Heat pumps – penetration scenarios

Policies

- Financial support for increasing the energy efficiency of the detached houses
  - Support for instance for following actions:
    - Connecting building to district heating network
    - Building a wood based heating system
    - Installing a heat pump as primary heating source
    - Installing a solar collector
    - Replacing electrical or oil-based heating by renewable energy sources
  - Maximum support 20…25 % of the total costs
- Tax credit for households for paying for the work performed in household’s premises
  - For instance, labor costs of the heat pump installation
System level impacts

- Impacts of heat pumps on energy and power
  - In all cases, the consumption of primary energy decreases
  - When installed in electric heated buildings, heat pumps decrease the consumption of electrical energy
  - In other than electric heated buildings, heat pumps increase the demand of electrical energy
  - On very cold winter days, air-source heat pumps cannot generate heat => peak-load remains the same, or even increases
  - Ground source heat pumps (dimensioned for peak heat) reduce also the peak load
    => Peak heat dimensioned heat pumps best from the energy system’s viewpoint
- If energy consumption decreases but peak load remains the same:
  - Savings in energy costs, but production capacity and grid dimensioning remains the same
  - Peak load production expensive and in many cases inefficient with high emission levels
System level impacts of heat pumps

Electric power of a 150 m² detached house (air and water heating and ventilation)

![Graph showing electric power consumption for different outside temperatures and heat pump types.]

- GSHP = Ground source heat pump (dimensioning 60 or 100 % from the heat demand)
- EAHP = Exhaust air heat pump
- 0.2 l/h and 0.5 l/h = ventilation rate of the building

Heljo, J. & Laine, H. Sähkölämmitys ja lämpöpumput sähkönkäyttäjinä ja päästöjen tuottajina Suomessa (electric heating and heat pumps as electricity consuming devices and sources of emissions in Finland). Tampere University of Technology, 2005 (In Finnish)
Heat pumps in Finland - conclusions

- Heat pumps provide an excellent tool to save heating energy
  - Profitable investment for end user => increasing penetration
  - Major usage in Finland for heating purposes due to the climate

- From electricity network perspective impacts are not only beneficial
  - In not electric heated houses, increases the electric energy usage and the peak load
  - In electric heated houses, decreases the amount of energy distributed in network but may increase the peak load
    - => Increased unit costs for distribution of electricity (snt/kWh)
    - => May add to a demand for increased network capacity

- Possibilities to use for DSM in theory – in practice, installations have not been done so that such a function could be enabled easily
Electric vehicles in Finland – penetration scenarios

<table>
<thead>
<tr>
<th>Year</th>
<th>Proportion of new cars</th>
<th>Cumulative amount of the sold cars</th>
<th>Proportion of annually driven distance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PHEV</td>
<td>EV</td>
<td>PHEV</td>
</tr>
<tr>
<td>Basic scenario</td>
<td>2020</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>50%</td>
<td>20%</td>
</tr>
<tr>
<td>Rapid scenario</td>
<td>2020</td>
<td>40%</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Slow scenario</td>
<td>2020</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>Vision</td>
<td>2020</td>
<td>15%</td>
<td>10%</td>
</tr>
</tbody>
</table>

EV = Electric Vehicle  
PHEV = Plug-in Hybrid Electric Vehicle

Vehicle taxation policies in Finland

- CO₂ based taxation system
  - Purchase tax 12.2 – 48.8 %, depending on the CO₂ emissions (60…360 g/km)
  - Annual tax 20 – 600 €/a, depending on the CO₂ emissions (66…400 g/km)
  - => incentives for low emission vehicles, including plug-in vehicles (technology neutral incentive)

- Annual fuel tax for the vehicles using other fuel than gasoline (or natural or bio gas)
  - Typically 250 – 400 €/year (depending on the weight of the vehicle)
  - Applied also for electric vehicles => decrease the incentives to purchase electric vehicles

- No special incentives for purchasing or using electric vehicles
Real estate networks and electric vehicles in Finland

- **Residential (3x25 A or 3x35 A) and agriculture houses** have good preconditions for EV charging because of the preheating possibilities
  - Need for intelligent load control and load alternation
- **Apartment houses**: Preheating poles in parking areas dimensioned traditionally for instance 1.5 kW/car (VVO 2009)
  - Major challenges in big cities (downtowns)
    - Preheating possibility of cars does not necessarily exist
    - Parking houses may have preheating possibility, but dimensioning of power supply may be insufficient
- **Terraced houses**: Various practices in preheating networks
  - Often parking place for the car with preheating possibility (for instance 1.5 kW/car)

**Challenge**: Lack of information of present situation of real estate networks
Charging mode (uncontrolled, intelligent charging, etc.) has a significant impact on the peak load level

- Load variations of medium-voltage feeders have to be taken into account in charging control

No remarkable reinforcement network investments needed in 2010-2020, (local investments; parking halls, substations for fast recharging?)

Charging of cars will be mostly slow type charging (1 x 16 A) at home, work places and holiday homes

- In the most cases, households are equipped with car pre-heating poles  Upgrading requirements, Smartgrids?
- Investments and renovation are needed in work place, apartment house and public parking areas; typically charging power restricted to ~500 W, 2-hour limited use etc.

Fast charging option to ”gasoline” stations

- Fast charging (~80 kW) in low-voltage network is too much
- Super fast charging (~ 250 kW) will be located in primary substations (for instance 20 cars → several MW)
Capacity and policies of other DER technologies

- **Photovoltaic panels**
  - Total capacity 170 kW on-grid, 7.5 MW off-grid

- **Wind turbines**
  - Statistical information available only about turbines larger than 70 kW:
    - Total capacity 170 MW, 125 turbines, annual production 277 GWh during year 2009 (0.3 % of total production)

- **Policies**
  - Guaranteed prices (feed-in tariffs) for wind power (>500 kVA) and biogas (>100 kVA) came into force in March 2011
    - 83.5 €/MWh for 12 years after commissioning of the plant
    - 105 €/MWh for wind power during first 3 years after commissioning (until 2015)

- **Penetrations scenarios**
  - Due to the feed-in tariffs, it is estimated that by the year 2020 total wind power capacity in Finland will be 2 500 MW (annual energy production 6 TWh)
Smart metering

- Currently a bit over 1 million AMR meters in Finland (rough estimation, total number of customers 2.5 million)
- At least 80 % of the customers have to be measured by AMR meters by the year 2014 (government decree)
  - Hourly energy metering and daily remote reading required
  - Meters have to be able to receive, transmit, and execute load control commands
  - Meters have to register begin and end times of the interruptions longer than three minutes
- If there is both consumption and generation, both of these have to be measured separately => It is not permitted to net the generation and consumption in the customer end
  - Single metering device with separate registers can be used if main fuse is smaller than 3*63 A
  - In case main fuse > 3*63 A, separate devices must be used, and also consumption of own generation have to be measured