Case Studies

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ANNEX 57 — Flexibility by implementation of heat pumps in multi-vector energy systems and thermal networks

Demo No.: D-001	**Location/City:** Sdr. Felding	**Country:** Denmark
Project name (short and full title): Sdr. Felding District Heating		
Quotation: "District heating company expands their existing biomass based production."		
Commercial project		**Year of realisation:** 2022
Leader organisation (owner, constructor, solution developer, research inst., etc.): Owner: DinForsyning (Utility company, Esbjerg), consulting engineers: Added Values ApS, Heat pump manufacturer: MAN Energy Solutions		
Participating organisations – demonstration project part (involved other organisations): -		
Budget of the demo (invest/monitoring etc.): Commercial project, no information on the budget available		
Summary of the project: The district heating company in Sdr. Felding has expanded their existing biomass-based production facilities with a large air to water CO2heat pump at 3,3 MW, a huge buffer tank 3370 m2 (4,5 m3/consumer) and a 10MW electrical boiler. This visionary installation really shows the future of district heating, which will be smokefree and serve as an important player in balancing the electrical grid. It will absorb large amounts of green electricity when it is available and utilize the stored energy from the tank when the electricity supply is lower than the demand.		
Expected results They expected to run the system at 70 °C but are running it at 85 °C which increases the storage capacity by 30 %. The District Heating plant is able to act in the ancillary service market with the Heat pump and electrical boiler in combination. And they are approved by the Danish TSO Energinet to deliver into the market both into the aFRR and mFRR regime.		
Published articles (paper, article etc.): N/A		
Country: Denmark	**Participating Organisation:**	**Contact/name:**

IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

Delivered by:

Team Denmark

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Project classes:

RD&D status

Large-scale demonstration	Small-scale demonstration	Lab scale (results based on measurements)	Design study (results based on simulation)
☒	☐	☐	☐

Type of heat pump

Decentralized HP (cold district heating)	Centralized HP with a district heating system
☐	☒
Heating	Cooling
☐	☐

Heat source of HP: Air

Power supply for HP (electricity grid, PV, wind turbine etc.): electricity grid

Buildings

New buildings	Existing buildings	Mix of new and existing buildings
☐	☐	☒
Residential	Non-residential	Mixed use
☐	☐	☒

Energy storage

Battery storage		Thermal energy storage	
Centralized	Decentralized	Centralized	Decentralized
☐	☐	☒	☐

Control for the flexible heat pump operation

The heat pump operation is scheduled from a higher level controller optimizing the operation of the complete heat production plant portfolio.

Heat driven control[1]	Predictive control[2]	Rule based control[3]
☐	☒	☐

[1] Operation of heat pumps to the cover heat demand depending on ambient temperatures
[2] Operation of heat pump using a model based heat demand prediction
[3] Heat pumps are controlled by a set of predefined rules (e.g. heat pump operation with blocking time)

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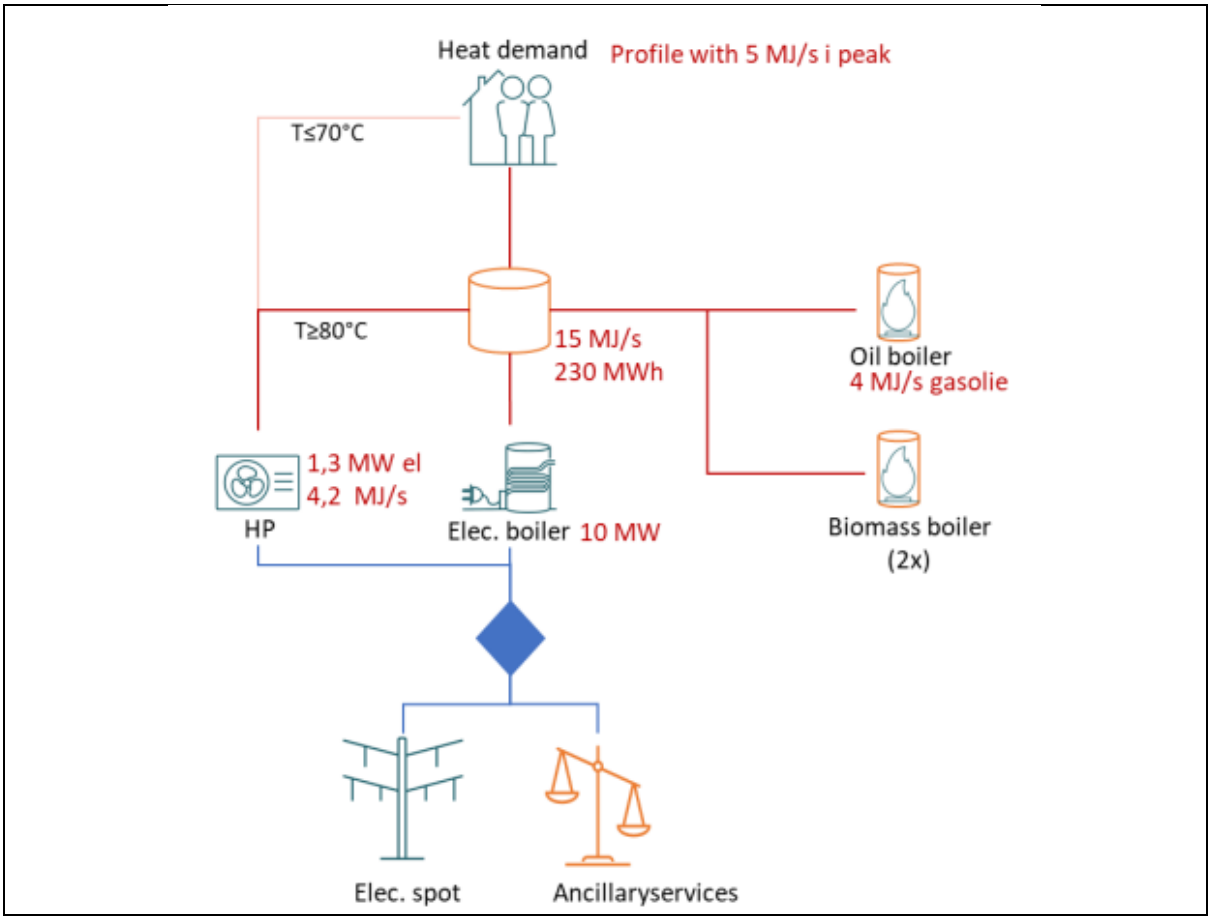
1. General description of the project

The district heating company in Sdr. Felding has expanded their existing biomass-based production facilities with a large air to water CO2heat pump at 3,3 MW, a huge buffer tank 3370 m2 (4,5 m3/consumer) and a 10MW electrical boiler. This visionary installation really shows the future of district heating, which will be smokefree and serve as an important player in balancing the electrical grid. It will absorb large amounts of green electricity when it is available and utilize the stored energy from the tank when the electricity supply is lower than the demand.

2. Building and system description of the project

The heat pump supplies 740 Households, in the town Sdr.Felding. The heat pump has been delivered and commissioned in February 2022. The system consists of a large air to water CO2heat pump at 3,3 MW, a huge buffer tank 3370 m2 (4,5 m3/consumer) and a 10MW electrical boiler, and a biomass boiler. This means that the buffer tank can store the energy amount needed for a weeks supply to the district heating system.

3. Energy supply – scheme of the heat supply system:



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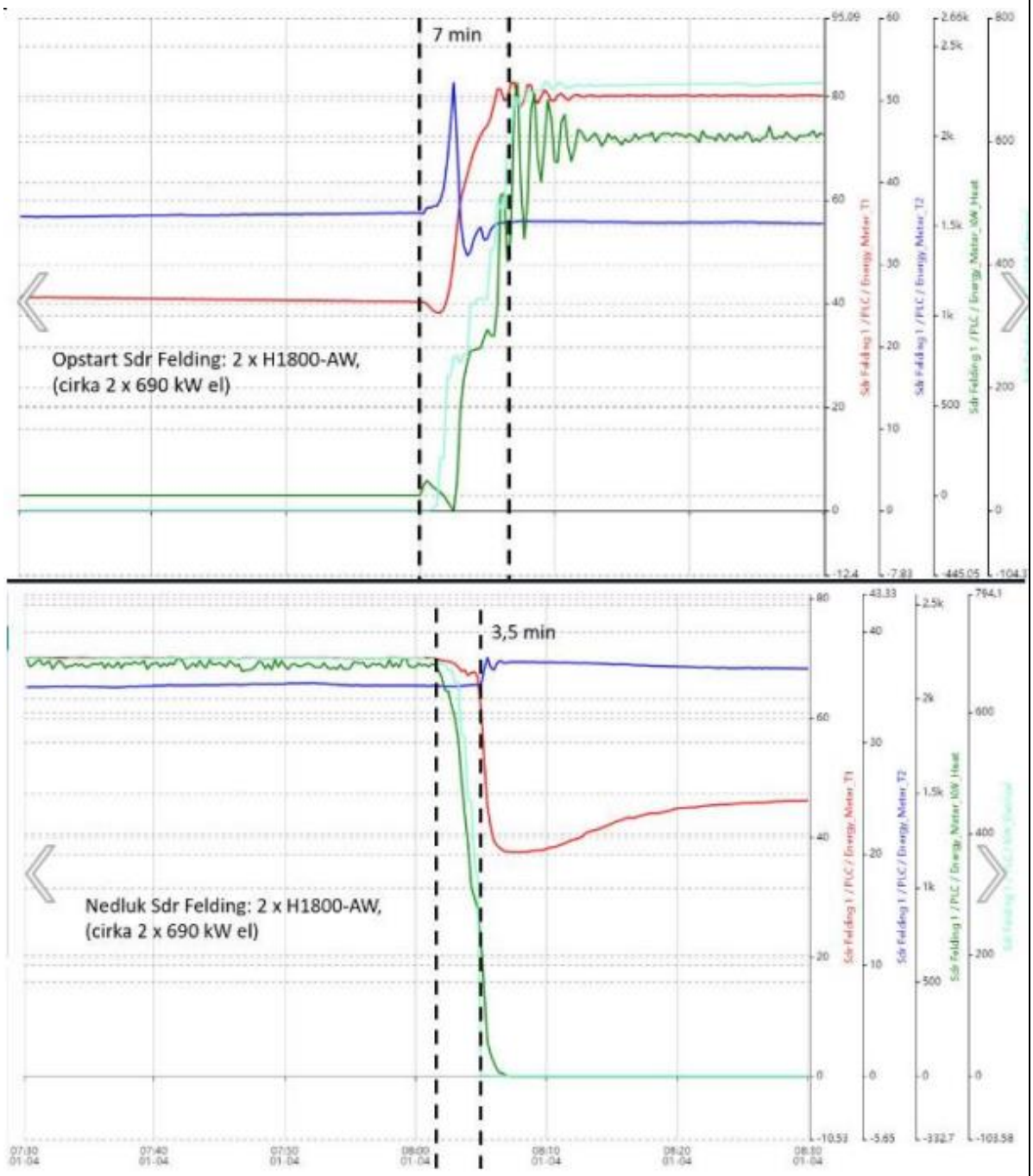
4. Flexibility – scheme and control strategy of the system:

The Heat Pump is tested regarding the reaction time. It has a start up time within 7 minutes, and a turn down time within 4 minutes, as shown in the graphs below. This means that it is able to act in the aFRR regime.



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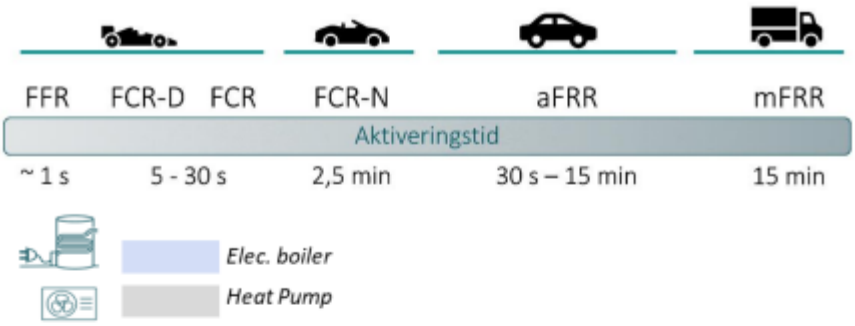
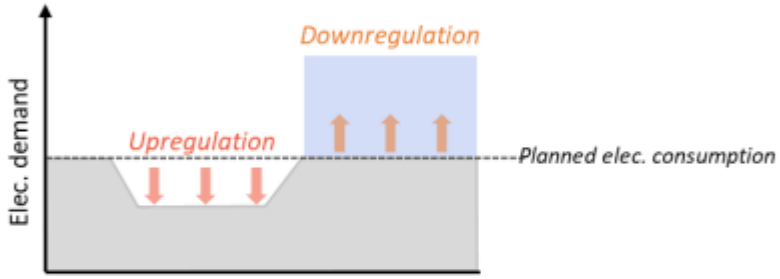
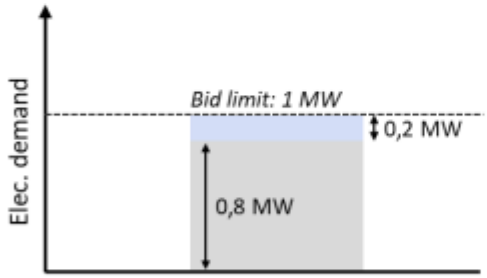
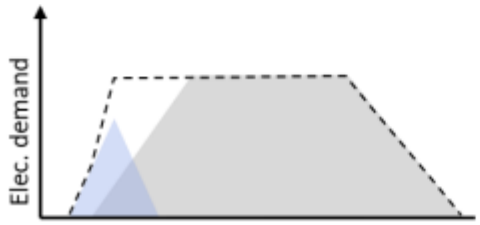
The heat pump and the Electrical boiler supplement each other, when it comes to deliver ancillary services the boiler can react very fast up and down, and can supplement the heat pump to reach the bid limet when the plant operator is putting offers in to the market.









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5. Description of the business model with a flexible HP-operation

At the district heating plant was the strategy that the heat pump should run 0% or 100 % in capacity, and always 70 °C outlet. As the heat pump with CO2 can deliver 85 °C outlet, was the strategy changed to 85 °which means that they can store 30 % more energy in the tank. The storage tank means that they have different strategies for the production depending on the actual storage situation and the weather and price forecasts.

The aim is to produce the heat as cheaply as possible.

Simulation of the plant done by the TSO Energinet shows, that the district heating company can reduce their production costs from the baseline costs when they start to act into the ancillary market.

6. Results of the project

- The project has shown that it is possible for heat pumps to react into the ancillary service market both the mFRR and aFRR.
- The combination of heat pump and electrical boiler gives advantages regarding reaction time and capacity. Biomass boiler are great when long periods with high electricity prices occur for example in two weeks periods with no wind.
- The storage with a weekly capacity increases the flexibility of the plant.
- It has been a good business case, and the consumers are having lover district heating prices.

7. Challenges / socio economical barriers and opportunities

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8. Additional information: Flexibility options

Share of heat source (in %)	1. Heat source: 2. Heat source: 3. Heat source:	%
Share of power supply (power grid, PV-units at site, wind turbine at site etc.)	1. Power supply: 2. Power supply: 3. Power supply:	%
System boundary by calculation of the SPF		
Seasonal performance factor in design and measured (SPF)	Water/water Air/water	3.58 3.0
COP of heat pump at the design condition (point in °C or traverse as function in °C), independent of site boundaries	Water / water (-4,5°C)/(30/55) Air/water(5°C)/(72/40)	3.58 3.0
COP incl. all peripheral devices at source and sink side		
Location of heat pump (e.g. heating centre (centralized heating installation), using existing infrastructure etc.)		

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Contents: district heating network

Land area for buildings served by heat distribution network		m²
Total heated floor area in buildings connected		m²
Trench length for heat distribution network		m
Heating capacity	1200	kW
Heat annually supplied into the heat distribution network		MWh/a
Heat annually delivered from the heat distribution network		MWh/a
Annual average supply temperature in the heat distribution network	72	°C
Annual average return temperature in the heat distribution network	40	°C
Heat generation based on renewable sources		MWh/a
Share of renewable sources		%

Contents: description of energy storage system

Energy storage type:	Distribution grid, geothermal probes
Storage size (capacity):	
Term of flexibility:	
Storage temperature (thermal energy storage)	

Contents: indicators for flexible heat pump operations

Cost (potential cost saving)		
Thermal level (losses of thermal comfort)		
Load matching factors (load supply & load cover factors)		