

The background is a solid blue color. It features several faint, light blue geometric shapes, including rectangles and lines, some of which are overlapping. There are also several small, light blue arrows pointing upwards and to the right, scattered across the background. The overall aesthetic is clean and modern, typical of a corporate or technical presentation.

# Electric vehicles and heat pumps -impact on the Nordic power system

NEP Oslo 17.3.2009

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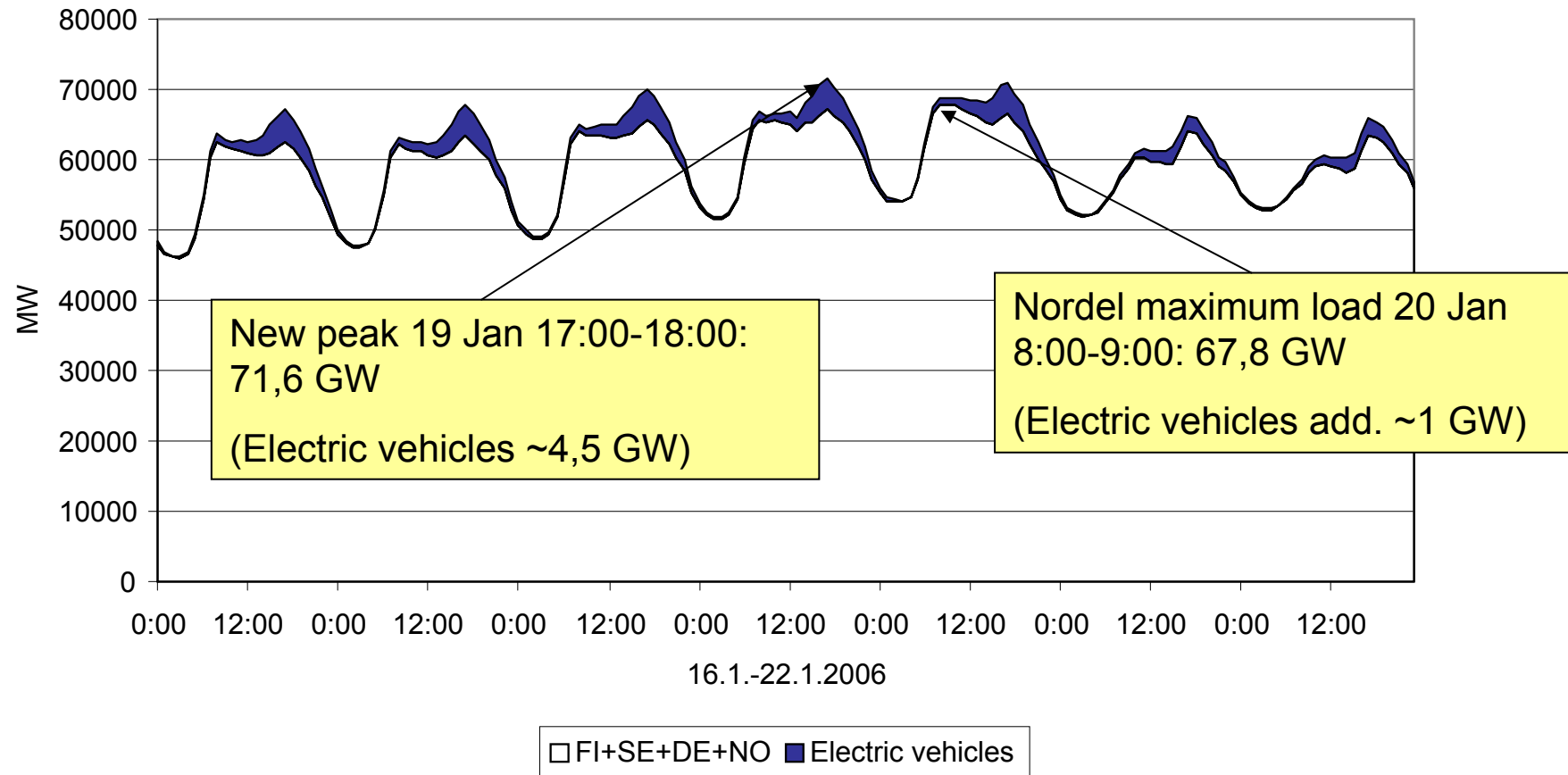


Business from technology

# Content

1. **5 million electric vehicles (EV) in the Nordic countries**
  - "Bad case": uncontrolled charging of EVs
  - "Good case": smart charging of EVs
2. **Oil heating converted to heat pumps (HP)**
3. **Direct electric heating converted to heat pumps**
4. **Combined effects in the Nordic countries 2030**
  - "Bad case": only EVs and conversion of oil heating
  - "Good case": in addition converting direct electric heating to heat pumps
5. **Effects on CO2 emissions**

## CASE: 5 MILLION ELECTRIC VEHICLES IN NORD POOL AREA - Peak load rises by 3,8 GW



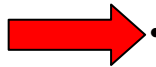
## ELECTRIC PERSONAL VEHICLES - some assumptions and definitions

	Electricity consumption kWh/km	Trip km/a on electricity	Annual consumption MWh/a	Share of electric vehicles
Full electric vehicles				
• FEV 0,25	0,25	17 400	4,34	5 %
• FEV 0,17	0,17	17 500	2,97	15 %
Plug-in hybrid vehicles				
• PHEV 0,25	0,25	14 100	3,53	20 %
• PHEV 0,17	0,17	14 000	2,38	60 %

- **Total annual electricity consumption**
  - 1 million vehicles: 2,8 TWh
  - 5 million vehicles: 14,0 TWh
- No demand/price response in charging
- 20% can charge at work or elsewhere
- Average no of trips per day: 3.0
- Average distance driven before plugged in: 39 km
- Slow charging, max 12A @ 220V
- No heating or airconditioning

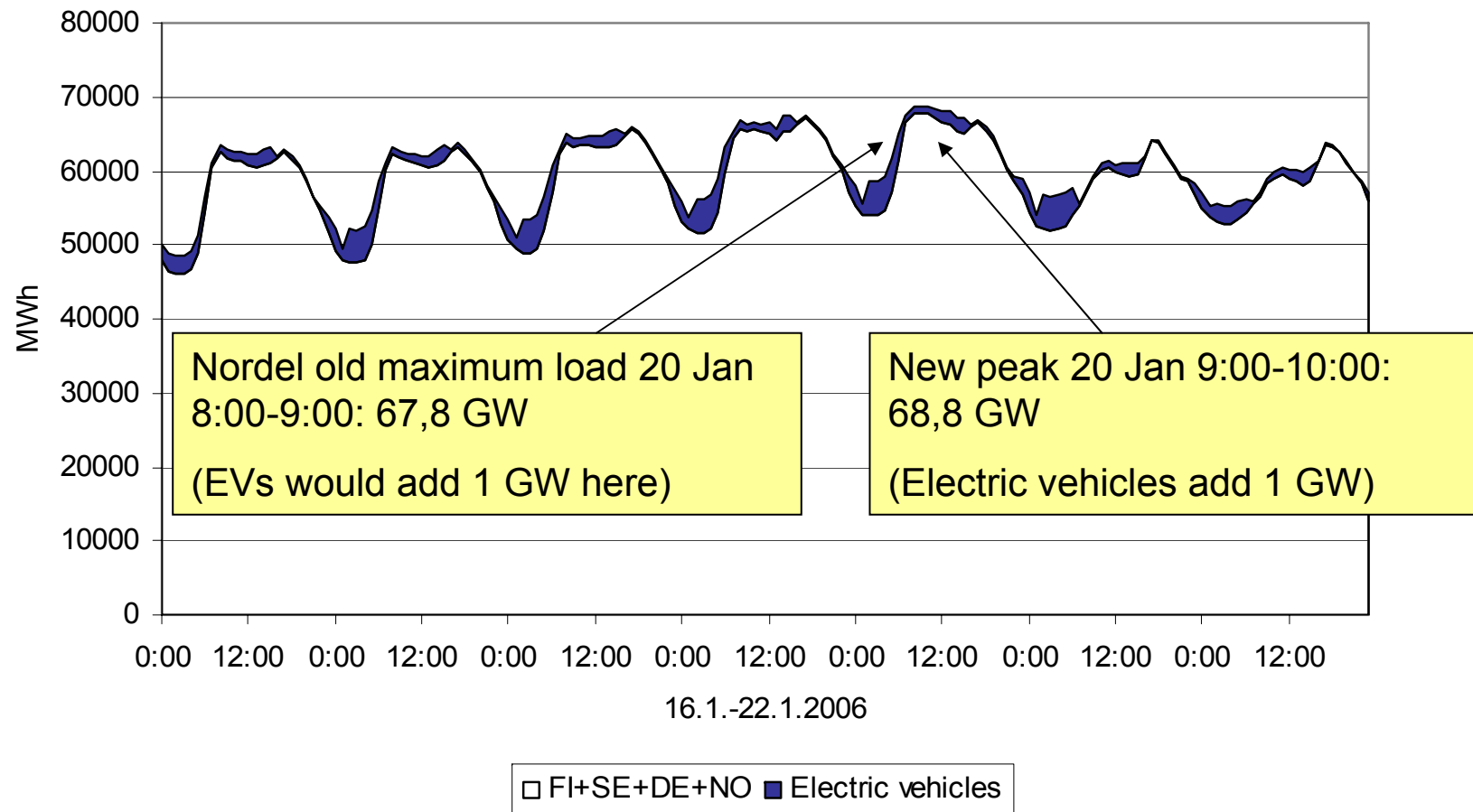
## An example of smart charging of EVs

- Peak load increases without smart charging with 3 800 MW, but base load with almost nothing
  - the system load and the EV charging peaks coincide
  - charging of EVs happens during the day and the evening, but almost never at night
  - Express charging (high voltage and power) will be a possibility, but only marginally used. Not part of our model



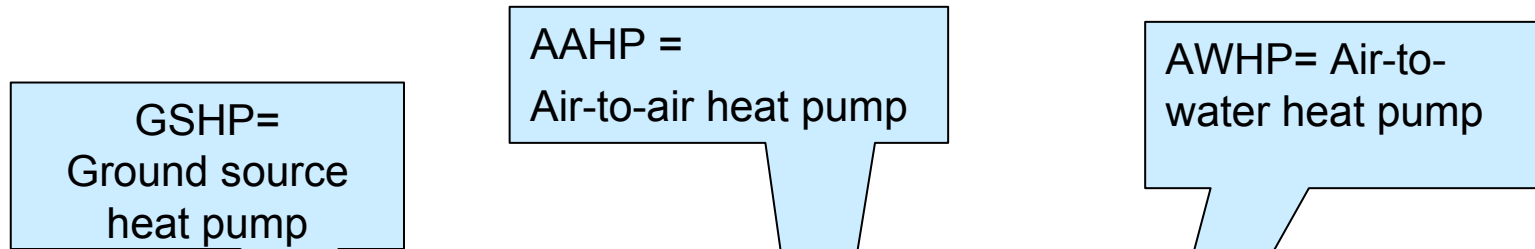
- Solution: smart charging
  - charging at times when it suits the system best, without noticeable discomfort to the user
  - automatic charge response to power system changes and signals, e.g. spot price, balance market price, frequency, direct steering
  - smart charging gives only small financial gains, therefore
    - binding recommendations are needed
    - also preparedness for the possibility to use batteries actively as electricity storage

## CASE: 5 MILLION ELECTRIC VEHICLES IN NORD POOL AREA - Peak load rises with smart charging by only 1 000 MW



# CONVERTING OIL HEATING OR DIRECT ELECTRIC HEATING TO HEAT PUMPS

## Results for a single detached house



Case	Base case 1	Base case 2	Case 1a	Case 1b	Case 1c	Case 2a	Case 2b
Heating type	Oil	Dir. electr.		Oil		Dir. electr.	
Heat pump	-	-	GSHP	AAHP	AWHP	AAHP	GSHP
Electricity (MWh/a)	0,0	33,2	10,7	5,9	16,9	25,4	10,7
Peak (kW)	0,0	14,2	7,3	1,9	12,3	15,1	7,3
Peak hours (h/a)	-	2346	1455	3030	1368	1682	1455

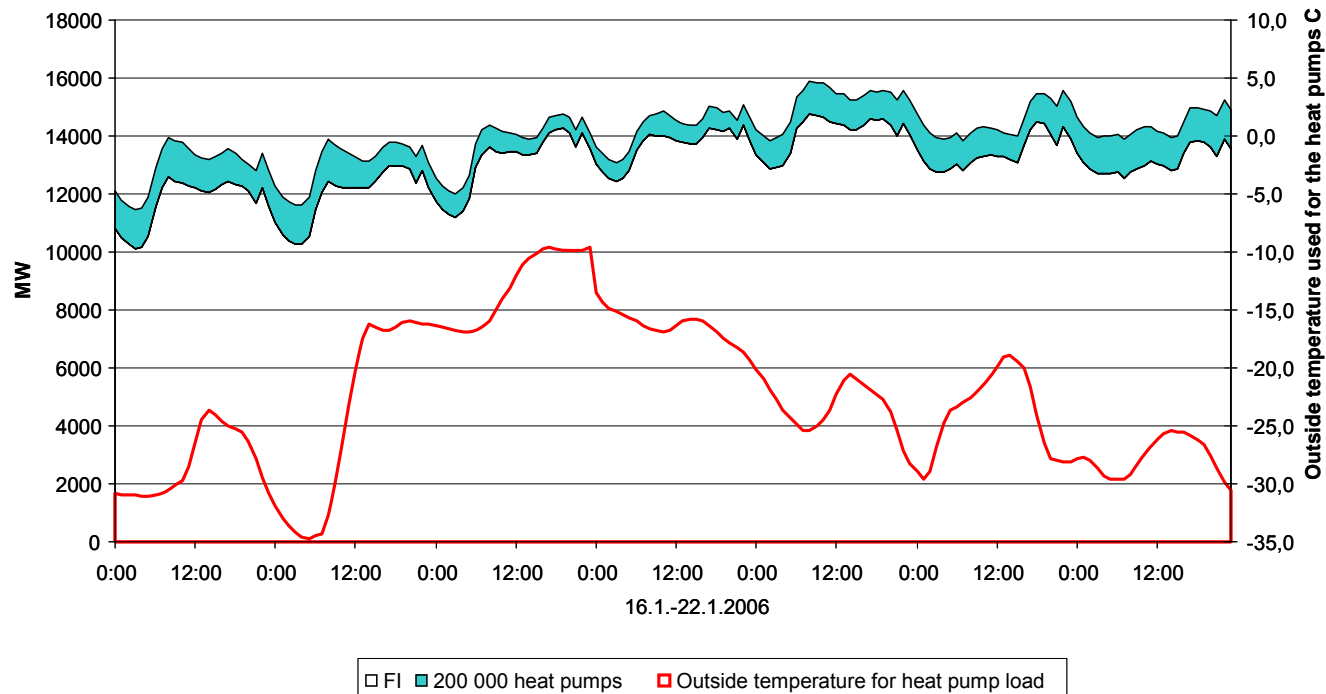
- **Case 1a.** oil heated house will be changed to a ground source heat pump house
- **Case 1b.** oil heated house will install the air-to-air heat pump as an auxiliary heating system parallel to the oil heating system
- **Case 1c.** oil heated house will be changed to a air-to-water heat pump house, the backup heating is direct electricity
- **Case 2a.** direct electric heated house will install the air-to-air heat pump as an auxiliary heating system parallel to the direct electric heating system
- **Case 2b.** direct electric heated house will be changed to a ground source heat pump house
- Reference cases: oil heated or direct electric heated house without heat pumps

## What-if analyses case 1

100 000 **oil heated houses** are changed to ground source heat pumps, and 50 000 are changed to have air-air heat pumps as supplement, and 50 000 are changed to air-water heat pumps

**=> The electricity consumption would increase by 2.2 TWh.**

**=> Peak load increase 1100 MW**

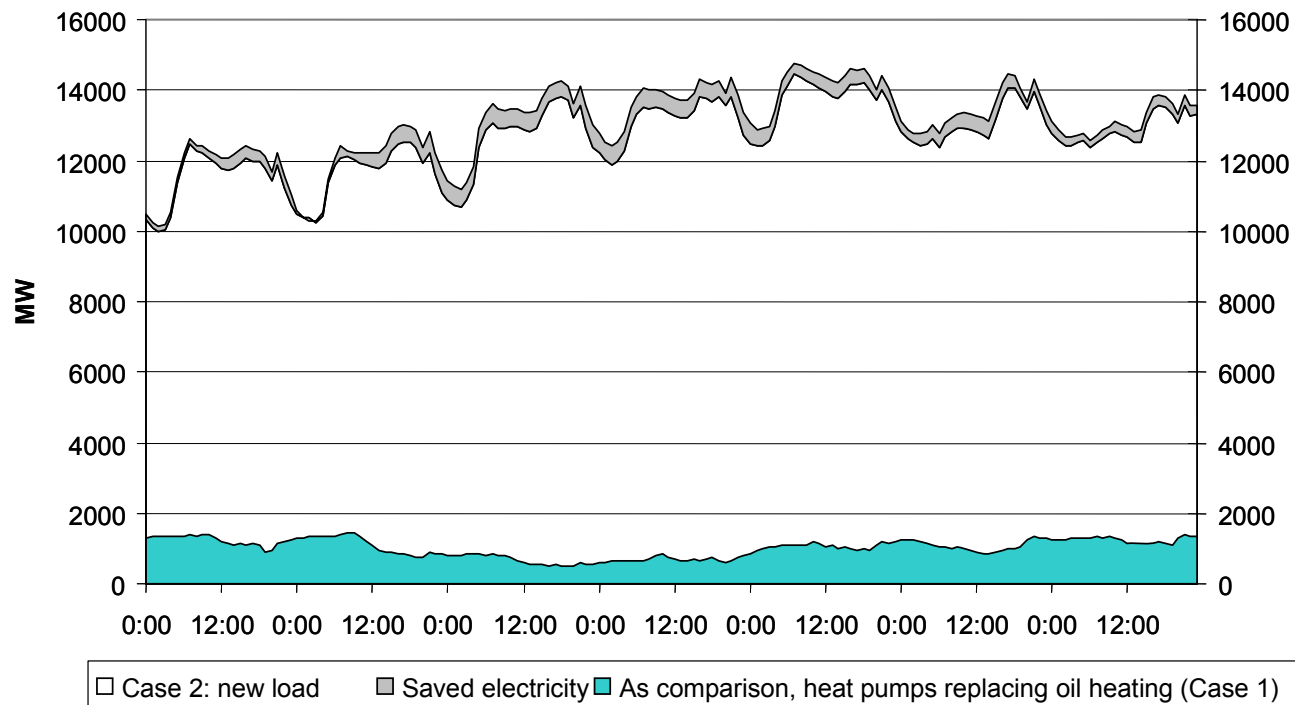


## What-if analyses case 2

50 000 **direct electric heated houses** are changed to ground source heat pumps and 150 000 to have air-air-heat pumps as supplement

=> **This case in turn would bring electricity savings of 2.3 TWh.**

=> **Peak load decrease 400 MW**



### Case 1 and 2 combined

- *net decrease of 0.1 TWh*
- *peak load increase with 700 MW*

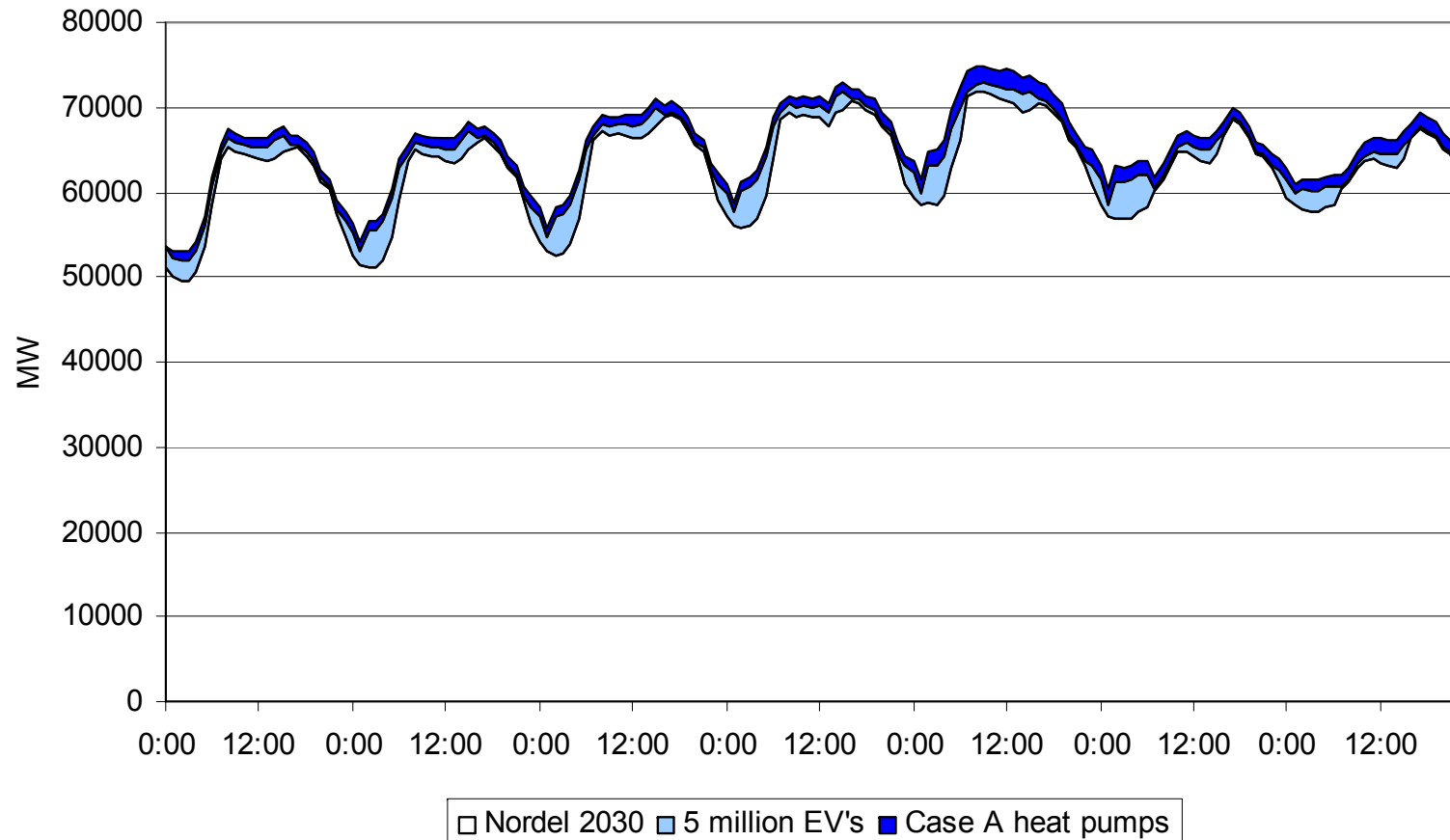
## CASE NORDIC COUNTRIES 2030

	Estimated energy (TWh)	Estimated change in peak load* in -10 °C (MW)	Estimated change in peak load* in -25 °C (MW)
Aggregate scenario for 2020	435.3		
Aggregate scenario for 2030	453.8		
<b>Case A:</b>			
5 million electric vehicles	14.0	970	970
Case A heat pumps total	4.4	1200	3300
- 200 000 ground-source heat pumps	2.2		
- 100 000 air-source heat pumps	0.6		
- 100 000 air-water heat pumps	1.6		
<b>Case A total for 2030</b>	<b>472.2</b>	<b>2170</b>	<b>4270</b>
<b>Case B:</b>			
5 million electric vehicles	14.0	970	970
Case A heat pumps	4.4	1200	3300
Additional heat pumps for case B	-6.9	-1300	-990
- 150 000 ground-source heat pumps	-3.3		
- 450 000 air-source heat pumps	-3.6		
<b>Case B total for 2030</b>	<b>465.3</b>	<b>870</b>	<b>3280</b>

- **Nordic case A:** Nordic demand 2030 including
  - 5 million smart charge EVs
  - 400 000 heat pumps to replace basically oil heating (double the amount of case 1 for Finland)
- **Nordic case B:** Nordic demand 2030 including
  - all in Nordic case A
  - in addition 600 000 heat pumps to electric heated houses (triple the amount of case 2 for Finland).
- Outside temps:  
-10°C ja -25°C

## Case A "bad" scenario (outdoor temperature -10 °C)

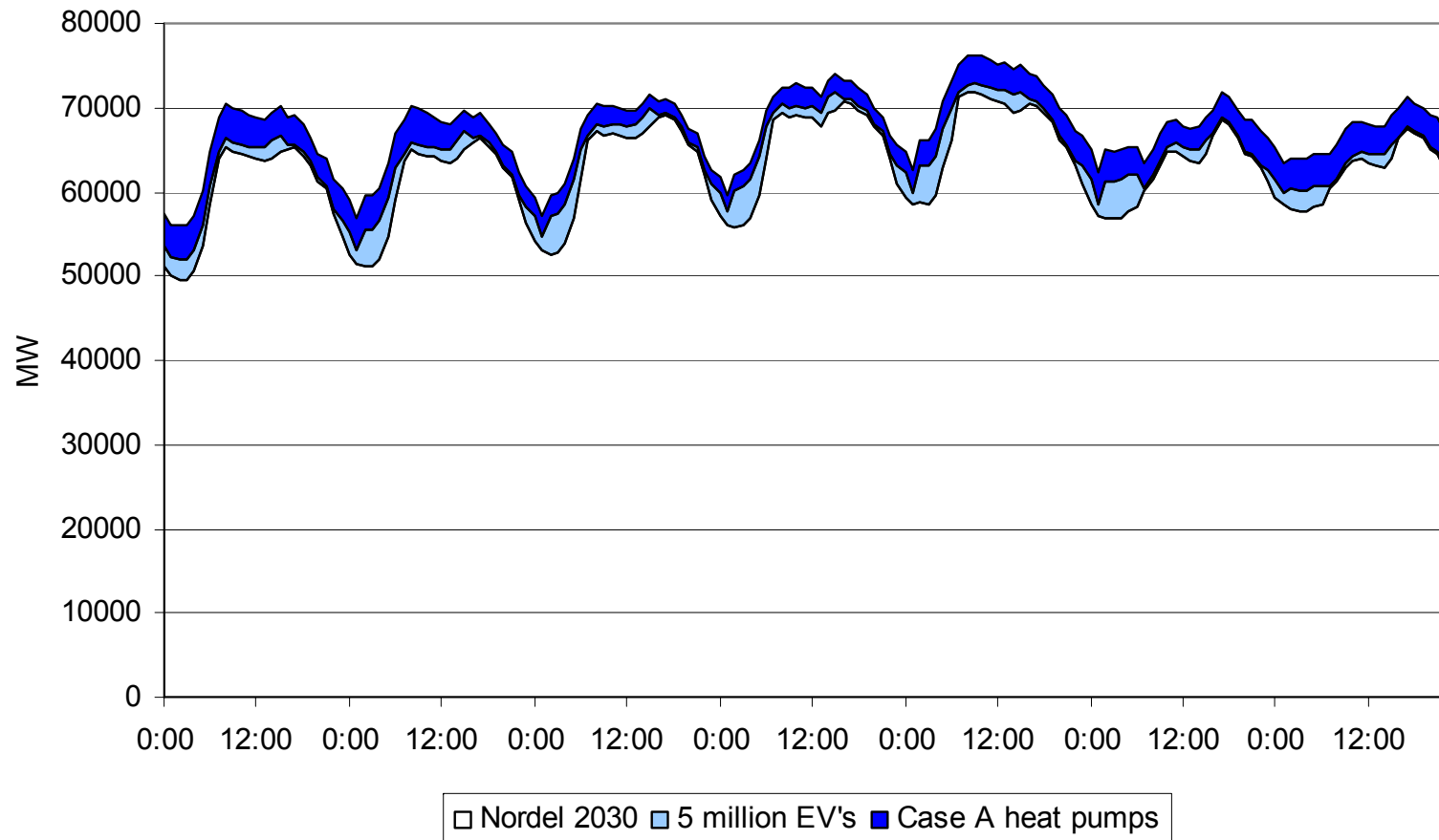
Third week of January, outdoor temperature -10 °C



## Case A "worst, but very unlikely" scenario (outdoor temperature -25 °C)

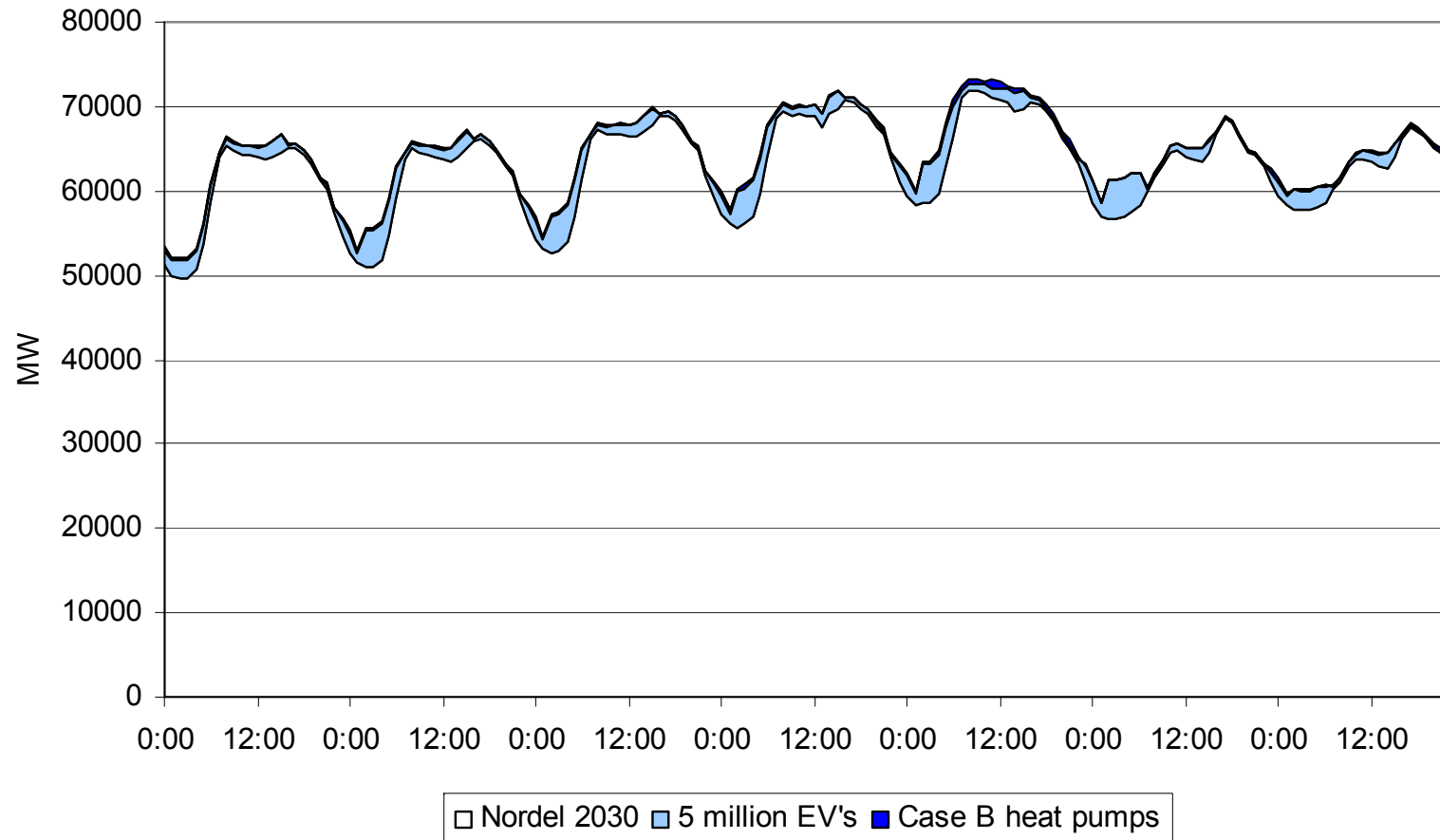
Highly unlikely to have a Nordic simultaneous outdoor temperature of -25 °C

Third week of January, outdoor temperature -25 °C



## Case B "most likely max" scenario (outdoor temperature -10 °C)

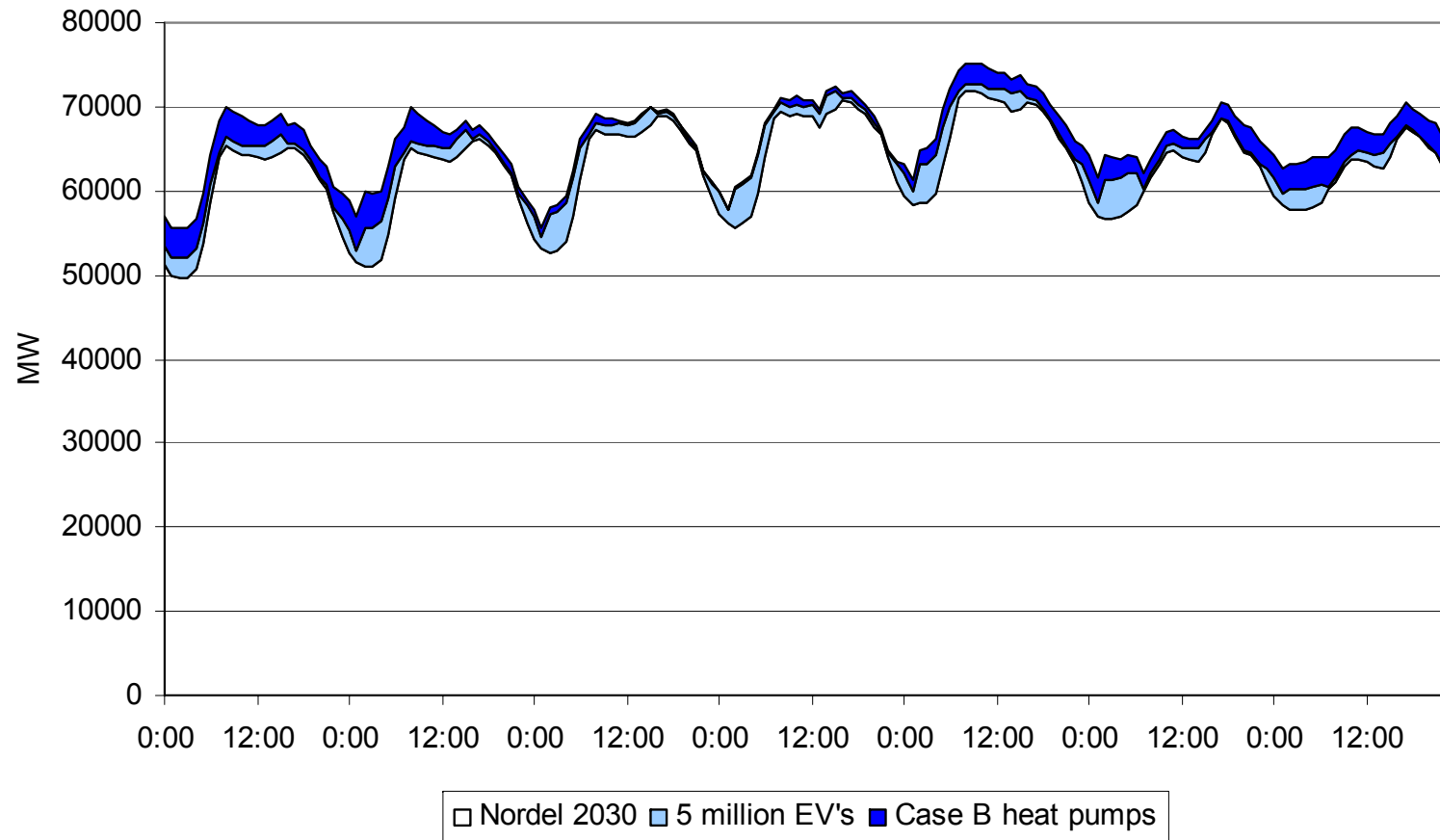
Third week of January, outdoor temperature -10 °C



## Case B "quite bad but unlikely" scenario (outdoor temperature -25 °C)

Highly unlikely to have a Nordic simultaneous outdoor temperature of -25 °C

Third week of January, outdoor temperature -25 °C



## CO<sub>2</sub> EMISSION REDUCTION

- **5 million EVS:** if we assume CO<sub>2</sub> emissions of 170 g/km for cars and
  - if we assume 670 kgCO<sub>2</sub>/MWh for electricity,  
=> a reduction of 3.2 MtCO<sub>2</sub>
  - if we assume 376 kgCO<sub>2</sub>/MWh for electricity (new CCGT),  
=> a reduction of 7.2 MtCO<sub>2</sub>
- **400 000 oil heated houses** (or a heating corresponding to a consumption of 1 520 million litres) :
  - if we assume 670 kgCO<sub>2</sub>/MWh for electricity,  
=> a reduction of 0.4 MtCO<sub>2</sub>
  - if we assume 376 kgCO<sub>2</sub>/MWh for electricity (new CCGT),  
=> a reduction of 1.7 MtCO<sub>2</sub>
- **600 000 electric heated houses** (or a heating base roughly corresponding to a consumption of 20 TWh) :
  - if we assume 670 kgCO<sub>2</sub>/MWh for electricity,  
=> a reduction of 4.6 MtCO<sub>2</sub>
  - if we assume 376 kgCO<sub>2</sub>/MWh for electricity (new CCGT),  
=> a reduction of 2.6 MtCO<sub>2</sub>



# VTT creates business from technology

