The role of heat pumps in smart cities
or
The role of heat pumps in the future Nordic energy system

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The Nordic Energy System

Nordic electricity - week by week

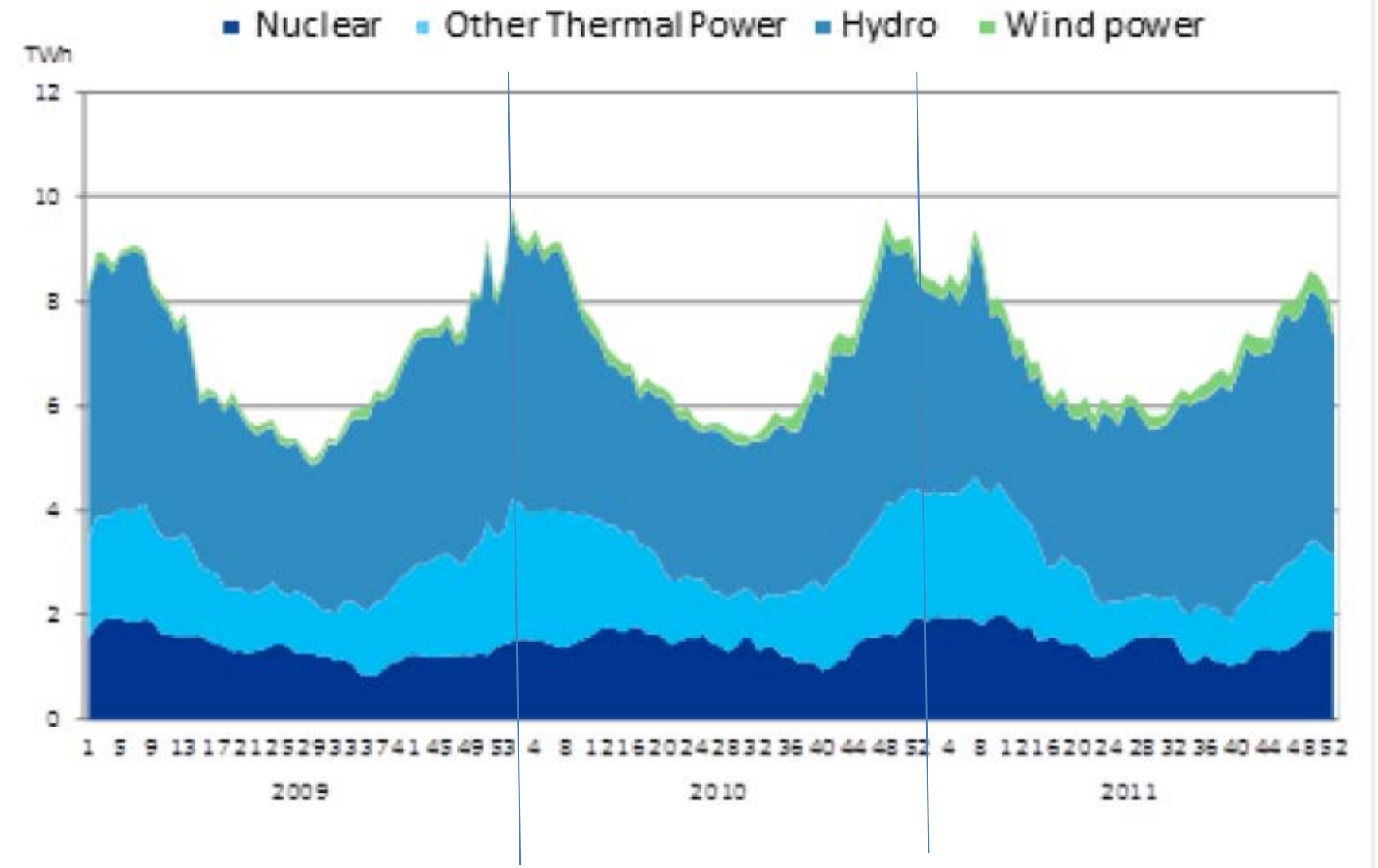
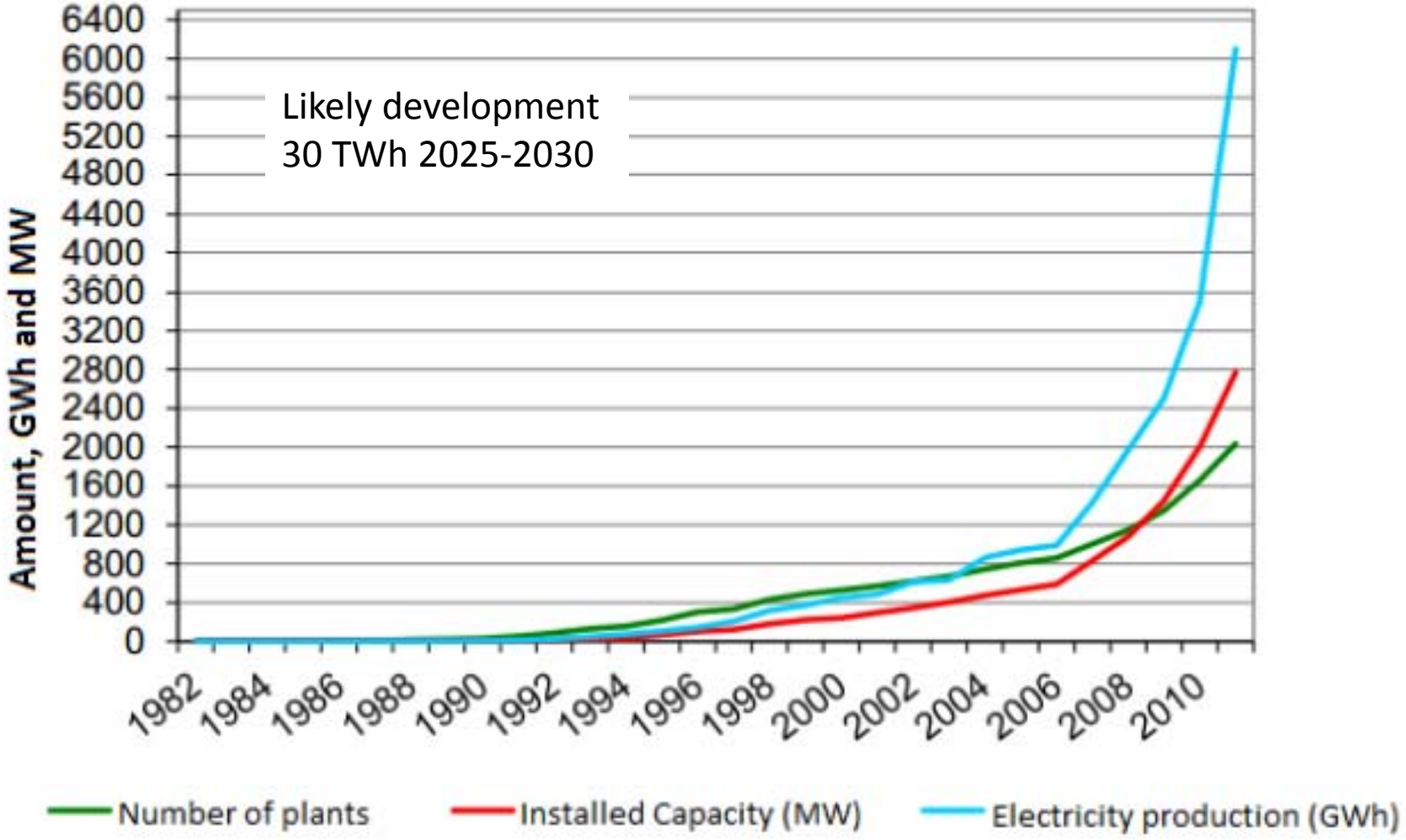


Figure 2: Energy mix in the Nordic region during 2009 - 2011(Nord Pool Spot, 2012)

Wind power in Sweden



A transition is going on…

- From ”Pull” – Power plants are controlled in advance (typically 24 h) and adjusted by so-called regulative power dependant on the actual ”demand”…
- To ”Push” – large amounts of fluctuating (but almost predictable) wind power and even more fluctuating solar power. Regulation needed on both sides of the system…

Heat Pumps will play a critical role

- Rapid demand side response for up or down regulation.
- Load shifting (Short term - day/night)
- Production optimization in district heating systems (fuel saving, cost saving, emission mitigation, increased income from regulative power)

Full potential still need to be quantified, preliminary studies from Sweden, Denmark, Germany confirm hypothesis. Recent detailed study at KTH (ongoing) confirmes heat pump benefits in DH systems.

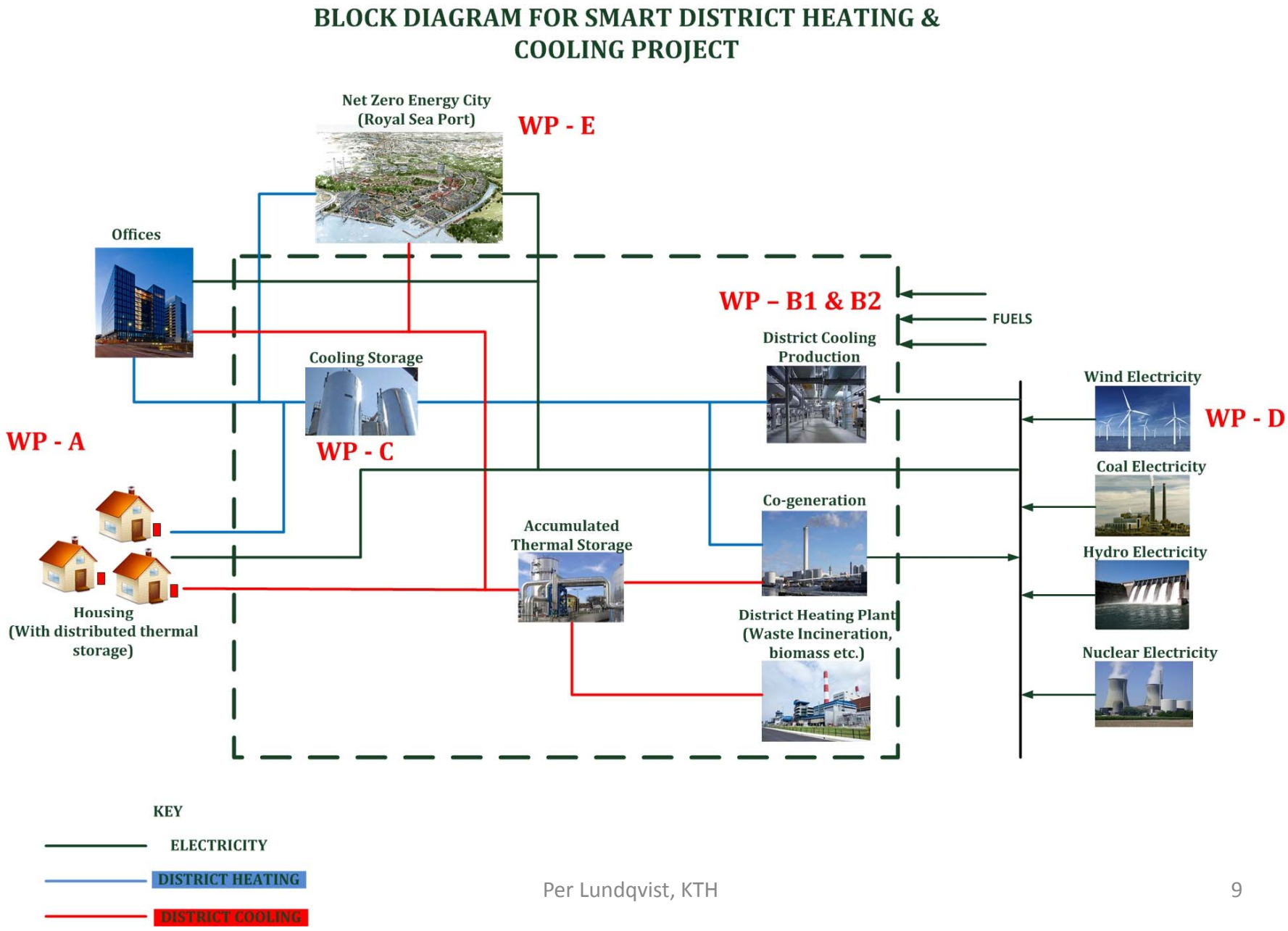
Technical option – small scale

- Distributed “smart grid heat pumps” for single family houses (enabling storage with time constants between 1 and 24 h without dedicated extra storage.
- With storage (PCM for example) several days. Probably too expensive unless generously rewarded in certain areas.
- Requirement: weather forecasting for both wind power (regional) and heat demand (local). Smart grid integration not needed
- Potential: still to be determined

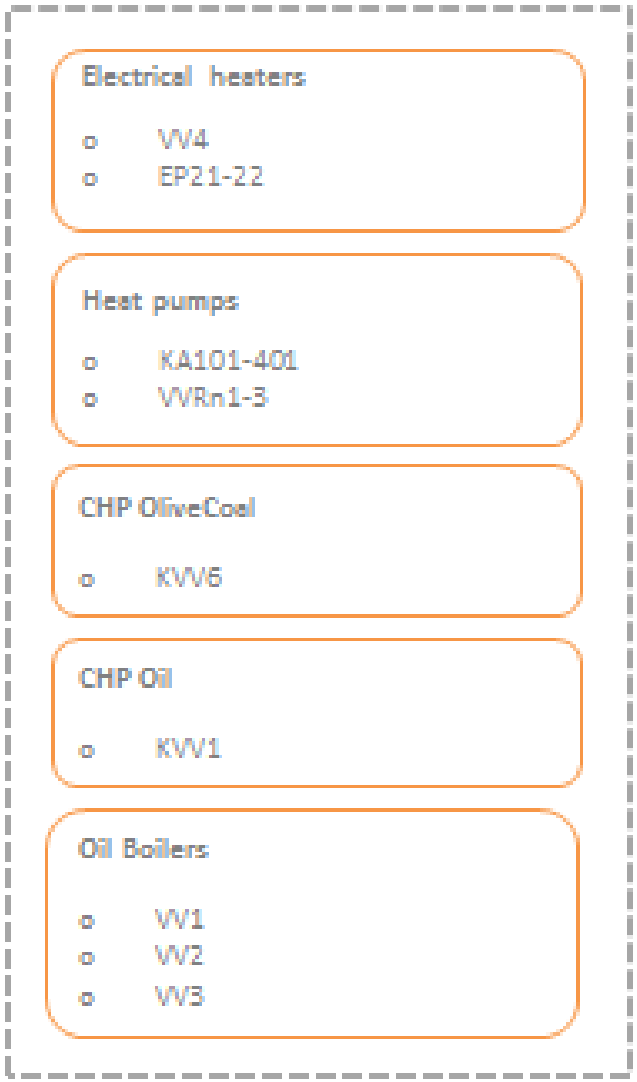
Technical option – large scale

- Large heat pumps in DHC systems. Operated together with biomass or waste driven CHP + peak boilers (oil or electricity)
- Down-regulation of CHP when wind-excess
- Up regulation of CHP when cold weather to maximize DH and electricity production
- Objective: cost savings, fuel savings, emissions

Smart city – smart thermal grids – case study



Case study DH Stockholm



Base case

Minimizing production costs based on:

- Fuel prices
- Nord Pool spot price (known 24 h in advance)
- Emission allowances and emission taxes

Regulatory case

Minimizing production costs based on:

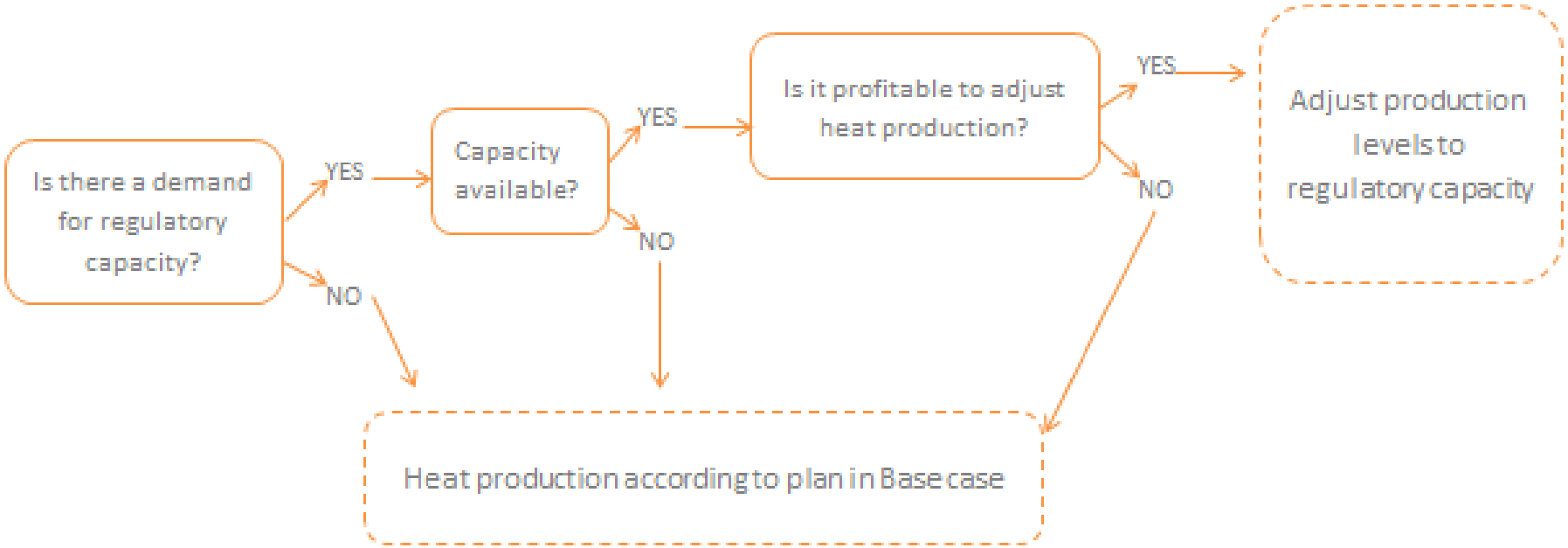
- Fuel prices
- Nord Pool spot price (known 24 h in advance)
- Emission allowances and emission taxes
- Possible savings from regulatory capacity

All savings and/or gains due to regulatory capacity will be calculated as negative costs for producing heat

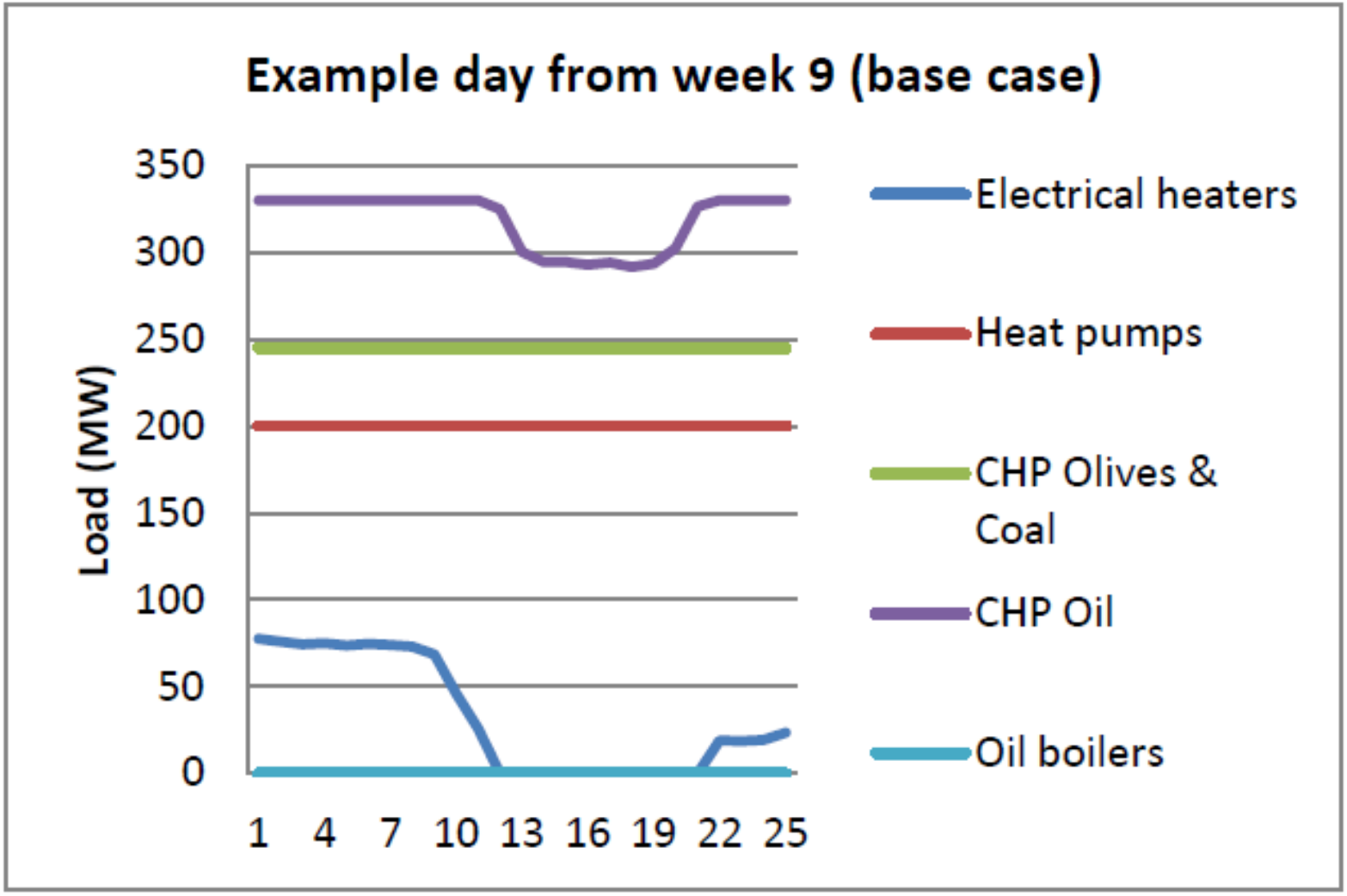
Input data to model

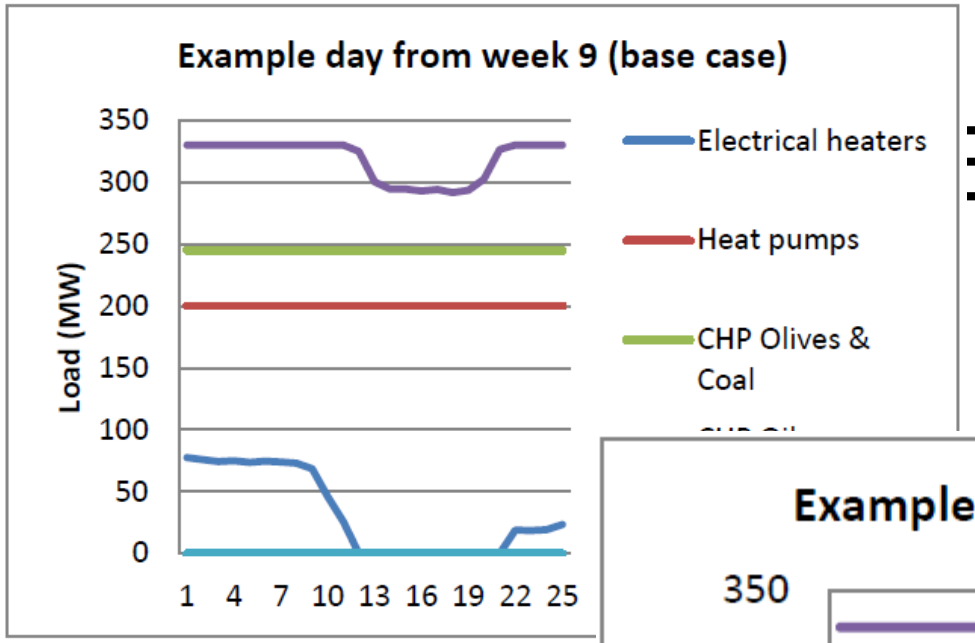
- Production plants (size, efficiencies)
- Fuel prices (tax, prices, green certificates, etc)
- Weather for 2010
- DH demand data for 2010
- Electricity prices for 2010 (spot market)
- Wind production according to real data (2010) but scaled up (in steps)
- Electricity prices accordingly (more volatile)

Model logic (decision tree)



Preliminary results DH





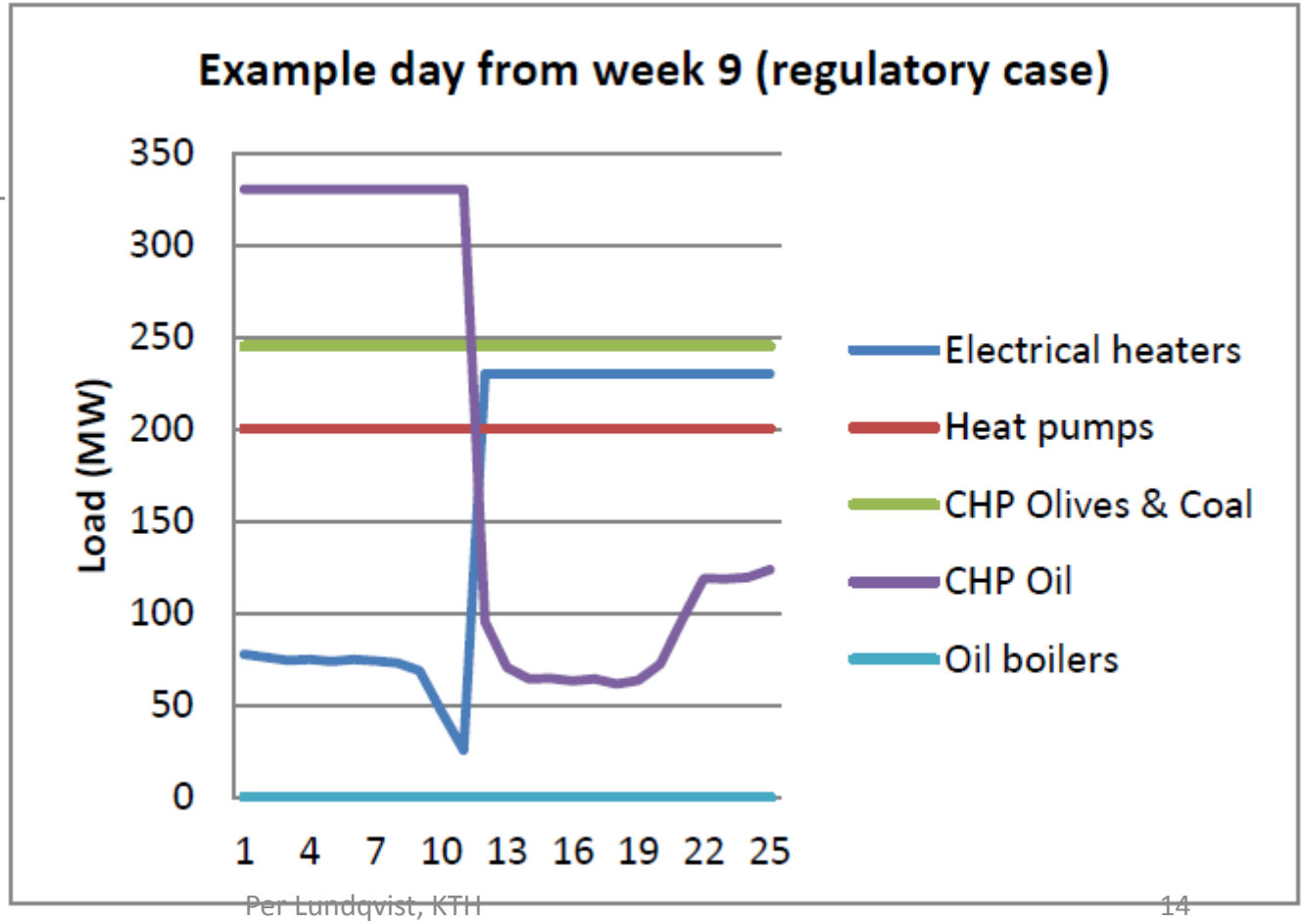
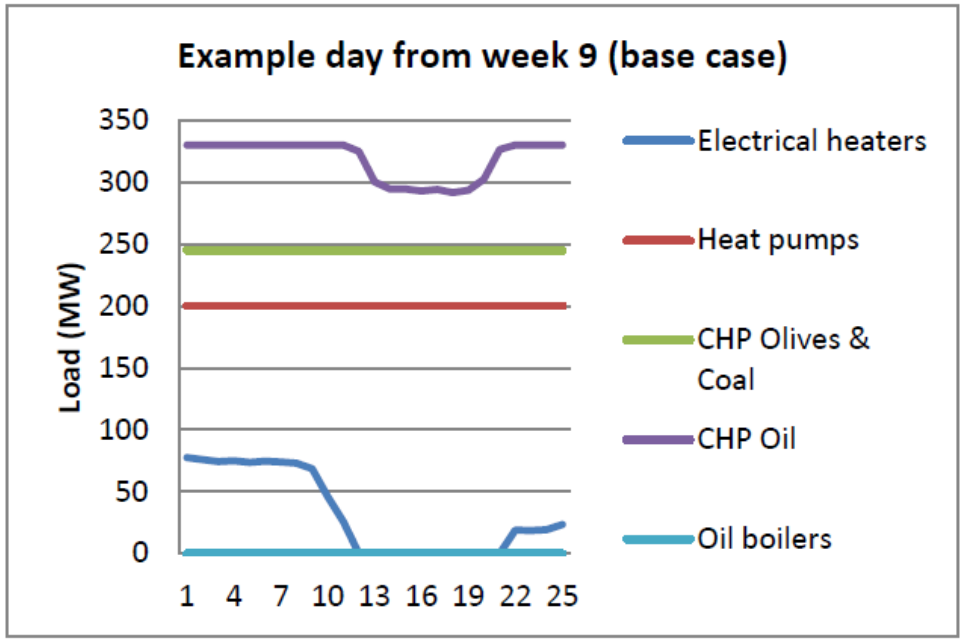


Figure 26 Production schedule for one day during the regulatory case week 9



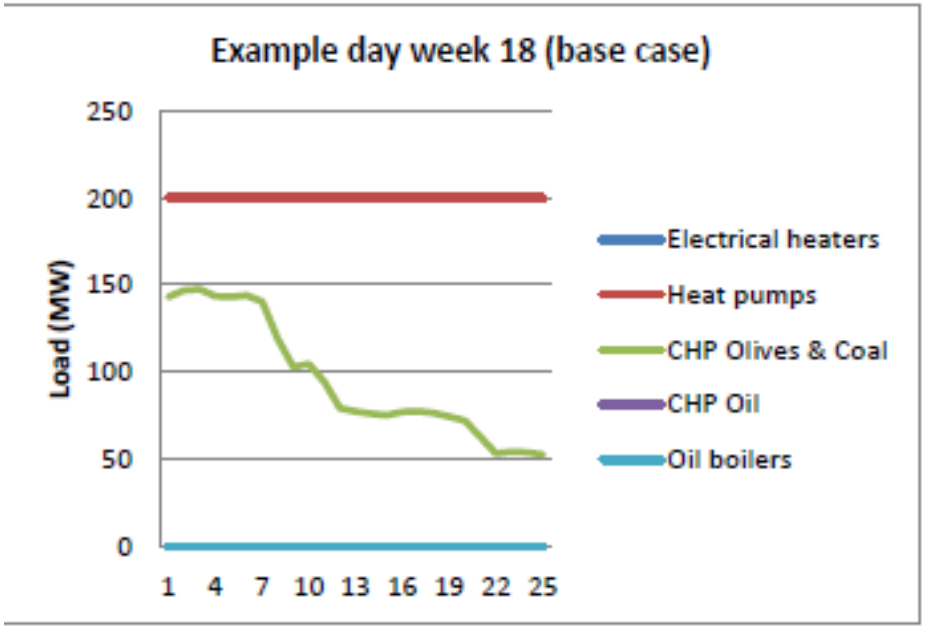
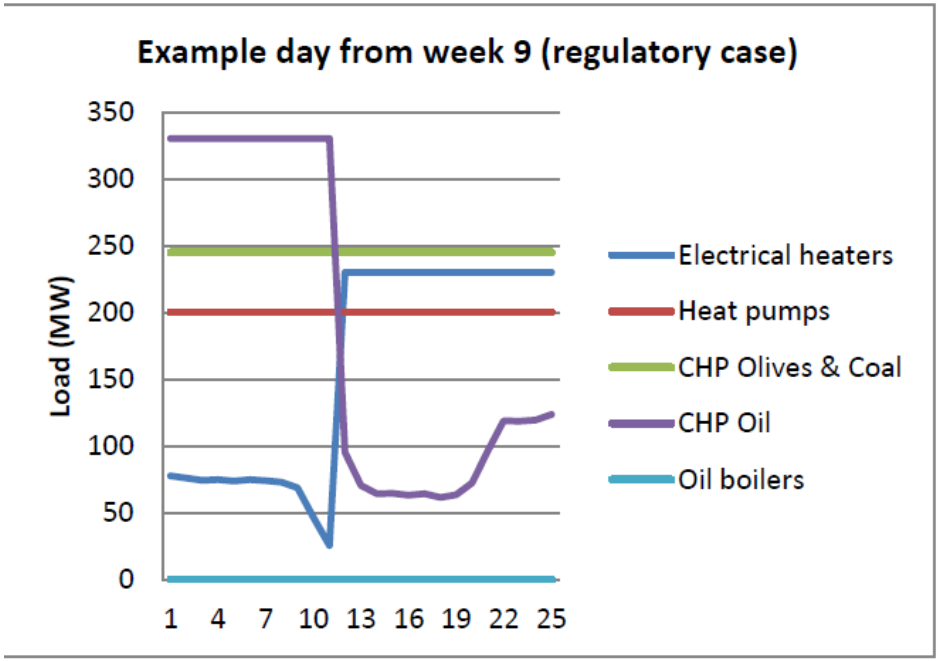


Figure 27 Production schedule for one day during the base case during week 18



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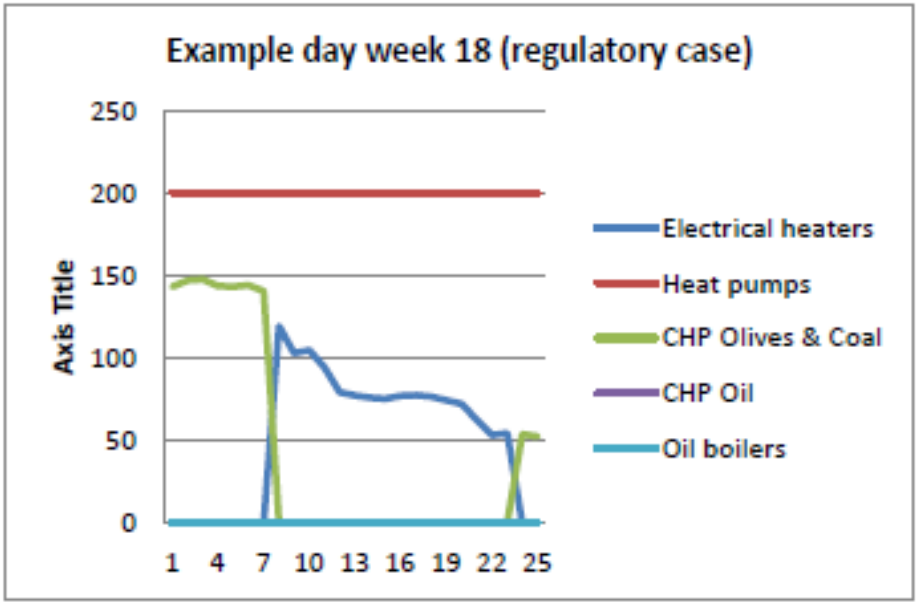
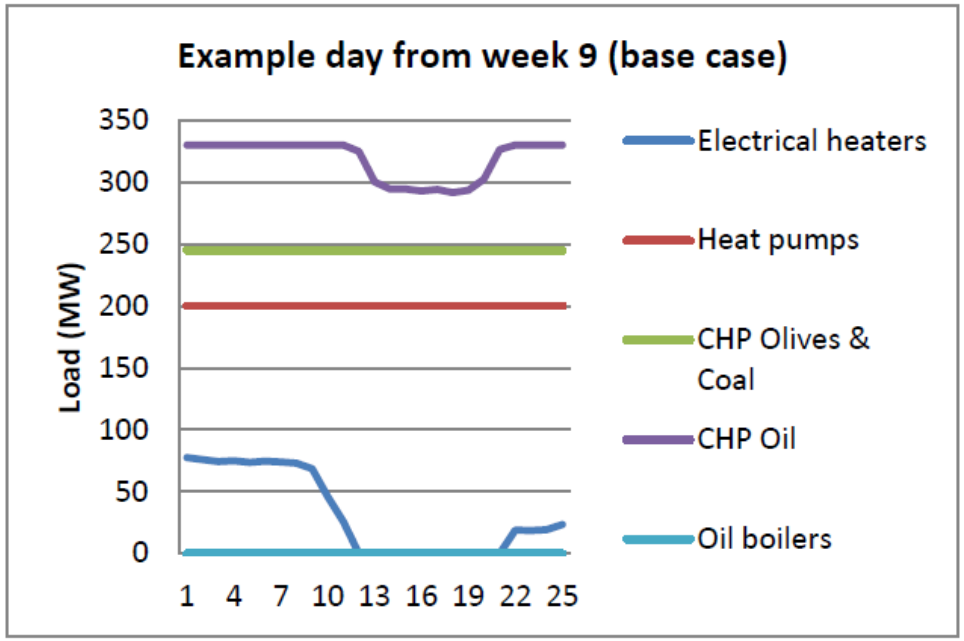
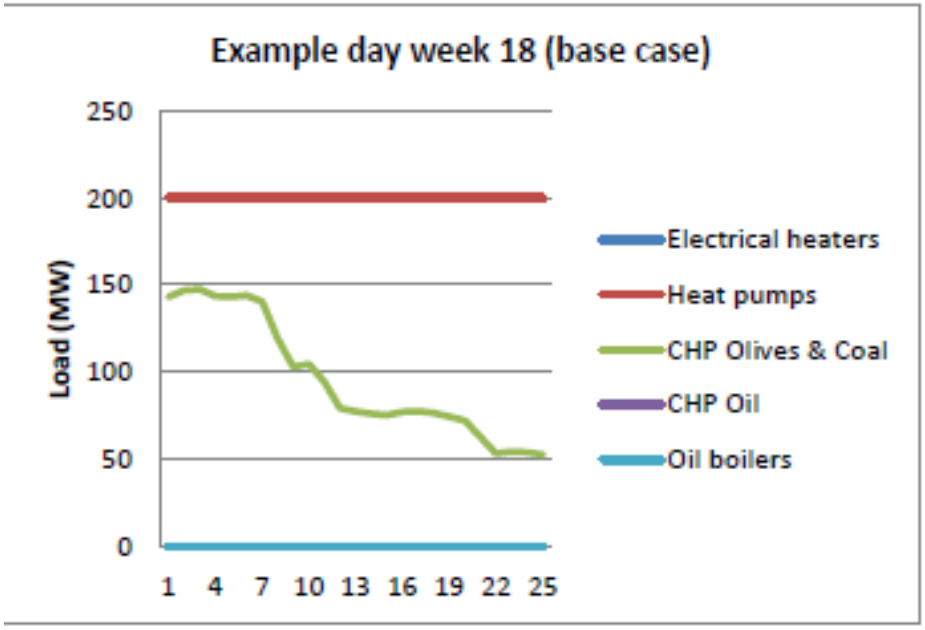


Figure 28 Production schedule for one day during the regulatory case week 18





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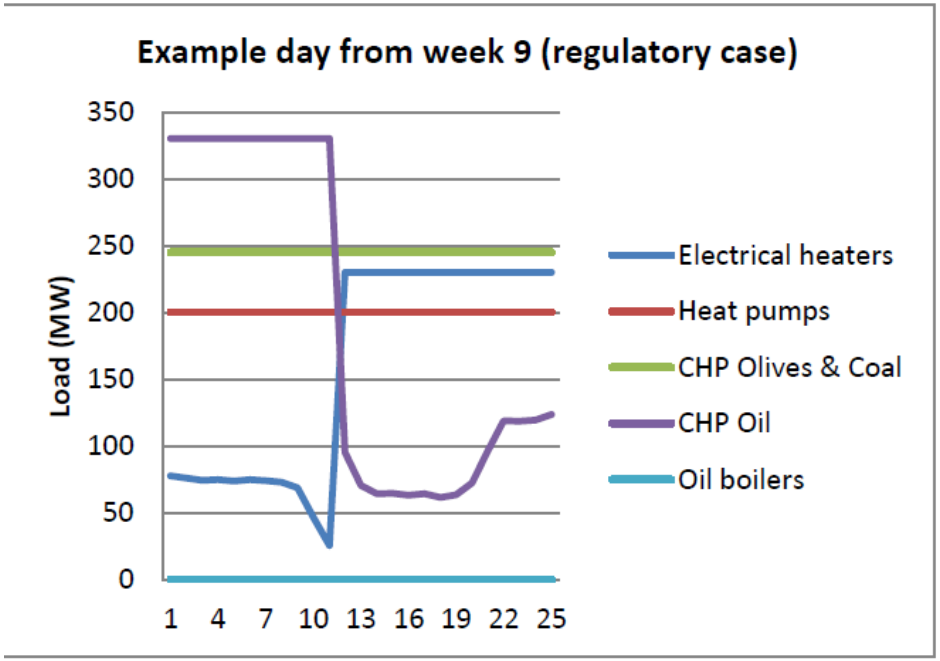

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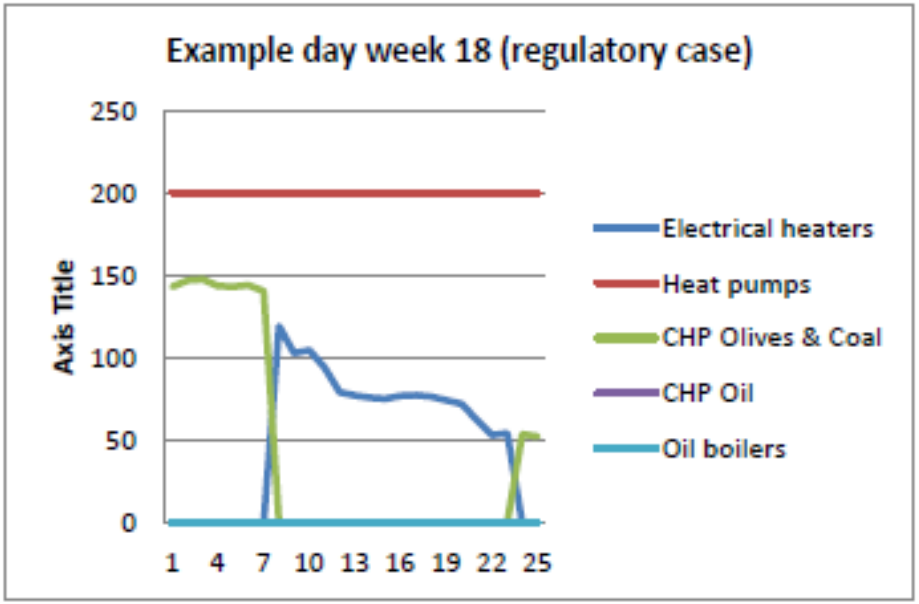

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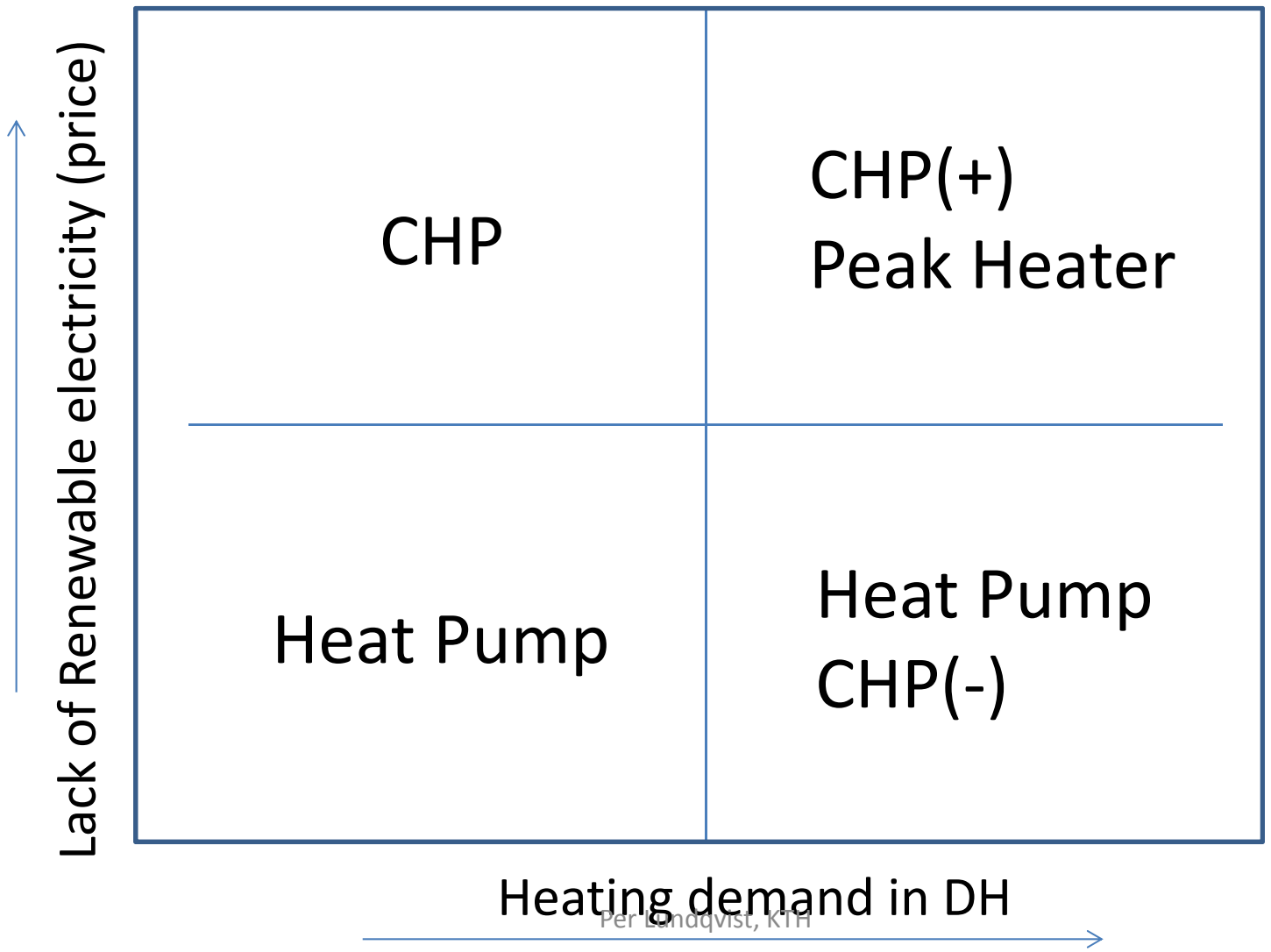
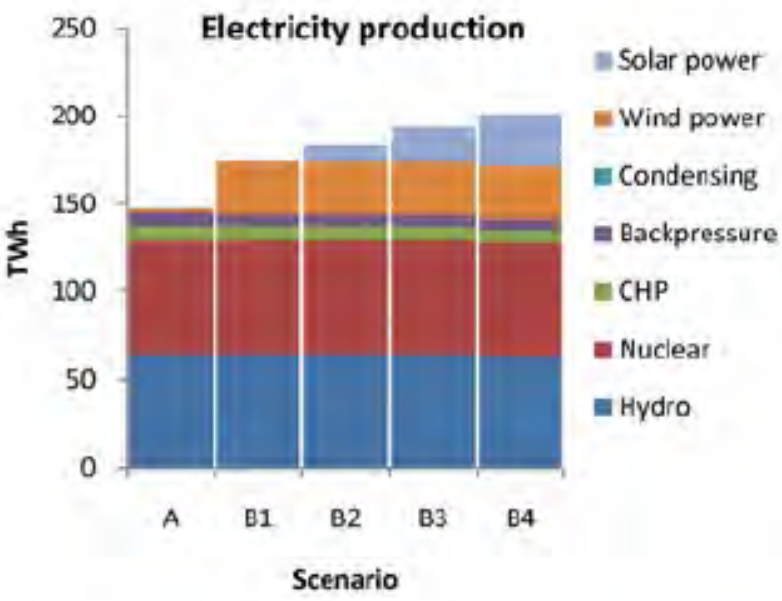
Results DH strategy

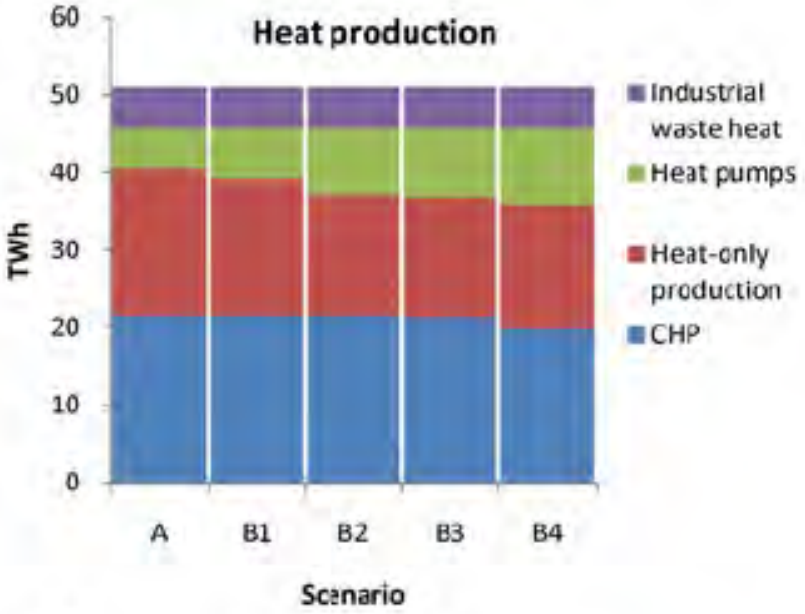


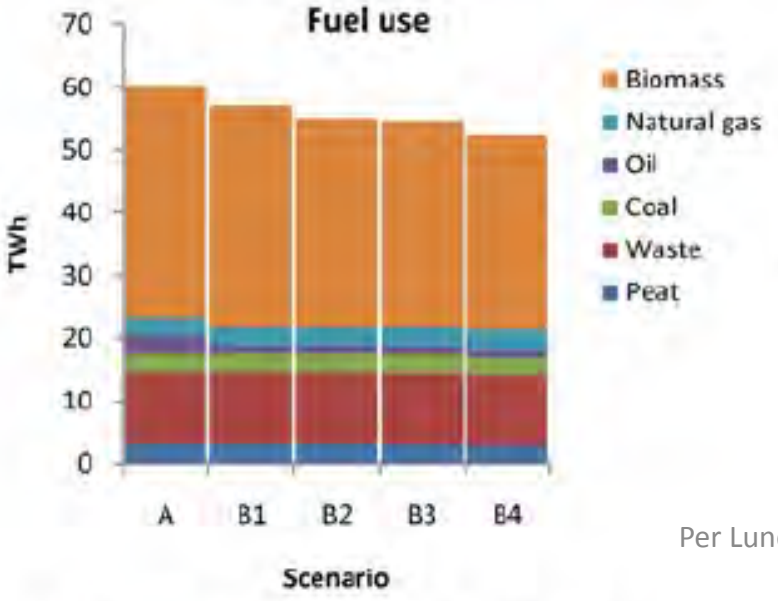
Denmark:

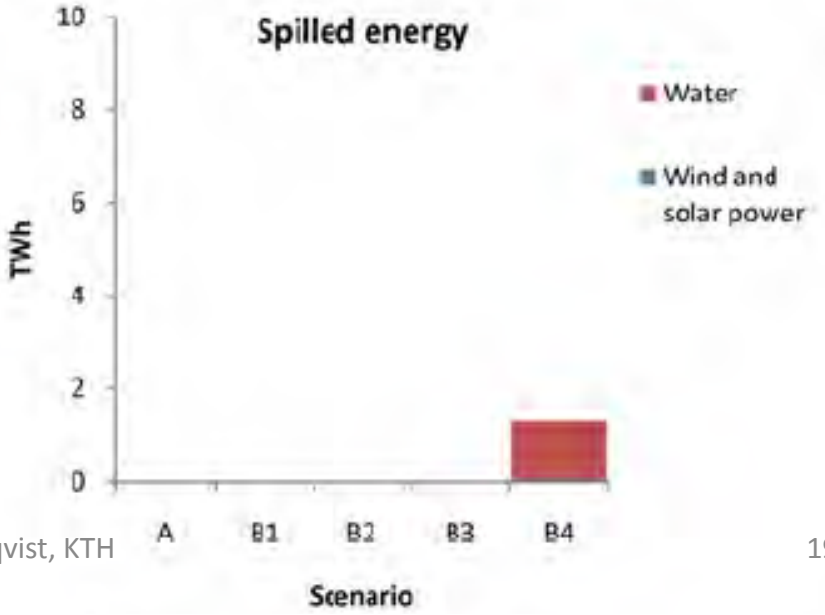
- The Climate Commission's report, published on 28 September 2010, concludes that "**we will heat our homes with heat pumps powered by electricity from wind turbines. Biomass, solar thermal energy, geothermal energy and heat pumps will collectively provide the energy for district heating.**"

One Swedish example









Germany:

New report from ECOFYS (end of 2011):

Potenziale der Wärmepumpe zum Lastmanagement im Strommarkt und zur Netzintegration erneuerbarer Energien

prognos ECOFYS

Conclusions

Heat pumps enables more wind power in a cost effective way

Heat pumps provides smart grid capabilites to conventional electrical grids in small and large scale.

Heat pumps and CHP provides a very flexible and efficient combination for DHC systems