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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:** Aalborg	**Country:** Denmark
Project name (short and full title): IKEA Aalborg District cooling central		
Quotation: "To have a CO2 neutral cooling production for the warehouse and use of excess heat from the cooling production in the district heating system".		
Schedule of the demo project (research study):		**Year of realisation:** 2022
Leader organisation (owner, constructor, solution developer, research inst., etc.): Aalborg Forsyning		
Participating organisations – demonstration project part (involved other organisations): Owner: Aalborg Forsyning, (design/production) Fenagy A/S, installation: Krebs A/Section of Thermal Energy - Technical University of Denmark		
Budget of the demo (invest/monitoring etc.): N/A		
Summary of the project: The facilities department in the warehouse has long struggled with the old obsolete refrigeration system. And now the time had come to scrap HFC cooling systems in favor of a CO2 heat pump with chiller function. The heat pump was designed and installed by Aalborg Forsyning. The plant was designed and produced by Fenagy A/S and sold and installed by Krebs A/S. The goal is a CO2-neutral cooling production for the warehouse, where excess heat from cooling production is delivered to the district heating network. The district cooling center can deliver pure cooling, pure heat or combined operation with cooling and heating.		
Expected results Aalborg Forsyning expects that remote cooling is becoming more and more attracted by the consumers in the area. The energy center at IKEA is prepared so that more customers in the local area can be connected – and there is great interest in this – just as district cooling is also spreading elsewhere in Aalborg.		
Published articles (paper, article etc.): N/A		
Contact information: Aalborg Fjernvarme: http: aalborgforsyning.dk		
Country: Denmark	**Participating Organisation:**	**Contact/name:**

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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: Geothermal probes 56 pcs x 330meter and 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

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

IKEA Aalborg and Aalborg Forsyning's CO2 emissions will be reduced when the department store replaces its traditional cooling system with remote cooling from Aalborg Forsyning. District cooling is both cheaper and more climate-friendly than traditional cooling, and thus completely in line with IKEA's focus on sustainability.

"The climate benefits have been decisive for our choice of the new district cooling system from Aalborg Forsyning. The facility will be a step on the way to 2030, when IKEA must be a climate-positive, circular business," says Peter Elmose, warehouse manager at IKEA Aalborg.

2. Building and system description of the project

The heat pump supplies cooling and heating for the IKEA Warehouse.
Excess heat is supplied to the district heating grid.

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

The heat pump is a water-to-water heat pump and is built into a sound box completely assembled from the factory. The heat pump extracts heat through 56 x 330 meter geothermal wells. In interaction with the electric and oil boiler, this setup gives the customer the opportunity to produce hot water with a heat pump solution with CO2 as coolant. The plant is equipped with ejector technology and controlled by Fenagy's PLC, which can control both the capacity and the evaporators.

There are four outdoor air energy collectors, developed in collaboration with Güntner and set up on 2 m legs mounted on point foundations with fascine for defrosting water. The heat pump supplies 750 kW refrigeration capacity to the warehouse four months a year, and heat production is supplied to the district heating network.

The heat pump has been delivered and commissioned in February 2022.

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

Aalborg Forsyning (District heating) is building a local energy center on the IKEA site with an electric heat pump, which initially has a cooling effect of just under 1 MW. The heat pump produces district cooling for IKEA, and at the same time the excess heat from the process is utilized. The heat produced at the plant is fully utilized by Aalborg Forsyning, which uses the heat directly in the district heating system to heat buildings in Aalborg. Compared to conventional cooling, the system is very efficient, as the excess heat is used as district heating.

In principle, is the energy used twice - IKEA gets district cooling and saves a lot of energy, and the district heating gets some heat, which can be send into the district heating system. The system is thus both good for IKEA, for the heating customers and for the environment.

The surplus heat that comes back from the cooling plant can annually heat the equivalent of around 480 standard houses or six warehouses the size of IKEA Aalborg with sustainable district heating.

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

District cooling is a new business area for Aalborg District Heating, where New Aalborg University Hospital in Region North Jutland is the first major district cooling customer. IKEA is the second, and several other customers are in the pipeline.

The market for district cooling has great potential, and IKEA is a strategically important partner for Aalborg District heating, because the project with them gives the opportunity to show that we can produce district cooling in several different ways. At the same time, there are several shopping centres, warehouses and businesses in Aalborg South, to which district cooling also can be supplied.

The energy center at IKEA will be prepared so that more customers in the nearest local area can be connected. The plan is for the remote cooling system for IKEA to be ready for use in a year.

6. Results of the project

- Technical capacity of approx. 1MW with the option to expand if more customers are interested.
- The plant has a total CO_2 saving of between 1120-1950 tonnes in the period 2022-2028.
- The excess heat from the system can annually heat up what corresponds to approx. 480 ordinary houses.

7. Challenges / socio economical barriers and opportunities

8. Additional information: Flexibility options

Contents: district heat pump

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)		