Smart District Heating

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PlanEnergi:
Consultant Engineers
33 years years with renewable energy

- biomass
- biogas
- solar thermal
- heat pumps
- district heating
- energy planning

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Smart District Heating

- Smart district heating as part of smart energy systems
- Fuels in future district heating systems
- Optimizing supply, distribution and enduse as a whole
- Example Dronninglund (The Sunstore® Concept)
- Example Rye (Solar and heat pump)
- Supply of larger cities

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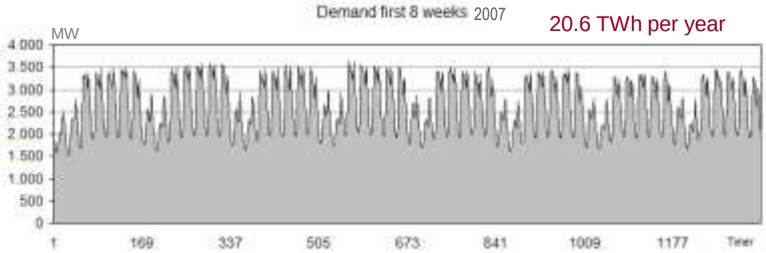
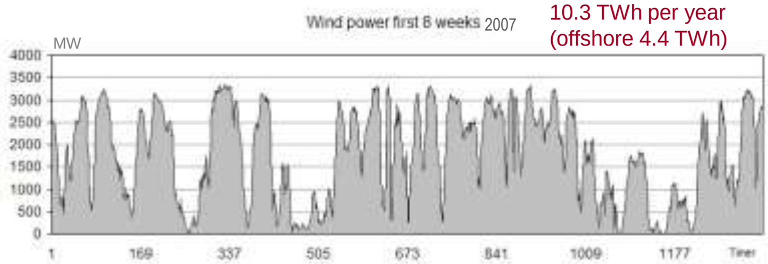
Balancing the powersystem DK1 ~ 50 % wind?

Vision of 50 % windpower !

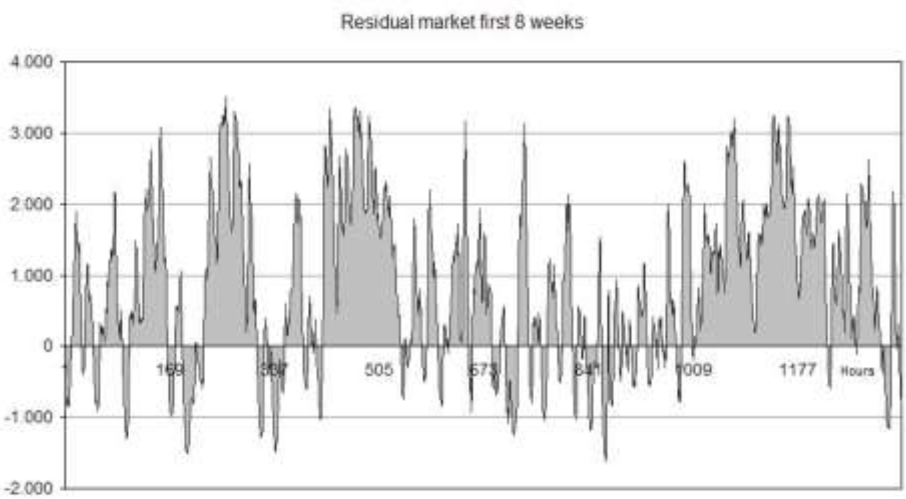
20.6 TWh per year



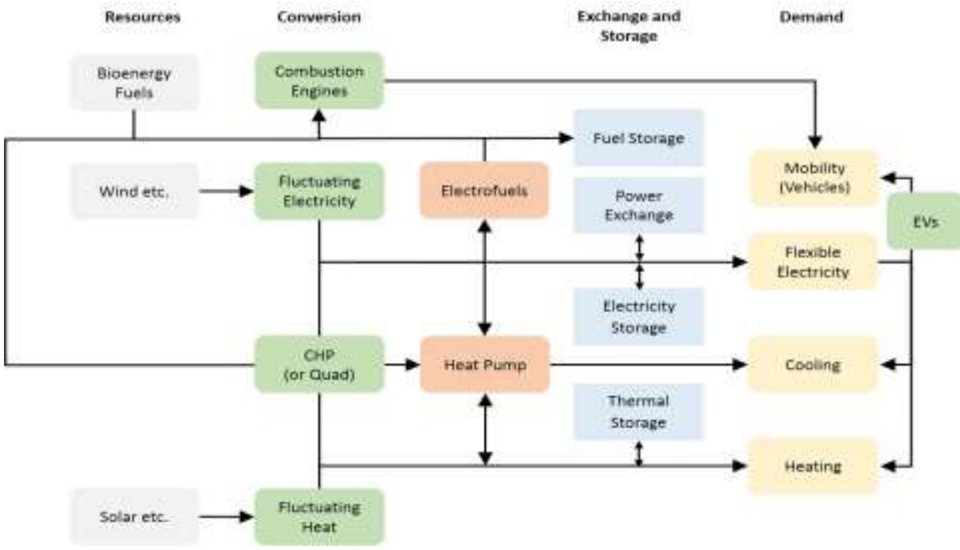
10.3 TWh per year
(offshore 4.4 TWh)



Subtracting wind power from demand leaves a residual demand and an overflow



SMART ENERGY SYSTEMS (source Aalborg University)



Overall Future Conditions for DH in DK

- Fossile fuels will be replaced by Renewable Energy Sources (RES). Individual natural gas will be replaced by district heating in most places.
- The sources will be excess head from waste incineration and industrial processes, biomass, solar thermal, geothermal heat and RES electricity. Biomass will be utilised for heat production only until the transport sector has to be converted to RES. RES electricity will primarely be used in heat pumps. Geothermal heat in Denmark will also be used as a heat source for heat pumps.
- Conclusion:Future district heating production will come from excess heat, solar thermal and heat pumps. Still CHP using green gasses will be part of some of the DH plants and thermal storages will be part of the plants to add flexibility
- Distribution system temperatures will go from 75/40 to 60/25. Lower temperatures are possible, but demands electric boilers or heat pumps in the substation in the building – and that has to be compared to heat pumps and electric boilers in the production units
- Substations in houses will include meters and control systems, that can react on high DH prices and DH from fossil fuels
- The entire system (production, distribution and end use) will be optimized as a whole

Optimization of the entire system

" Future Green Buildings" , Aalborg University 2016:

- It is essential that the building stock is part of the energy transition through energy savings by around 40% (to 80 kWh/m^2) between today and 2050. This will lower the consumption, the peak demand and the temperature level required from heat supply technologies
- It is less important to place focus on new buildings to save energy in the future energy system since 90% of the building stock existing today will exist in 2050
- Buildings should not be prioritised as a source of flexibility in the energy system since the flexibility can be provided by cheaper means in other parts of the system

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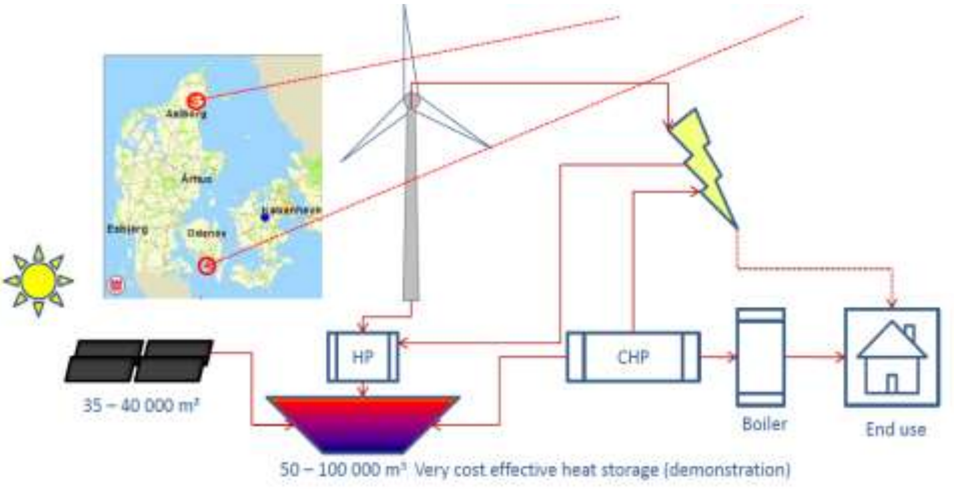
The SUNSTORE® Concept Examples Dronninglund and Marstal



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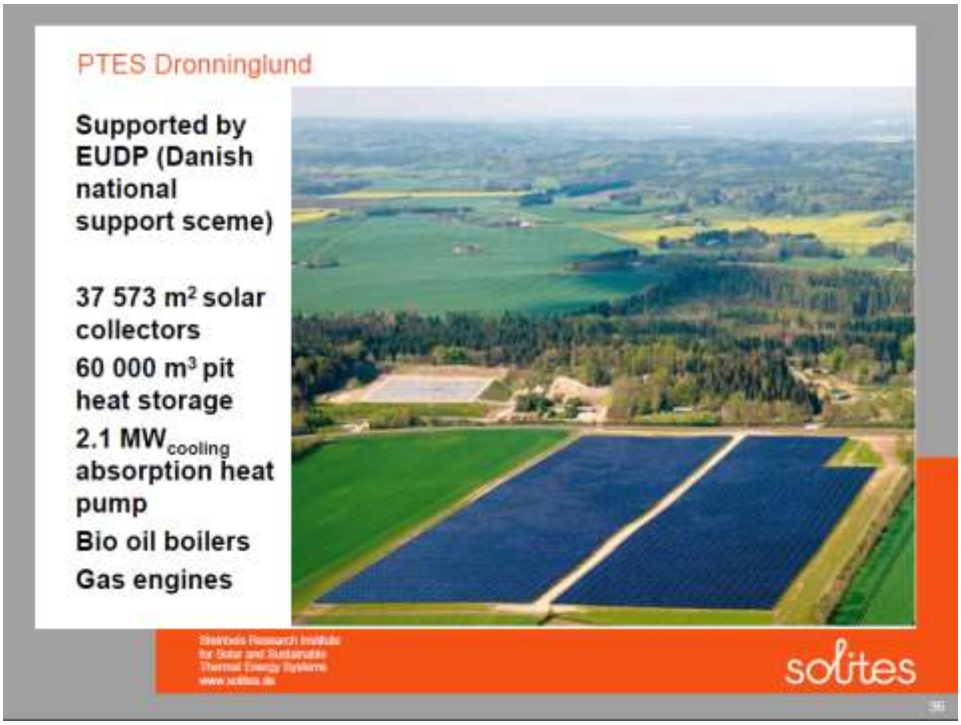
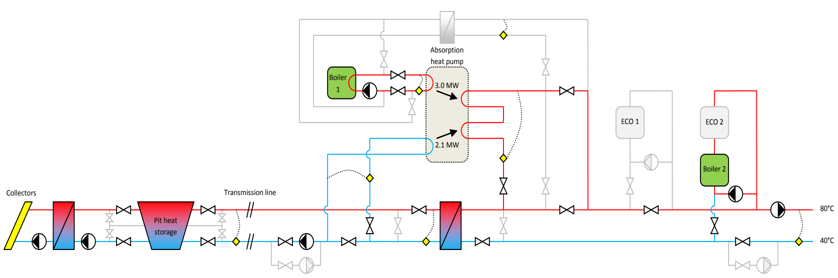


Principle diagram for Dronninglund



Implementation Dronninglund

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Data for storage Dronninglund

Built 2013
Size: 60,000 m^3 water
Price 2.3 mio. € or 38 €/m^3 or 0.416 €/kWh
Temperatures 10 – 90^o C
Capacity: 5,570 MWh
Charge and discharge capacity: 27 MW
Calculated heat loss: 1,602 MWh/year

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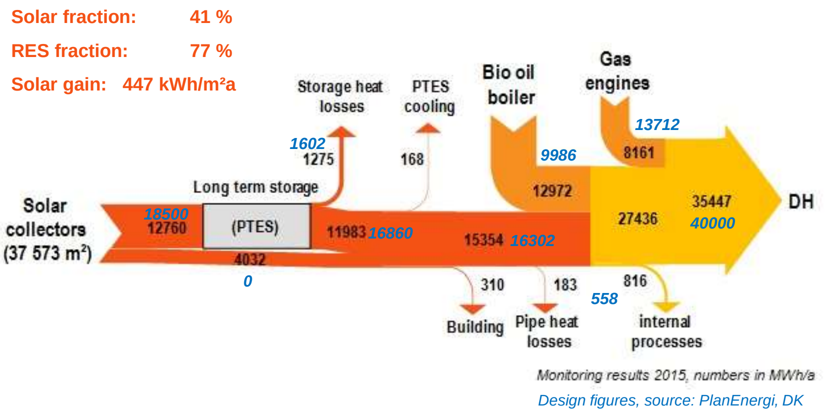
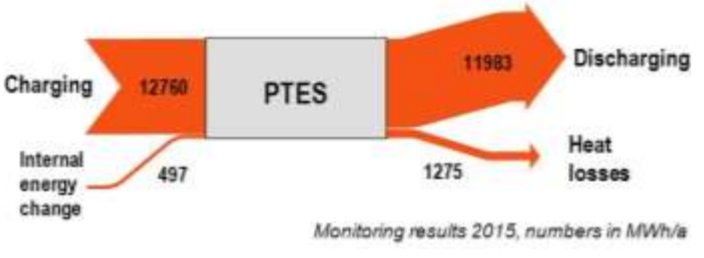
Dronninglund | Energy flow diagram year 2015 (Source Solites)



Dronninglund | Pit storage energy flow 2015 (Source Solites)

Storage efficiency:	**90 %**	**T-max:**	**89 °C**
No. of storage cycles:	**2.2**	**T-min:**	**10 °C**
Heat capacity (64 K):	**5 500 MWh**		



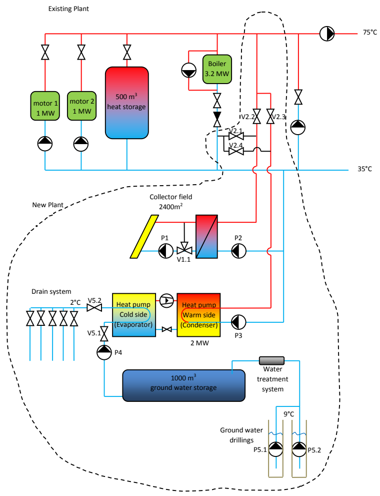
Dronninglund

Solar District Heating and Heat Pump, Rye

Design of the plant

Rye CHP plant

Established: 1995
Consumers: 365 (2014)
Heat demand: 9 325 MWh/y



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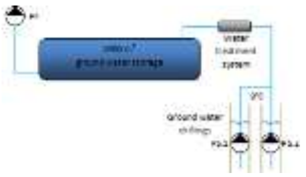
Dimensioning

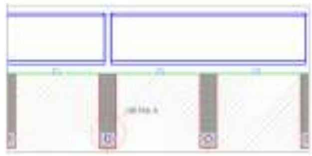
- Solar collector area
  - Optimized from exsisting storage tank and available land.
  - 2 400 m² (12 % coverage of yearly heat demand)
- Heat Pump
  - Optimal size: 1-1.2 MW_{heat} running 5-6 000 hours/year
    - Not able to help the electricity system
  - Oversize: 2-2.4 MW_{heat} running 2-3 000 hours/year
    - Running only when the electricity prices are cheapest (periods with highest share of wind power)
    - Supported by EUDP to demonstrate the ability to use and help the electricity system with a high share of fluctuating renewable electricity

Dimensioning

- Ground water supply
  - Number of water wells and size of storage optimized economically.
  - Placement of water wells and impact on local drinking water facility verified by a numerical hydrogeological model (also authority requirement)



- Drain system
  - Based on measurements and calculations of the infiltration capacity of the soil.
  - 1.830 m of drain pipes



Implementation

Layout of the plant

Implementation

Site built heat pump

Low pressure compressors

High pressure compressors

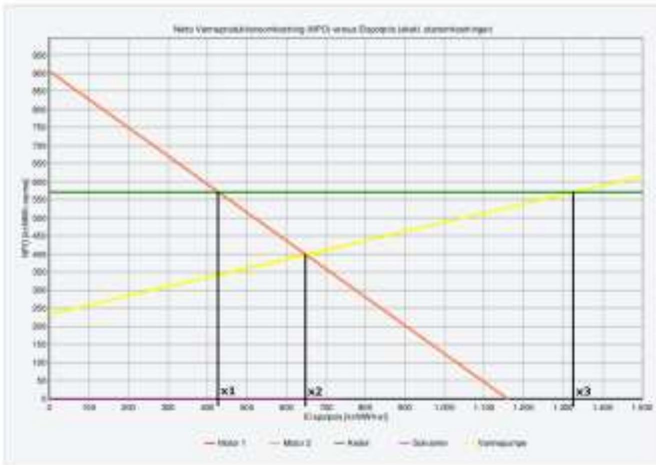
Implementation

Drain system

Solar collectors

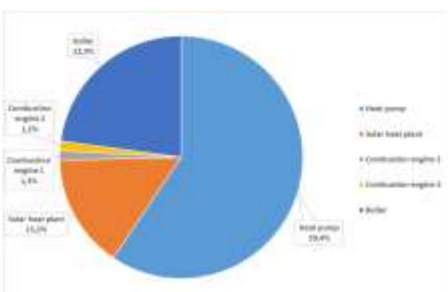
Control Strategies

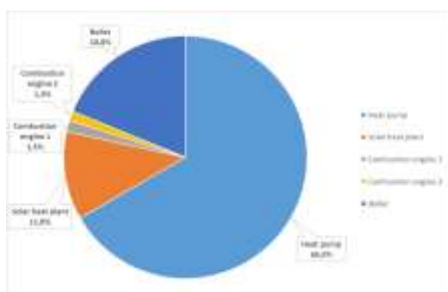
1) Choose the cheapest production unit



Monitoring Results

Results from February 23rd 2015 (start of operation) to December 31st 2015 (evaluated by Technological Institute)





Monitoring Results

<u>Heat pump design values:</u>

Heat output: 2 048 kW

Electrical input: 509,4 kW

COP: 4.02

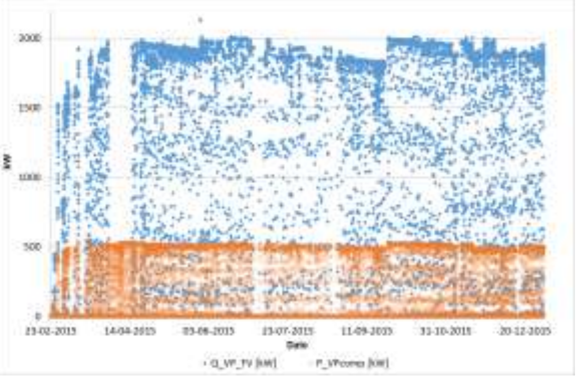
<u>Measured average values:</u>

COP: 3,74

<u>Deviations:</u>

Startup effects.

Higher return temperature as design figures.

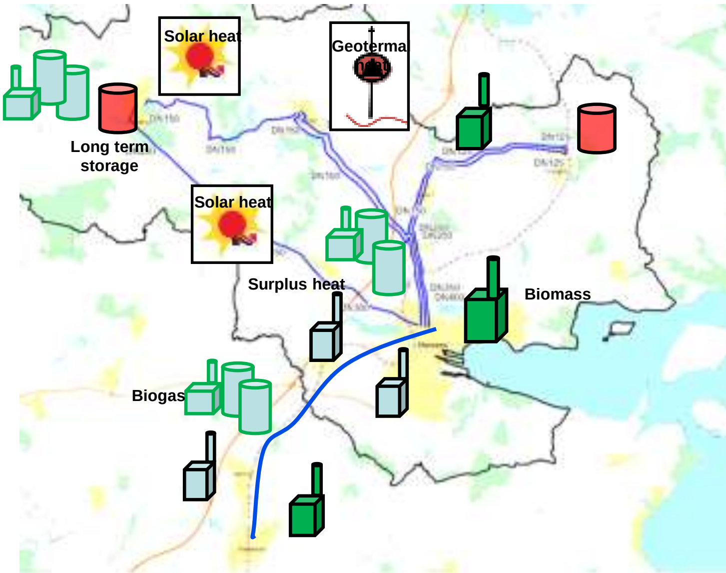


Example of Hybrid Plant, Horsens

How can 100% RES be reached in a municipality with a larger city, where the barriers are:

- Heat from incineration is not 100% utilized in Summer periods
- Excess heat from industries is not utilized
- Not RES enough to convert individual gas heating to district heating
- Bad utilization of geothermal heat if it is found
- No place for solar heat and storages for Horsens city
- Organisational problems in the future for small utilities

The Flex Cities project



The future ?! Smart district heating and cooling!?

- ✓ Flexible
- ✓ Renewable
- ✓ CO_2-neutral
- ✓ Cost effective

Thank you for your attention

Per Alex Sørensen

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