Small CHP plants and heat pumps

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Agenda

- Part 1
  - Investigation for the Danish Energy Agency
- Part 2
  - Combining solar thermal plants with heat pumps

Investigation for the Danish Energy Agency

- Project consortium
  - PlanEnergi
  - Teknologisk Institut
  - GEO
  - Grøn Energi
- The investigation is ongoing, and all data are preliminary!

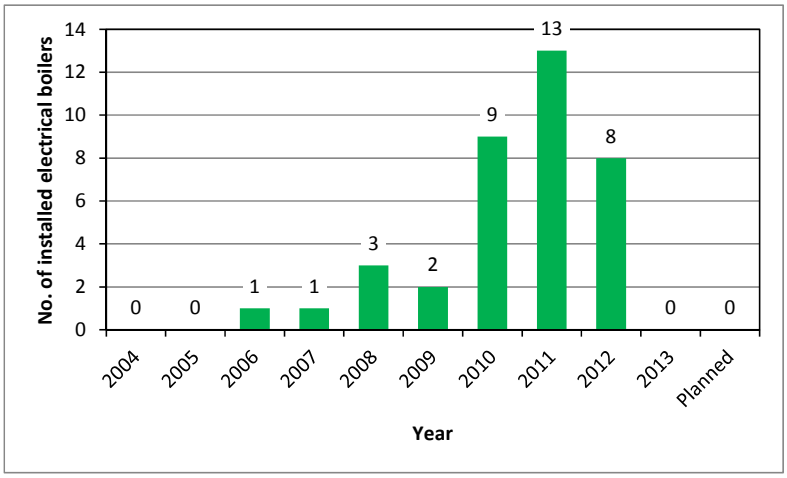
Objectives

- Part 1
  - Listing of existing heat storages, electric boilers and large heat pumps
  - Potential for new storages and heat pumps
- Part 2
  - Description of current technology and future potential for storages and heat pumps

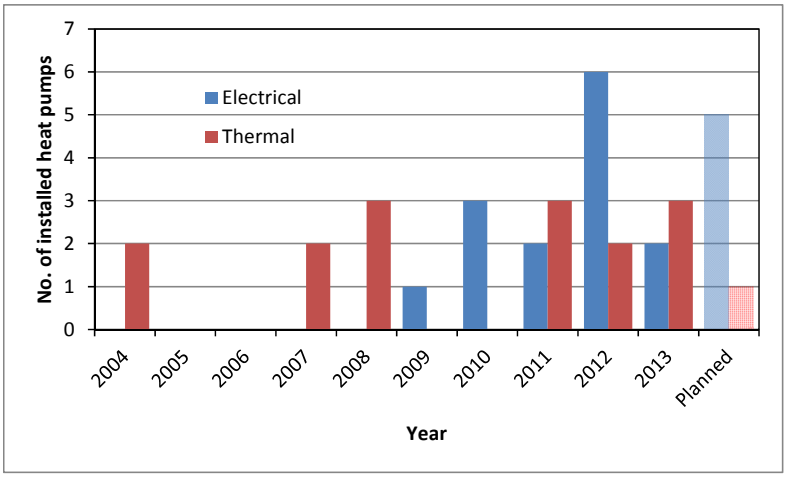
Existing DH storages

- Steel tanks (preliminary)
  - 278 out of 278, 1984-2013, 768.000 m^3 in total
- Pit heat storages
  - Ottrupgård, 1995, 1.500 m^3
  - Marstal, 2003, 10.000 m^3
  - Marstal, 2012, 75.000 m^3
  - Dronninglund, 2013, 60.000 m^3
- Borehole storages
  - Brædstrup, 2012, 19.000 m^3 soil
- Aquifer storages
  - Bjerringbro, 2013

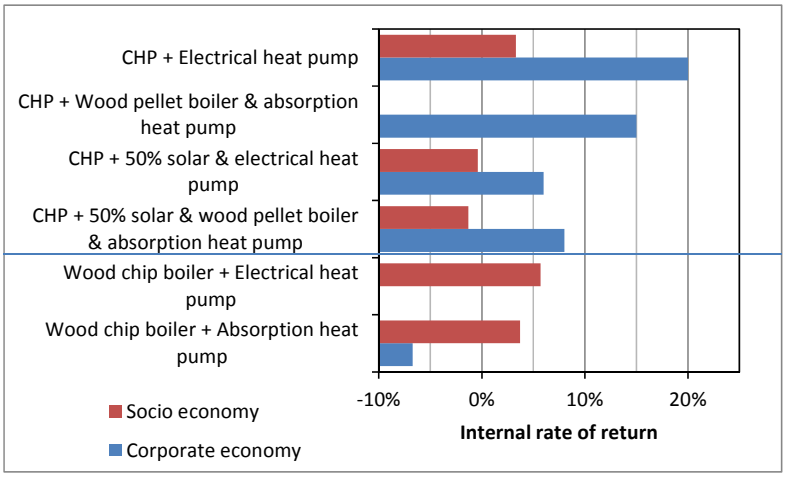
Electrical boilers – 295 MW



Heat pumps – 18 / 119 MW_{th}



Model calculations



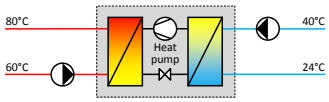
Combining Solar Thermal Plants with Heat Pumps

A solar thermal plant

$$q_{coll} = \eta_0 \cdot G - a_1 \cdot \Delta T_{coll} - a_2 \cdot \Delta T_{coll}^{\ 2}$$

… a heat pump …

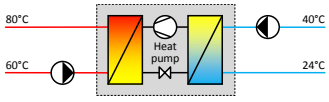
$$q_{coll} = \eta_0 \cdot G - a_1 \cdot \Delta T_{coll} - a_2 \cdot \Delta T_{coll}^{\ 2}$$



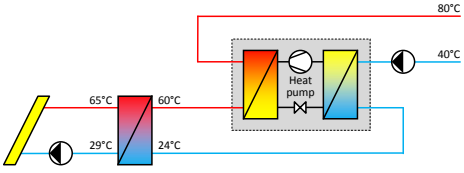
$$COP_{hp} \equiv \frac{q_c}{P_{hp}}$$

… and a combination

$$q_{coll} = \eta_0 \cdot G - a_1 \cdot \Delta T_{coll} - a_2 \cdot \Delta T_{coll}^{\ 2}$$

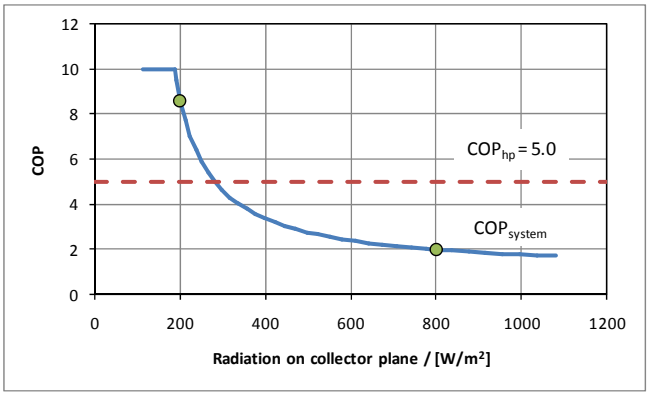


$$COP_{hp} \equiv \frac{q_c}{P_{hp}}$$

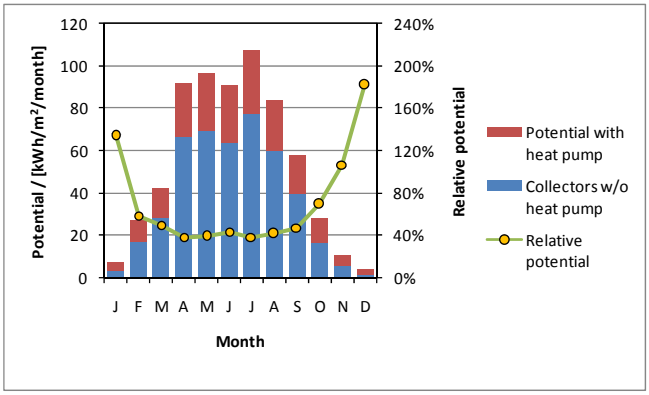


$$COP_{system} \equiv \frac{\Delta q_{system}}{P_{hp}}$$

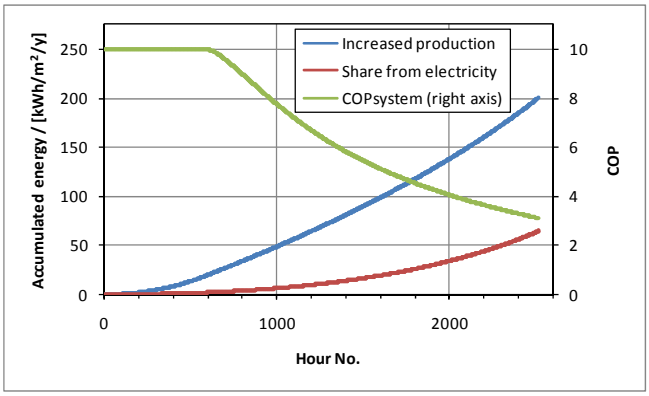
COP as function of the radiation



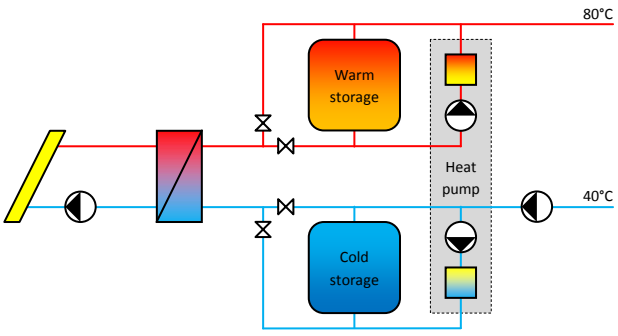
Production potential



Compromise between COP and potential



An example with storages



Conclusions

- COP_{system} is not the same as COP_{hp}
- COP_{hp} can be measured, COP_{system} cannot
- When the radiation is low
  - COP_{system} is high
  - and production potential is low
  - A compromise must be found between these
- Dimensioning is challenging
- Dynamic simulations are necessary
- The heat pump should be compared to more collectors

Thank you for your attention

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