Heat pumps and other DER technologies in Finland

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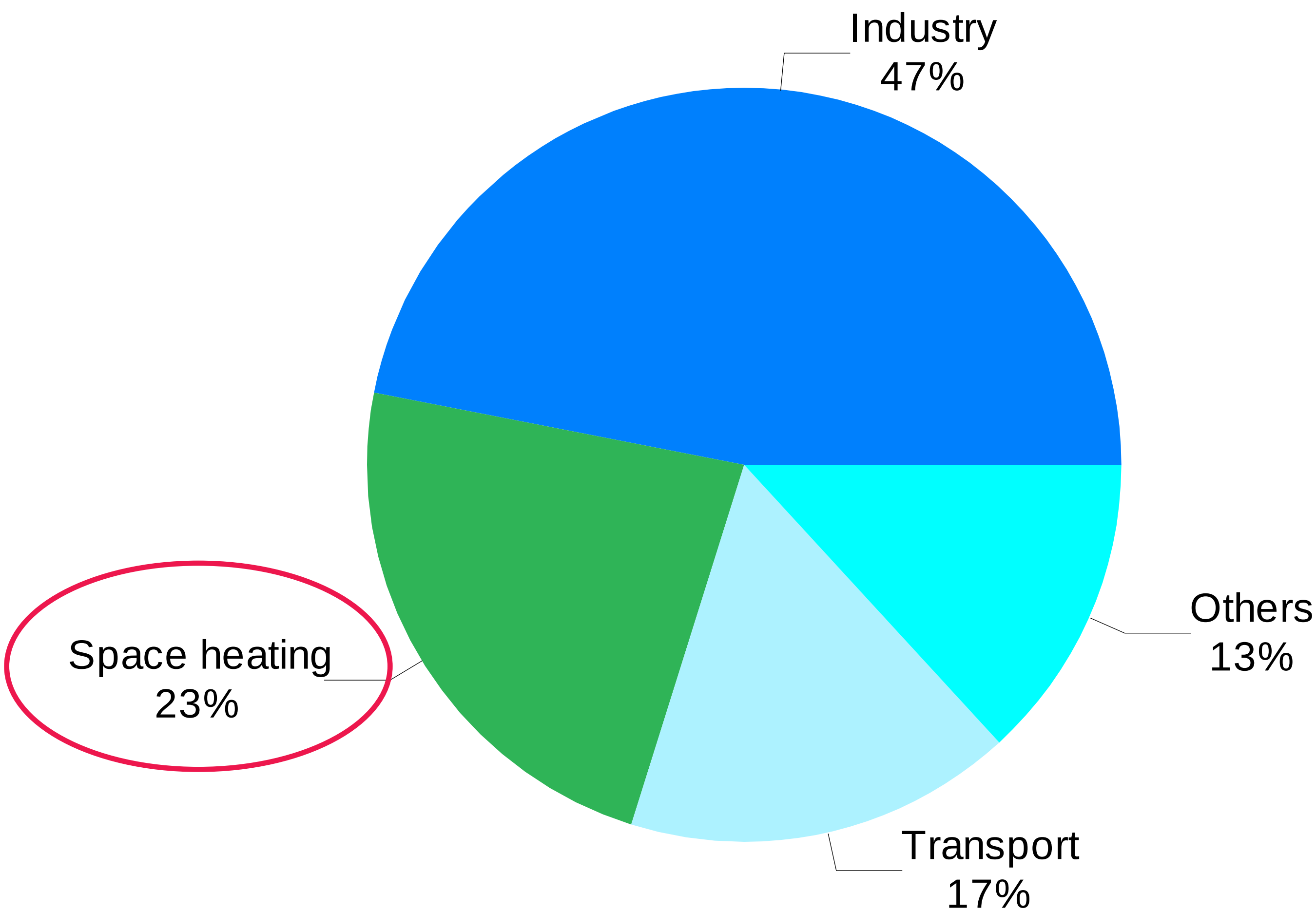
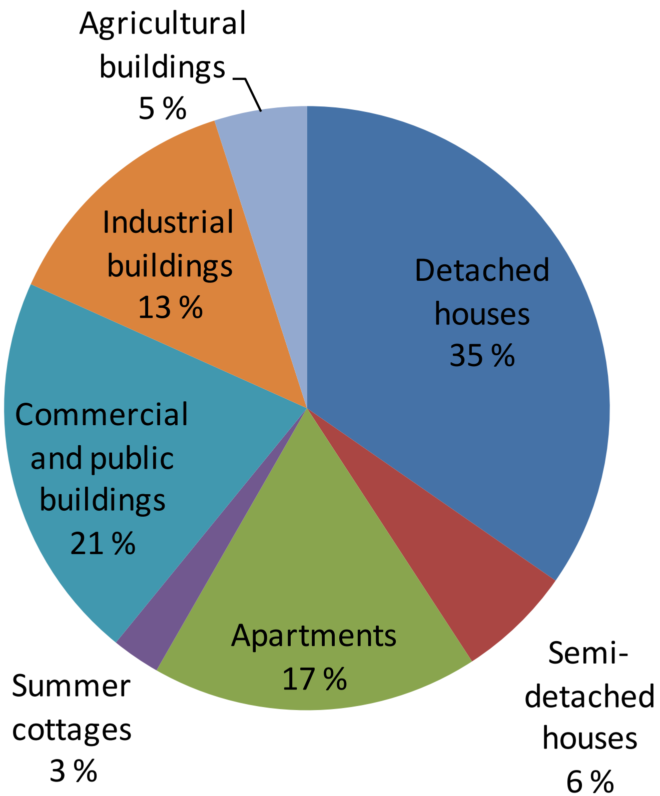
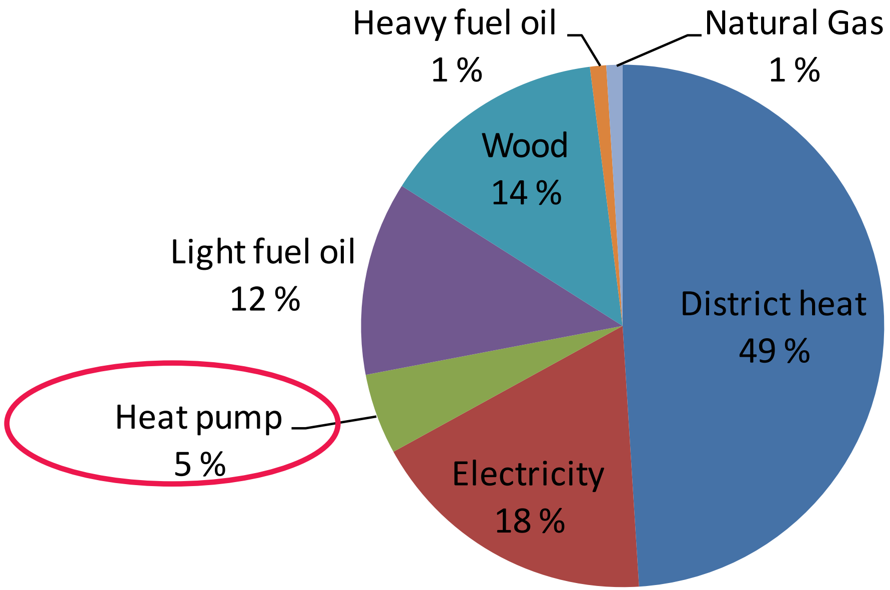
Final energy consumption by sector in Finland in year 2009



Source: Statistics Finland

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

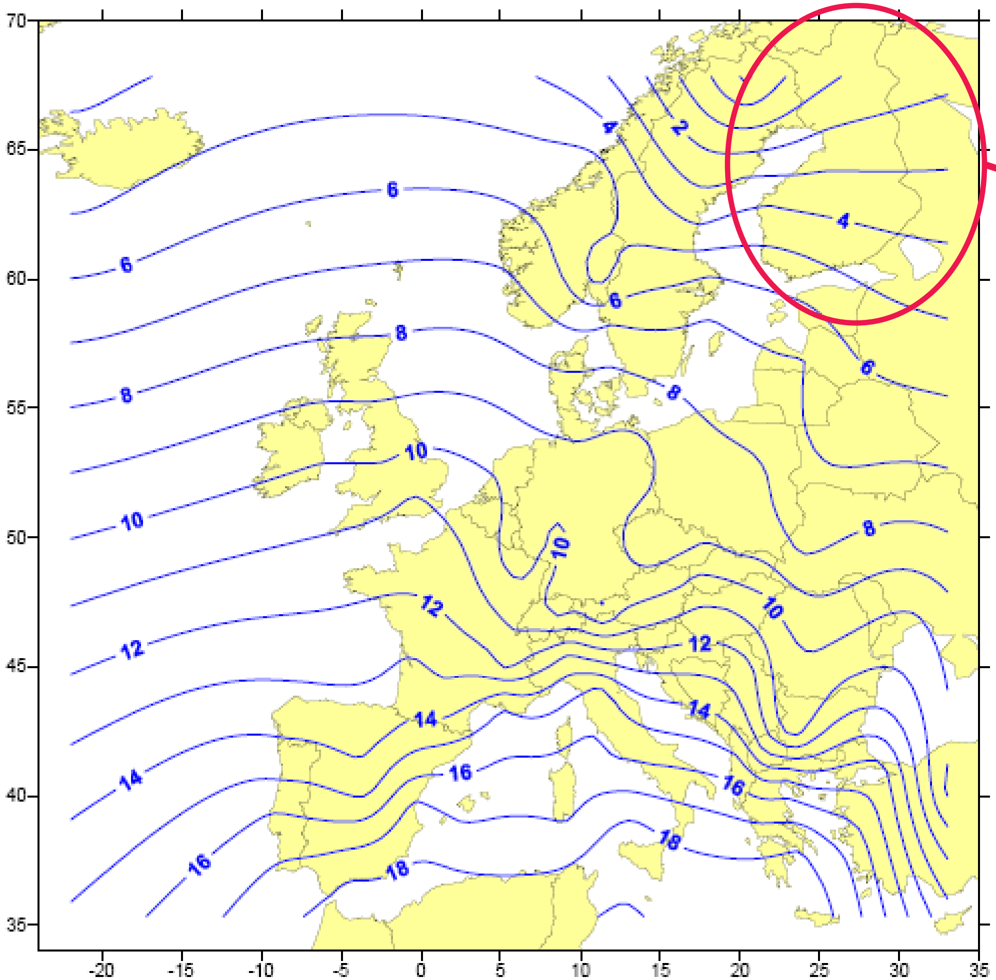




Source: Statistics Finland, Finnish Energy Association

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.**

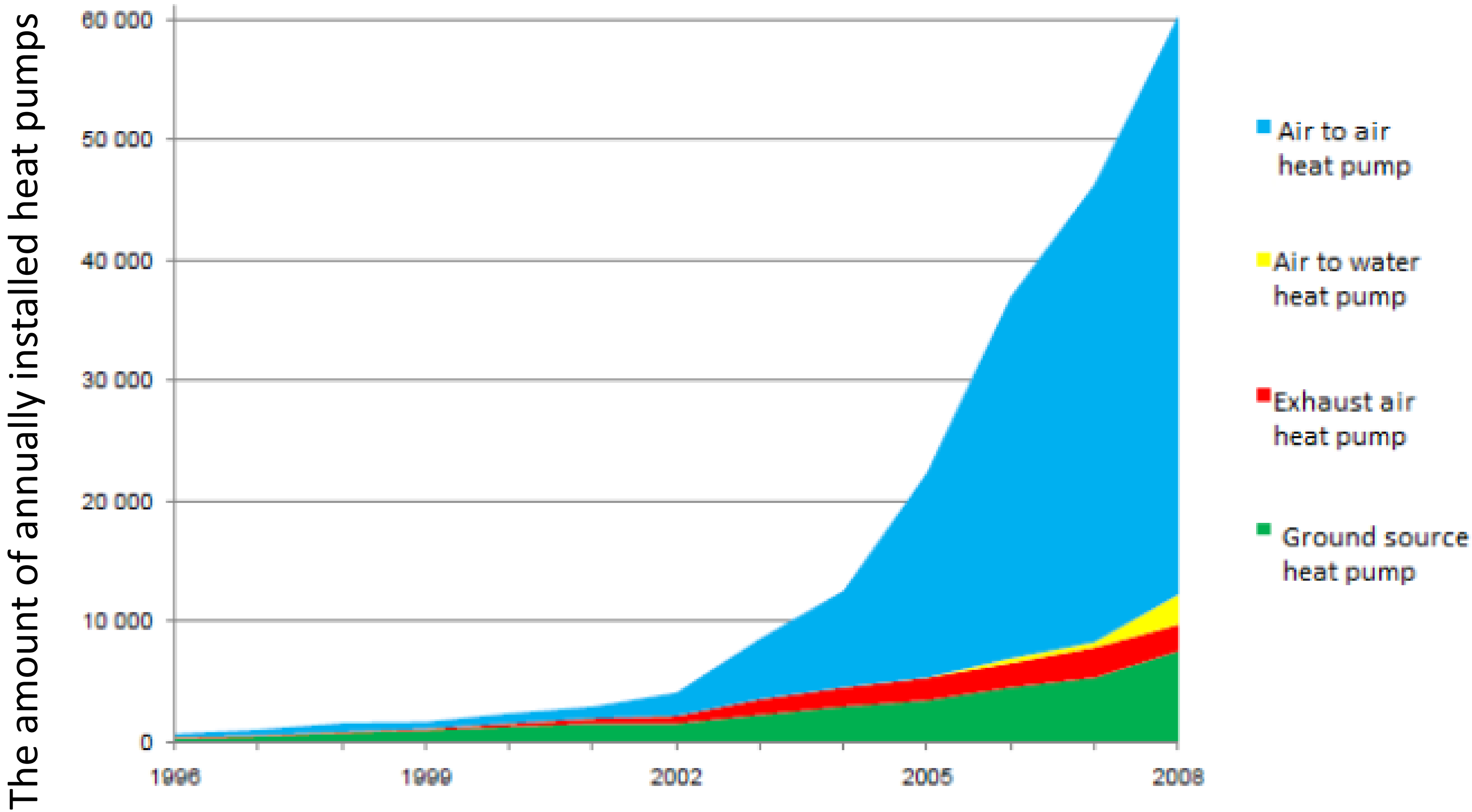
- Due to the climatic conditions, air-source heat pumps can be used only as supportive heating source

Penetration of heat pumps in Finland – total amount

	Air source heat pumps *			**Ground source heat pumps**		
Year	Amount	Heating capacity [MW]	Generated heat [GWh]	Amount	Heating capacity [MW]	Generated heat [GWh]
1997	4 427	17	26	15 592	147	585
1989	5 228	20	30	16 324	153	612
1999	5 725	22	31	17 264	162	621
2000	6 525	26	32	16 835	158	536
2001	7 566	31	41	16 376	154	601
2002	9 696	41	51	15 708	148	584
2003	15 560	67	80	15 696	148	581
2004	24 710	109	124	16 953	159	608
2005	43 170	194	211	20 073	189	691
2006	75 272	348	380	24 551	231	849
2007	104 818	489	535	29 698	279	1 004
2008	156 721	750	851	37 336	351	1 202
2009	198 235	958	1 132	42 996	404	1 532

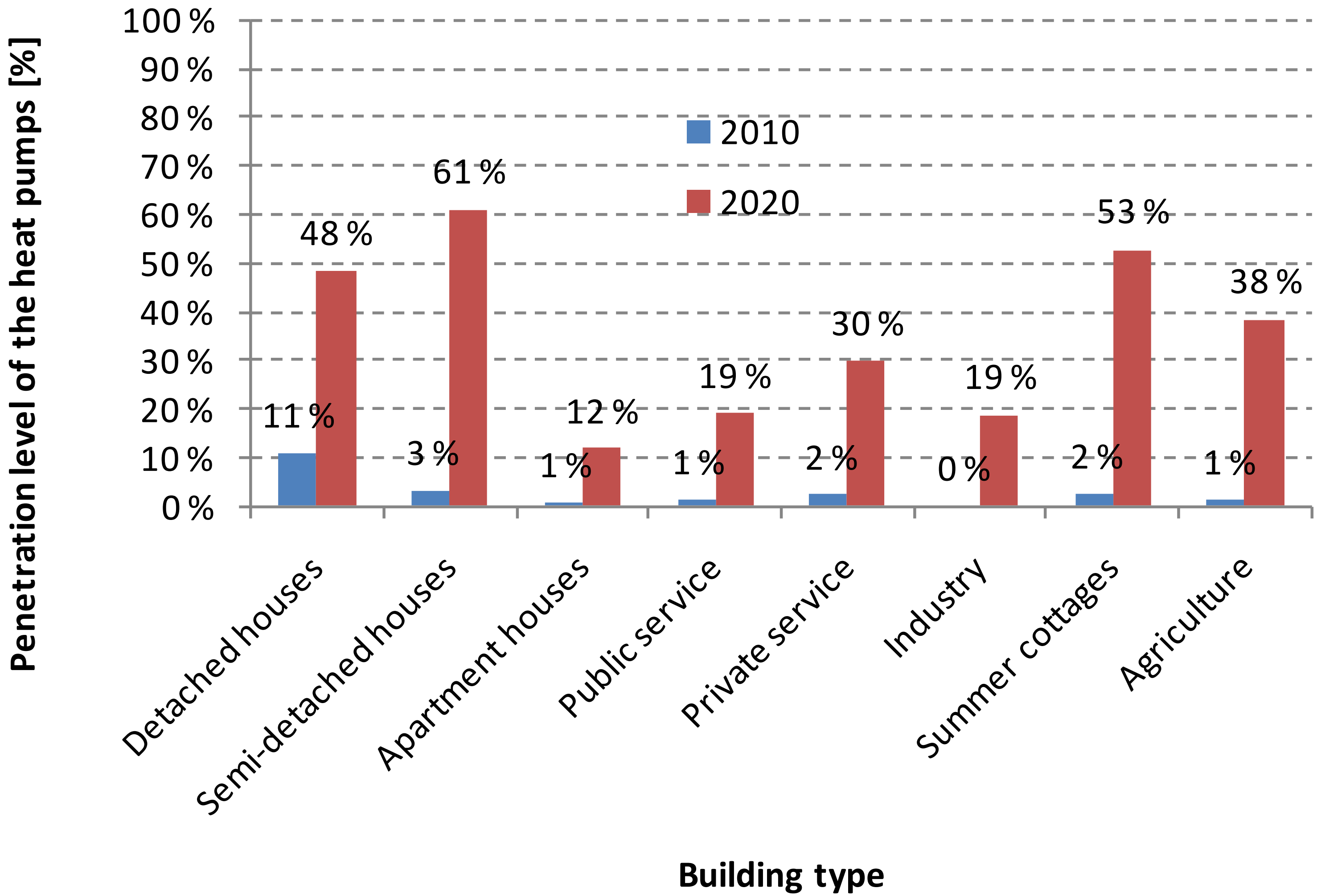
** Air source heat pumps include air/air, air/water and exhaust air heat pumps.*
Source: Statistics Finland.

Penetration of heat pumps – annually installed pumps



Source: Finnish heat pump association (Sulpu ry.)

Heat pumps – penetration scenarios



Tuunanen, Jussi. "Lämpöpumppujen vaikutukset sähköverkkoliiketoiminnan kannalta" (The effects of the heat pumps from the perspective of the electricity network business). Master's thesis. Lappeenranta University of Technology. 2009 (In Finnish)

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

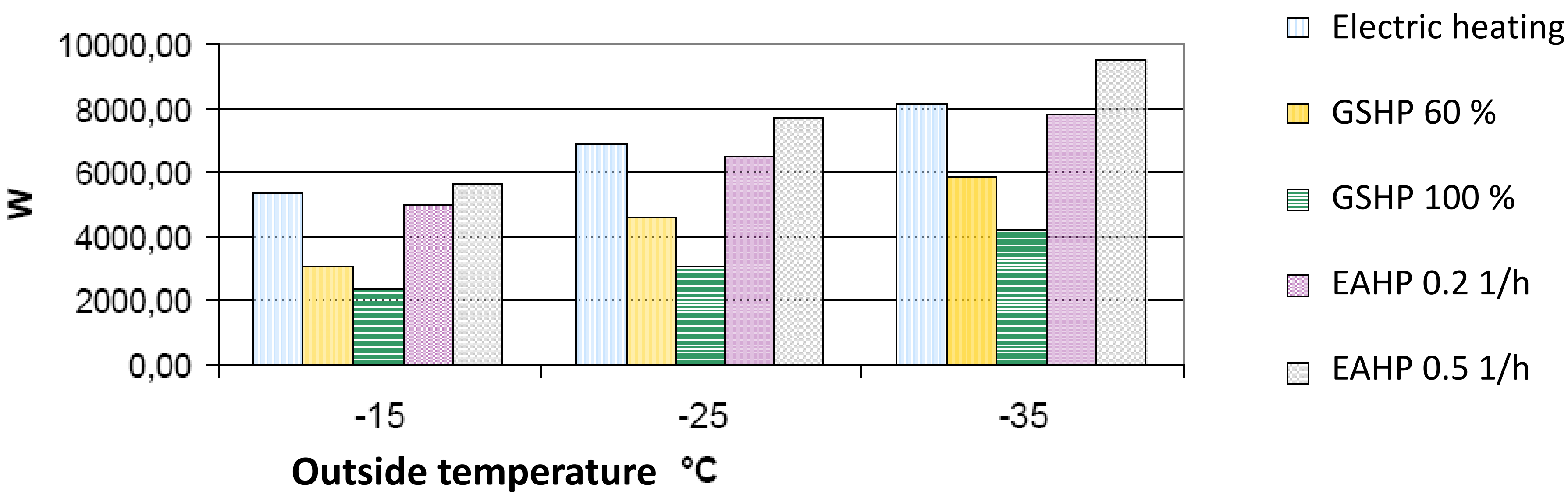
System level impacts

- 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 m^2 detached house (air and water heating and ventilation)



GSHP = Ground source heat pump (dimensioning 60 or 100 % from the heat demand)

EAHP = Exhaust air heat pump

0.2 1/h and 0.5 1/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

	year	Proportion of new cars		Cumulative amount of the sold cars		Proportion of annually driven distance	
		PHEV	EV	PHEV	EV	PHEV	EV
Basic scenario	2020	10 %	3 %	66 000	13 000	3 %	0,6 %
	2030	50 %	20 %	480 000	160 000	19 %	7 %
Rapid scenario	2020	40 %	6 %	190 000	26 000	8 %	1 %
	2030	60 %	40 %	960 000	450 000	38 %	19 %
Slow scenario	2020	5 %	2 %	38 000	12 000	2 %	0,5 %
	2030	20 %	10 %	207 000	92 000	8 %	4 %
Vision	**2020**	**15 %**	**10 %**				

Scenarios of background report (Basic, Rapid and Slow scenarios)

Vision of the working group (Vision)

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

Ministry of Economy and Employment. 2009. Electric vehicles in Finland (TEM 2009. Sähköajoneuvot Suomessa – taustaselvitys. 6.8.2009. Työ- ja elinkeinoministeriö.) [In Finnish]

Vehicle taxation policies in Finland

- CO_2 based taxation system
  - Purchase tax 12.2 – 48.8 %, depending on the CO_2 emissions (60…360 g/km)
  - Annual tax 20 – 600 €/a, depending on the CO_2 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

VVO VUSU 2009, available in Finnish: http://www.vvo.fi/attachements/2009-09-29T15-48-2938.pdf

Electric Vehicle; conclusions on analysis of impacts on Finnish distribution 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