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Handbook

Experiences from other urban waste heat recovery investments

WP 6
Task 6.1
Deliverable D6.1

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This page is used to follow the deliverable production from its first version until it is approved by the Coordinator. Please give details in the table below about successive releases.

When	**Who**	**Comments**
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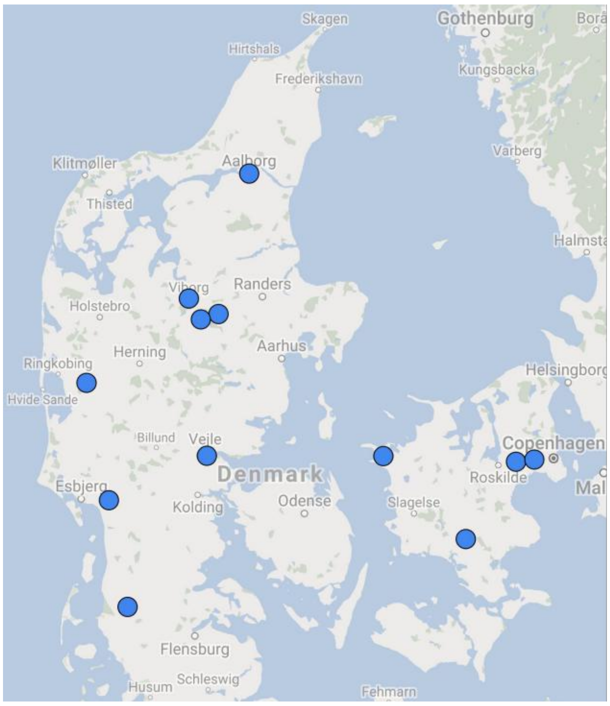
ReUseHeat website: www.reuseheat.eu

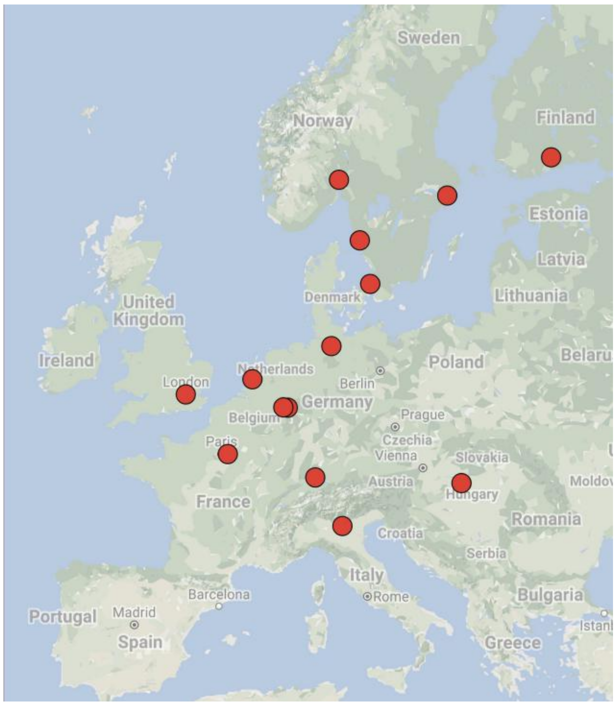
Handbook

25 cases of urban waste heat recovery

Introduction

This catalogue contains 25 existing or planned projects which make use of urban excess heat. The cases gathered serve as small-case inspirational projects on how to utilize excess heat from urban sources for heating and cooling purposes. Most of the cases exploit low-temperature waste heat sources through heat pumps for district heating solutions. Of these, 12 cases are Danish and 13 cases are from other European countries. The locations of the 25 Danish and European cases are plotted on the following maps. In the Danish context there are multiple projects regarding recovery of waste heat from urban sources with heat pumps. Information on Danish cases has been collected internally in Danish District Heating Association (DDHA). Information on cases outside of Denmark has been found using knowledge from the EU project CELSIUS and has been collected from the countries of the demonstrators in the ReUseHeat-project. Heat sources within this catalogue are, to the extent possible, matched to the ones used by the demonstrators. That is waste heat recovery from data centres, sewage water, hospitals and underground stations. No cases have been found in the demonstrator countries Spain and Romania.





Cases

Danish Cases

International Cases

1 Waste water as heat source

In 2017 operation of a 10 MW electric heat pump, utilizing heat from waste water to produce district heating, was initiated in Kalundborg. It is currently the largest heat pump facility in Denmark.

Description

The heat pump has an important role in the city, as the nearby central power plant Asnæsværket, is set to convert from coal to biomass. During the conversion period, the heat pump will supply the local district heating network with 30 % of the total heat production. Afterwards the heat pump is supposed to cover 10 % of the heat production and act as a peak- and reserve load. The conversion of Asnæsværket is expected to be finished at the outset of 2019.

The heat pump utilizes heat from the nearby waste water treatment plant with waste water temperatures above average, due to the local industries Novo Nordisk and Novozymes. The heat pump is the final part of a setup, which utilizes the waste water three times:

- Firstly, it is utilized at Novozymes, where organic content is withdrawn from the waste water and used for biogas production.
- Secondly, the waste water treatment plant utilizes the temperatures between 20 °C and 35 °C to accelerate biological processes.
- Thirdly, the waste water with a temperature between 20 °C and 25 °C is recovered in the heat pump. The wastewater is cooled approximately 10 °C in the heat pump.

The heat pump facility is set to replace two obsolete oil-fired peak- and reserve load boilers of 5.1 MW and 8.7 MW from 1968 and 1975. By replacing natural gas from oil boilers, the heat pump contributes with energy and CO_2-savings, benefiting both consumers and the environment.

Facts about this case

Installed heat capacity: 10,000 kW
Heat source: Waste water (20-25 °C)
Heat pump COP: 3.6-4.0
Annual operation hours: 8000 hours the first two years and 900 hours after 2019.
Investment cost: € 7.25 M
Savings: € 33,600 per week until 2019

Period: Finished in 2017
Organization: Kalundborg Forsyning A/S
District heating network: 5010 consumers
Link to web page: https://www.kalfor.dk/

Contact information:
Hans-Martin Friis Møller, Kalundborg Forsyning A/S, +45 6116 9940, hmm@kalfor.dk

Source: Kalundborg Forsyning

2 Excess heat from vegetable market

In 2016, the old vegetable market in Høje Taastrup was replaced by Copenhagen Markets, a new and comprehensive vegetable market with a large cooling demand. Low-temperature heat from district cooling is used to produce district heating.

Description

The local district heating company, Høje Taastrup Fjernvarme, delivers district cooling to the vegetable market through a large joint grid. An electric refrigeration compressor supplies the cooling. Hereby, individual and less efficient cooling systems were replaced by a centralized cooling unit that benefits from economies of scale. Return flow from the district cooling network contains heat, which is upgraded through a heat pump to supply hot water to the district heating consumers. The overall system takes advantage of co-producing cooling and heating, where production of cooling cannot be delivered without production of heat.

The system is currently the most comprehensive district cooling system in the Nordic Region. Fruits, vegetables, and flowers are preserved at optimal temperatures while district heating prices are lowered. The district cooling system displaces old refrigerator units which lowers the overall energy consumption and benefits the environment. The next stage in Høje Taastrup is to expand the district cooling network and add more heat pumps, thereby increasing the numbers of consumers. District cooling proves to be an important part of the future urban development for both comfort and process needs and there is a large potential for district cooling in Denmark.

Source: Høje Taastrup Fjernvarme A.m.b.a.

Facts about this case

Building type: Vegetable market
Cooled floor area: 15,000 m^2
Installed cooling capacity: 2000 kW
Installed heat capacity: 2300 kW
Heat source: Heat from district cooling (16 °C)
Refrigerator COP: 2.16
Heat pump COP: 3.14
Temperatures: District cooling is delivered at −8 °C, using an extra chiller, and returns at 16 °C
Investment cost: € 3.36 M

Production: the heat pump contributes with 3 % of the total heat consumed in Høje Taastrup
Period: Finished in April 2016
Cooling potential: The overall cooling potential in Høje Taastrup is 56 MW.
District heating network: 6784 consumers
Link to web page: http://www.htf.dk/

Contact information:
Uffe Schleiss, Høje Taastrup Fjernvarme amba, +45 4355 3019, uffe.schleiss@htf.dk

Source: Høje Taastrup Fjernvarme A.m.b.a.

3 Super Supermarkets

The aim of the project is to evaluate, demonstrate and implement the possibilities of utilizing supermarket refrigeration systems as sources for district heating networks.

Description

Different tasks examine the potential of recycling heat from refrigeration systems and use the demand side of flexibility to fulfill three sub-goals.

1. **Recycling heat from cooling operations for in-house use and export to district heating networks**
   The sub-goal is to develop and demonstrate a Best Practice for recycling heat based on experience of already installed systems and extensive knowledge from project partners. Hereby the newest knowledge from cooling, heating and legislative sources are combined and 10 to 15 feasibility studies are carried out to examine the potentials.

2. **Use heat pump capacity in supermarkets for district heating production**
   In Denmark 2684 supermarkets have an installed heat pump/cooling capacity of approximately 400 MW, however, only 30 % of this capacity is used. The spare capacity has a potential as decentralized district heating production.

3. **Optimize power consumption through increased power market flexibility**
   The sub-goal is to investigate and potentially demonstrate cooling systems designed for selling power system services. Multiple supermarkets can be aggregated to represent a larger power system service.

Existing supermarkets and district heating companies are examined in three demo-projects:

- SuperBrugsen in Bramming and Bramming Fjernvarme.
- SuperBrugsen in Bjerringbro and Bjerringbro Varmeværk.
- SuperBrugsen in Vindinggård and Mølholm Varmeværk.

There is a large potential in replacing current refrigerator systems with CO_2 cooling and refrigerator systems. Hereby, gas cooling temperatures are increased, and excess heat can be utilized directly in the district heating network. There is accordingly no need for extra heat pumps to increase the temperatures. Multiple supermarkets in Denmark already use excess heat from supermarkets, there is, however, still a large unexploited potential. The heat harnessed from a supermarket typically correspond to the annual heat consumption of 20 ordinary Danish households.

Facts about this case

Building type: Supermarkets
Heat source: Heat from cooling in supermarkets
Project budget: € 640,000
Participating countries: Denmark and Sweden
Period: 2016-2019
Expected results:

- A book of guidelines with targeted communication to all interest groups.
- 500-1000 retrofitted supermarkets in Denmark in a period of 3-5 years after the project ends.
- Pursue export potentials and open for Danish export of technology solutions to the rest of Europe, North America and China.

Project leader: CLEAN
Project partners:

- Danfoss A/S, COOP DANMARK A/S, Dansk Fjernvarme, Dansk Fjernvarmes Projektselskab Amba, Bramming Fjernvarme Amba, Andelsselskabet Mølholm Varmeværk, Bjerringbro Varmeværk Amba, Teknologisk Institut, KTH Royal Institute of Technology Stockholm, Ivar Lykke Kristensen Rådgivende Ingeniøre A/S, AK Centralen A/S, OK A.M.B.A.

Link to web page:
http://supersupermarkets.dk/

Contact information:
Lone Gramkow, CLEAN, +45 2031 6463, log@cleancluster.com

Source: http://supersupermarkets.dk

4 Synergies between industry and district heating

In 2013 the pump manufacturer Grundfos and the local district heating company Bjerringbro Varmeværk, made a mutual investment in three heat pumps to co-produce heat and cooling.

Description

The traditional cooling systems at Grundfos in Bjerringbro have previously been disposing excess heat to the surroundings. This excess heat is now utilized in heat pumps which offers both a supply of heat to the district heating network and a supply of cooling to Grundfos.

Grundfos have a large cooling demand, mainly through summer periods, where the heat demand from the city is small, and vice versa. Therefore, an aquifer thermal energy storage (ATES) is used in the summer to deliver cooling to Grundfos. In the winter, when the cooling demand is low, the ATES is replenished with cooling from the heat pumps, which deliver heat to the city. Thereby excess heat is transferred from summer to winter.

The heat pumps increase flexibility at the district heating plant. When electricity prices are high, the natural gas-powered engines are operating and produce both heat and electricity. When the electricity prices are low, the heat pump system is used. This results in considerable CO_2-savings when using the heat pumps for cooling and district heating, as gas-based heat and outdated cooling facilities are displaced.

Bjerringbro Varmeværk believe that heat pumps are the future of district heating. Simultaneously Grundfos needed to replace their outdated cooling-systems with a large central cooling unit. The heat pumps are accordingly a great example of how synergies between the industry and district heating can be utilized through recovery of excess heat. The overall system is continuously optimized to keep the operation costs as low as possible, which eventually benefits the consumers of district heating and reduce the price of heating.

Source: Bjerringbro Varmeværk

Facts about this case

Installed heat capacity: 3700 kW
Heat source: Excess heat from cooling at Grundfos (40 °C)
Heat pump COP: 4,6
Production: 15 % of the district heating is based on excess heat from Grundfos
Investment cost: € 4.22 M
Period: Finished in 2013
District heating network: 2271 consumers

Link to web page:
http://www.bjerringbro-varme.dk/

Contact information:
Klaus E. Christensen, Grundfos Bjerringbro, +45 87 50 14 00,
Charles Hansen, Bjerringbro Varmeværk, +45 40 54 12 99, cwh@bjerringbro-varme.dk

Source: Bjerringbro Varmeværk

5 Heat recovery from local paper mill

The paper mill in Skjern, Skjern Papirfabrik, has invested in a large heat pump to make use of low-temperature waste heat from the paper drying process.

Description

In the paper drying process at the paper mill, a huge potential for energy recovery was discovered in the hot exhaust air. The hot exhaust air was previously emitted to the surroundings, however by extracting heat from the energy intensive air, a vast potential of excess heat is enabled.

In 2012, three heat pumps of 1.33 MW were installed at Skjern Papirfabrik, corresponding to a total heat pump capacity of 4.0 MW. Heat extracted from the system is sold to the local district heating company, Skjern Fjernvarme. The paper mill owns the heat pump and the district heating company established a transmission line to connect the heat pump facility with the district heating network. The paper mill already delivered district heating before enabling the heat pump solution through 2.0 MW direct heat exchange on natural gas boilers at the mill. The heat pump facility accordingly enlarges the well-working cooperation between the local industry and the district heating company.

In 2016, the annual heat production in Skjern Fjernvarme was approximately 76,000 MWh and the heat delivery from the mill was approximately 39,000 MWh, corresponding to 52 % of the total district heating production in Skjern. The remaining heat productions facilities at Skjern Fjernvarme are biomass boilers, which produced approximately 26,600 MWh in 2016, and natural gas units which produced approximately 10,000 MWh in 2016. The heat pump accordingly displaces both natural gas and biomass, corresponding to savings above 8000 tonnes of CO_2.

The district heating water is heated from 37 to 70 °C with exhaust air temperatures between 50 and 58 °C. The high air temperatures enable direct heat exchange, which reduce the temperatures to 43 °C. This low-temperature heat is utilized in the three heat pumps, as direct heat exchange is not possible. The heat pumps are accordingly needed to utilize the remaining heat. The district heating network is coupled directly with the heat pump system at the paper mill, where a storage tank can stabilize the delivery from the mill. The annual COP is approximately 6.9, however COP-factors between 8 and 10 occurs in periods of part load operation.

The price of heat is calculated monthly, based on the actual production costs of the heat pump facility and the marginal costs at Skjern Fjernvarme. The transfer price is placed in between these two prices to ensure fairness for both parties. The production costs at the mill and the district heating company are dynamic and depends on fluctuating variables such as the natural gas price and the spot price on electricity. Purchase of heat from Skjern Papirfabrik is always the most beneficial option for the district heating company.

Facts about this case

Installed heat capacity: 3 x 1.33 MW heat pumps + 2.0 MW direct heat exchange
Heat source: Low-temperature heat from the production process (43 °C)
Heat pump COP: 6.9
Production: 52 % of the district heating is based on waste heat from Skjern Papirfabrik
Investment cost: € 670,000 (Skjern Fjernvarme) and € 3.0 M (Skjern Papirfabrik)
Payback period: 5 years (Skjern Papirfabrik)
Period: Finished in 2012
District heating network: 3196 consumers
Link to web pages:
http://www.skjernfjernvarme.dk/
http://skjernpaper.com/

Contact information:
Karsten Jørgensen, Skjern Fjernvarme,+45 9735 1444 KJ@skjernfjernvarme.dk

Source: Skjern Papirfabrik, www.skjernpaper.com

6 Industrial waste water used for district heating

In 2016, the district heating company Rødkærsbro Fjernvarmeværk established two sets of transmission pipelines, connecting the nearby Arla dairy with the district heating network. The transmission system enables heat transfer from a newly installed biogas engine at Arla and transmission of hot waste water to a heat pump at the district heating plant.

Description

Through the transmission pipelines, Rødkærsbro Fjernvarmeværk receive excess heat from industrial processes at the dairy. The main purpose of utilizing excess heating from the local industry was to replace the former natural gas based production units. By doing so, both economically and environmentally benefits are obtained, due to lowered heating costs and reduced fossil fuel consumption and hereby reduced carbon emissions. The waste water from the dairy processes is low-temperature and was previously discharged into a nearby stream, but holds a large energy potential with temperatures between 22 and 25 °C. A 1.6 MW heat pump utilize the hot waste water and cools the water to approximately 5 °C, before it is discharged into the stream. This further derive positive environmental benefits.

Rødkærsbro Fjernvarmeværk have approximately 600 consumers and an annual heat production of 15,000 MWh. Of this, approximately 6500 MWh is delivered as baseload from the biogas engine, due to it being the cheapest heating production unit in the system. Another 6500 MWh is delivered from the waste water heat pump, while the remaining 2000 MWh primarily is bought from a small biogas plant. The heat pump is constructed as two serially connected heat pump units. District heating water is heated from 38 to 52 °C in the first heat pump and further increased to 70 °C in the second heat pump. At the diary, a heat exchanger cools the industrial waste water though an intermediate circuit, before the waste water is transferred 1800 m to Rødkærsbro Fjermvarmeværk. The temperatures delivered to the heat pump is approximately 20 °C and returns to the heat exchanger at Arla at approximately 3 °C. Waste water temperatures are constant throughout the year, enabling an annual COP of 4.6.

Heat pump operation begun in March 2017 and the unit have been running without major challenges since. The waste water utilization displaces great amounts of natural gas based heat production and reduce the CO_2-emissions with approximately 1000 ton CO_2 annually. The heat pump can produce between 40 and 45 % of the total heating demand in Rødkærsbro. The total investment was € 1.8 M of which the project received a grant from the Danish Energy Agency of € 320,000. The simple payback period is expected to be 7 years.

Facts about this case

Installed heat capacity: 1600 kW
Heat source: Low temperature industrial waste water (22-25 °C)
Heat pump COP: 4.6
Production: 6500 MWh per year
Investment cost: € 1.8 M (grants of € 320,000)
Payback period: 7 years

Period: Finished in March 2017
District heating network: 600 consumers
Link to web page: http://www.xn–rdkrsbro-fjernvarme-nxb98a.dk/

Contact information:
Vagn Rasmussen, Rødkærsbro Fjernvarme, rf@rkfjv.dk

Source: PlanEnergi

7 Energy optimization in a supermarket

A fire at the local supermarket in Høruphav on the island of Als near Sønderborg forced subsequent renovations. Multiple energy optimizations potentials was found, including a low-temperature heat recovery system. Since 2015, excess heat from the supermarket refrigeration system has been delivered to the local district heating company, Sønderborg Fjernvarme.

Description

The new refrigeration system has been installed at the local supermarket SuperBrugsen in cooperation with Danfoss and Sønderborg Fjernvarme. Heat recovery from the cooling system is capable of supplying the entire store with space heating and hot water. The cooling system is a CO_2-refrigeration unit. Hereby, gas cooling temperatures are increased compared to traditional refrigeration systems, and excess heat can be utilized directly in the district heating network. There is accordingly no need for additional heat pumps to increase the temperature. As a supplement to the refrigeration system a 1.8 m^3 hot water storage tank with a reference temeperature of 65 °C has been installed. CO_2-emission are reduced by 34 % by utilizing excess heat from the refrigeration system compared to the previous gas-based system.

As the supermarket heating system is designed for low-temperature operation, the payback period of the total investment is below 12 months. Hereby lower temperatures are required to heat the store and less energy is consumed in the refrigeration system. When the refrigeration system is paid for, excess heat can be sold to the local district heating company with economic benefits for SuperBrugsen in Høruphav. The heat recovery system investment was approximately € 7400 including the necessary piping but without the refrigeration system and the new low-temperate heating system. The annual saving is approximately € 27,000 depending on the actual cooling needs.

There is a large potential in not only Denmark, but worldwide, for supermarkets to become an integrated part of district heating. Excess heat can be used both internally in the supermarket and delivered to the district heating network consumers, resulting in large energy savings. SuperBrugsen in Høruphav can supply approximately 16 standard households of 130 m^2 annually.

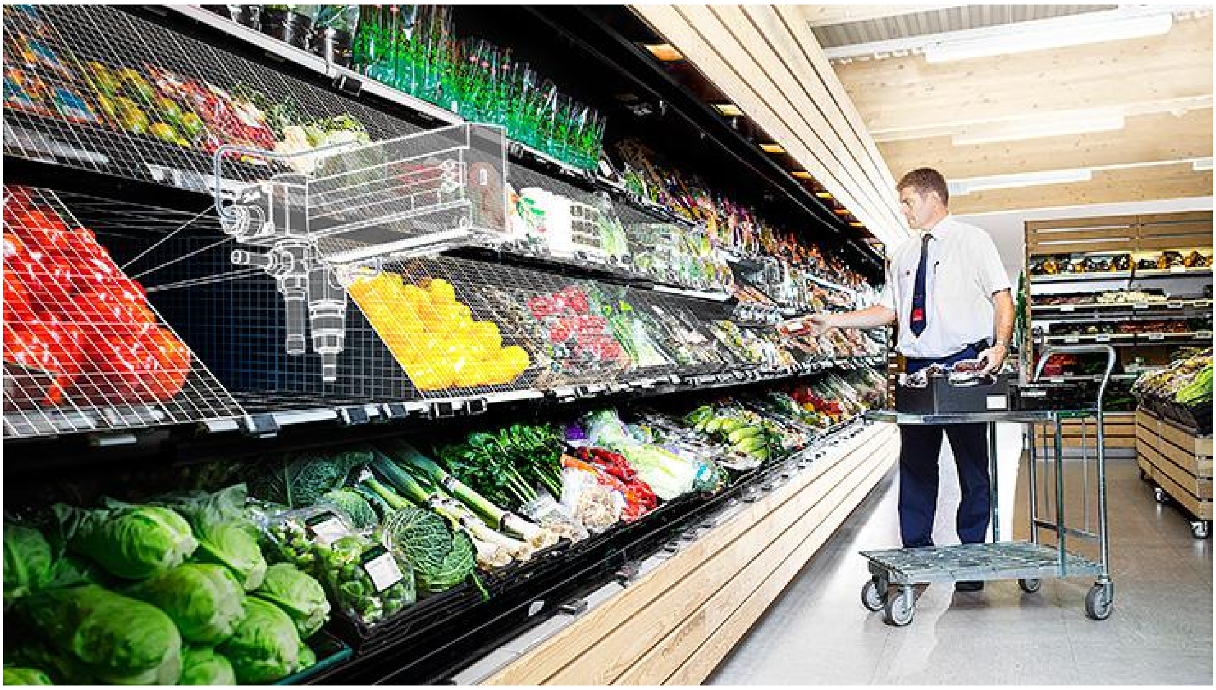
In addition to the heat recovery system, the supermarket installed a 50 kWp PV-system that covers approximately 5 % of the annual in-store electricity consumption. The investment costs for the PV-system was approximately € 54,000 with a payback period below 10 years. SuperBrugsen replaced their old lighting system with LED lighting resulting in annual electricity saving of approximately € 2700. The LED lighting further reduce the cooling demand in the hottest moths, as lighting temperatures are lowered.

Facts about this case

Heat source: Heat from cooling in supermarkets
Heat delivery: 16 standard households of 130 m^2
Energy optimization: Heat recovery system, PV-system installed on roof, LED-lighting
Investment costs: € 7400 (Heat recovery system only)
Annual savings: € 27,000
Payback period: Less than one year

Period: Finished in 2015
Link to web page:
http://www.sonderborg-fjernvarme.dk/
http://refrigerationand airconditioning.danfoss.com

Contact information:
Sønderborg Fjernvarme, Erik Wolff, ew@sfjv.dk
Danfoss, http://refrigeration andairconditioning.danfoss.com



Source: Danfoss

8 District heating from crematory

In connection to installation of a new filtration system at the municipally owned crematory in Aalborg, it was agreed, that a system utilizing energy from combustion should be installed. Hereby, the local district heating company, Aalborg Fjernvarmeforsyning, can receive excess heat from the crematory.

Description

The project has been enabled due to extra regulation on flue gas cleansing from crematory ovens. The regulation demands a filtration system to remove mercury. To do so, the flue gasses must be cooled. Instead of emitting heat to the surrounding ambient air, it is possible to use the excess heat in the district heating network. Hereby excess heat is extracted, benefiting the district heating consumers. The heat from the crematory can annually heat approximately 20 to 25 regular Danish households in the order of 120 and 140 m^2.

To enhance the lifetime of the filtration system, the flue gasses are cooled from approximately 800 °C to approximately 120-140 °C. This cooling process contain potential excess energy. In Aalborg, the crematory is expected to produce approximately 585,000 kWh per year based on 2340 cremations annually. The average amount of energy produced for each cremation is approximately 250 kWh. About 55,000 kWh of the energy produced from flue gas cooling is used internally, while the remaining is delivered to the district heating network. To reach high operation temperatures often above 800 °C, additional energy is added to the crematory ovens.

Cremation is a well-established funeral excerpt in Denmark and it more frequent than casket funerals. The issue of using heat from cremation in district heating has created moral discussions in Denmark and other European countries. The Danish Council of Ethics have processed district heating from crematoriums and concluded, that there is no acts of indecency when utilizing crematory heat, if it is used for district heating. The members of the council have on the contrary found great environmental benefits from utilization of crematory heat opposed to disposing it to the surroundings. As the main purpose of crematoriums is not to produce heat, the excess heat can be seen as a by-product from the cremation. Most of the heat further comes from the energy used to reach operation temperatures in the crematory ovens. Using the excess heat with direct heat exchanger to the district heating network, expensive and energy demanding cooling towers are avoided. Potential gains from sales of heat to district heating companies must however, according to the Danish Council of Ethics, be used internally to lower process operation costs. Hereby exploitation of crematory excess heat is does not have a commercial purpose.

Throughout Denmark, multiple crematoriums have begun to utilize the excess heat to produce district heating. The crematoriums are often located in urban areas and close to existing district heating networks. Among other Danish cities, that use excess heat from crematoriums are Ringsted, Holstebro, Randers, Hillerød, Svendborg, Hjørring and Glostrup. The potential is present in other European countries as well. A single crematorium is not capable of supplying district heating on its own, however they can assist both Danish and European cities in their district heating production.

Facts about this case

Heat source: Aalborg Crematory, flue gas (800 °C)
Capacity: 2 x 550 kW ovens
Production: 530,000 kWh per year
Temperatures: Supplied flow have a temperature between 75 and 85 °C.
Operation: 8 hours per day for 5 days a week

Investment cost: The extra costs for the district heating company is approximately € 40,000, due to new transmission lines
Annual socio-economic benefit: € 20,000
Period: Finished in 2010

Contact information:
Jens Bovbjerg, Aalborg Energikoncern, +45 9931 4886, jens.bovbjerg@aalborg.dk

Source: Danske Krematoriers Landsforening

9 Co-production with a gas engine driven heat pump

A gas engine driven heat pump unit in Tønder is expected to begin co-production of cooling and district heating in November 2017. Heat is supplied to the local district heating company, Tønder Fjernvarmeselskab, and cooling is supplied to the local company SAPA Extrusion. Previously, the heat production in Tønder was based solely on natural gas boilers.

Description

The heat pump unit consist of two parallel mechanical heat pumps driven by either natural gas engines or an electrically powered engine, depending on the present economic conditions. Depending on the cooling needs at SAPA, the heat pumps can be driven by either ambient air or cooling water from SAPA. Using ambient air with a temperature of 7 °C, the thermal capacity of the gas engine is 4.3 MW and for the electric motor it is 3.3 MW. By using more than one heat source, the heat pump investment is more robust, in the case of SAPA withdrawing their cooling needs. However, the two heat sources enable the heat pumps to operate with a larger heat pump capacity, compared to sole utilization of excess heat from SAPA.

Tønder Fjernvarmeselskab has approximately 2700 consumers connected to the district heating network and the annual heat production is currently 92,000 MWh. The annual heat production from the heat pumps, using ambient air, is expected to be at least 36,100 MWh, corresponding to nearly 40 % of the total heat deliverance. If cooling water from SAPA is to be used, the potential is larger, as the efficiency of the heat pumps would increase. Water from SAPA can be delivered with a temperature of approximately 20 °C, which is cooled to a temperature between 6 and 10 °C. When using the gas engine, the heat pumps are basically natural gas boilers with average annual efficiencies above 200 %.

In addition to the heat pumps, an accumulation tank has been established to store cold water, ensuring the supply for SAPA. The heat produced cannot be stored, meaning that the heat pumps must deliver supply temperatures around 70 °C directly to the district heating network. Nonetheless, the heat pumps decrease the amount of natural gas used at the district heating company. Simulations predict annual savings between € 725,000 and € 950,000, depending on the natural gas price. If the gas price increase, the savings increase as well.

While SKAT, the Danish Customs and Tax Administration, which is Denmark's tax authority, have stated, that the heat is not excess heat, co-production is still used to exploit an industrial heat source and thus resembling reuse of heat from an urban source.

Facts about this case

Installed heat capacity: 4.3 MW gas and 3.3 MWelectric
Heat source: Process cooling (20 °C) and air
Heat pump COP: 2.16 using air and 2.9 using excess heat
Production: 40 % of the total heat production in Tønder can be produced by the heat pump (based on air)
Temperatures: Excess heat is deliveres to the heat pump at approximately 20 °C
CO_2-savings: Above 4000 ton CO_2 annually
Investment cost: € 4.92 M (does not include necessary investments for SAPA Extrusion)
Savings: Between € 725,000 and € 950,000 annually
Period: Finished in 2017
District heating network: 2700 consumers
Link to web page: http://www.tonder-fjernvarme.dk/

Contact information:
Johnny Pedersen, Tønder Fjernvarmeselskab A.m.b.a., +45 7472 2801, e-mail@tonder-fjernvarme.dk

Source: Tønder Fjernvarmeselskab A.m.b.a.

10 Excess heat from hospital chillers

A heat pump solution at the Regional hospital in Viborg is planned to utilize excess heat from chillers and distribute it to the local district heating network. Hereby great amounts of unused energy can be harvested from the hospital dry-chillers.

Description

The project comprises a new heating distribution system for the Regional hospital in Viborg, where excess heat from the dry-cooling process is enhanced through heat pumps to deliver district heating to the local district heating company Viborg Fjernvarme. Hereby the existing steam boilers can be decommissioned.

The cooling needs of the hospital is not only fluctuating on annual basis, but also with hour-to-hour variations within a single day. It is possible to reuse some of this unused heating internally at the hospital in Viborg and there is no delivery of excess heat during winter. The excess heat is accordingly available from April until start November. The heating potential is annually 4700 MWh of which the majority is in the three hottest months, June, July and August. During daytime, the excess heating capacity reach approximately 3 MW while it drops to, or close to, zero during night. Hereby the operation hours will be limited to specific periods of the year. There are however no problems with heat allocation, as the heat demand in Viborg is sufficient during summer.

The cooling water is 43 °C when it reaches the heat pumps and is 36 °C when it returns to the cooling unit. With district heating temperatures increasing from 40 to 65 °C, the COP is very high. At the given temperatures and operation conditions, the cooling capacity of one heat pump is approximately 1 MW. Calculations on the optimal heat pump system show, that two heat pumps can utilize 87 % of the total excess heat. Hereby a COP of 7.9 is reached. The two heat pumps accordingly reach a high utilization ratio and a low electricity consumption. The total cooling capacity of the system is approximately 2 MW, while the heating capacity is approximately 2.5 MW. The heat pumps can cover the main cooling needs during summer. The existing dry-cooling system is however still needed to supply cooling peaks. The two heat pumps are serially connected to the district heating grid, increasing the temperature in two stages from 40 to 53 °C and from 53 to 65 °C.

The total investment costs are expected to be approximately € 1.0 M, of which € 537,000 are the heat pump facility. Other costs include buildings, district heating connections and electricity connections. The total heat cost is expected to be € 28 per MWh of heat, which is a low cost compared to other heating production units. Of this the majority is capital investment costs and expenses for electricity consumption.

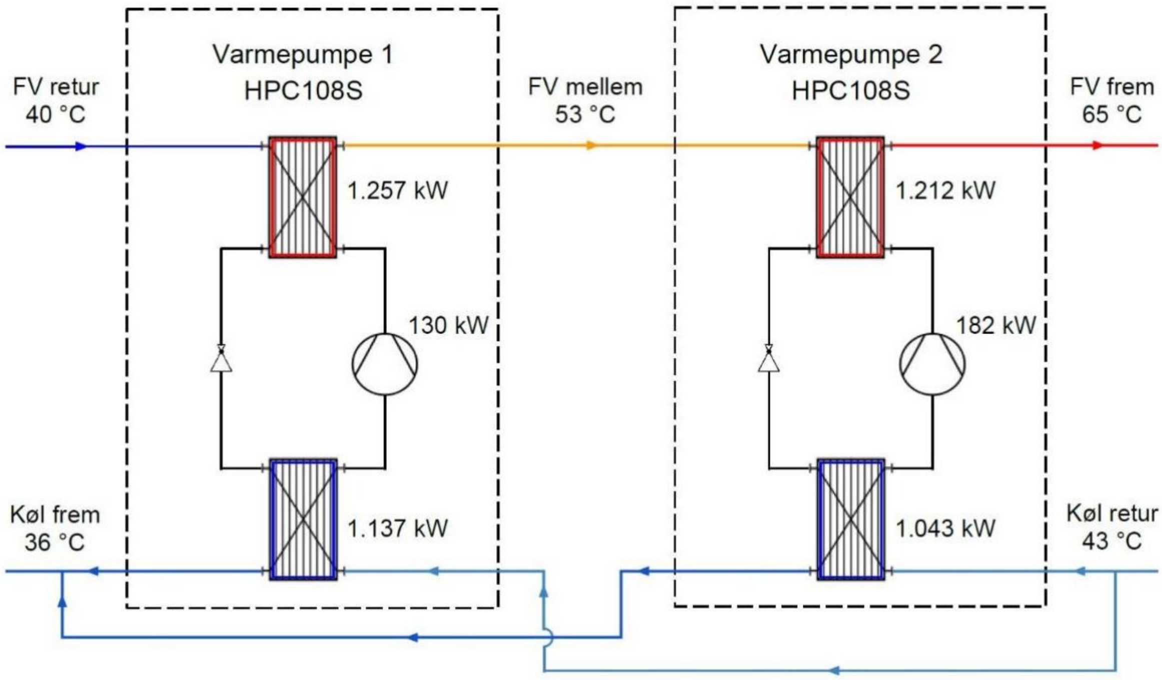
Facts about this case

Installed heat capacity: 2.5 MW
Heat source: Excess heat from chillers (43 °C)
Heat pump COP: 7.9
Production: 4700 MWh per year (the majority is in the three hottest months)
Investment cost: € 1.0 M

Period: Project begun in 2017
Link to web page: http://www.viborg-fjernvarme.dk/

Contact information:

Morten Abildgaard, Viborg Fjernvarme, +45 2532 6000, mab@viborg-fjernvarme.dk



Source: PlanEnergi/Viborg Fjernvarme

11 Excess heat from mink coat storage

Kopenhagen Fur have from fall 2017 been allowed to send excess heat to the local district heating company, Glostrup Varme. The excess heat is from Kopenhagen Furs large cold storage, where mink coat is stored before it is redistributed. Hereby excess heat is utilized instead of being chilled using coolers.

Description

By extracting excess heat from the cold storage facility at Kopenhagen Fur the previous refrigeration units are replaced with a heat pump. The project was a part of Kopenhagen Fur needing a new cooling unit for both process and comfort cooling. It is expected that the heat pump can deliver cooling with an annual capacity of 1 MW. Glostrup Varme have a next-door heating central where the excess heat from Kopenhagen Fur is send to the district heating network, hereby supplying local consumers with heating from mink coat storage.

Currently, Kopenhagen Fur is supplied with district heating from Glostrup Varme. Glostrup Varme is however a part of a major district heating transmission network called VEKS, which supply multiple district heating companies around Greater Copenhagen. Kopenhagen Fur is expected to deliver a baseload of 1 MW heating to the network, which is a relatively small capacity compared to the total VEKS-network. The heat pump can produce 6000 MWh of heating annually which is delivered at approximately 70 °C to the district heating network. If needed, the heat pump can deliver heating at 90 °C. The COP is expected to be 5.0 if heating is delivered at 70 °C.

The total cost is € 295,000, of which € 161,000 is financed by Glostrup Varme and € 134,000 is financed by Kopenhagen Fur. The total heat pump costs are approximately € 134,000 higher than if only the cooling system was constructed.

Facts about this case

Installed capacity: 1.0 MW
Heat source: Industrial excess heat from cooling
Heat pump COP: 5.0
Temperatures: Heating can be delivered at temperatures between 70 and 90 °C
Investment cost: € 295,000 (€ 161,000 financed by Glostrup Varme and € 134,000 financed by Kopenhagen Fur)

Period: Finished in 2017
Link to web page:
https://www.glostrupforsyning.dk/varme/

Contact information:
Henrik Nicolaisen, Glostrup Varme,
hn@glostrupforsyning.dk

Source: Rambøll

12 Exploiting excess heat from a converter station

The Danish and Dutch TSO's Energinet and TenneT is currently establishing an international connection between Denmark and the Netherlands called COBRA cable. The HVDC converter station in Endrup near Bramming is expected to deliver excess heat to the local district heating network.

Description

In Denmark multiple HVDC converter stations exist, which connect the Danish electricity grid with surrounding countries and enable international electricity transmission. Near Endrup in Jutland such a converter station is built, where DC is transported to Eemshaven in the Netherlands through the COBRA cable. The cable has a voltage of 320 kV with a transmission capacity of 700 MW and is expected finished and ready for usage in 2019. The converter station will generate surplus heat, which, without energy recovery is cooled away by fans. The surplus temperature will reach approximately 35 °C and the converter station will have a full load capacity of 3150 kW. Due to the origin of this excess heat, there is no tax involved, which benefit the project.

The accessible end-user of excess heat from the converter station is the district heating company Bramming Fjernvarme, located 7 km from Endrup. Bramming Fjernvarme currently has a decentralized natural gas powered CHP unit and a district heating network with approximately 2500 households and buildings connected. Multiple options for harvesting the excess heating potential from the converter station exist, but so far, no real project proposal have been made. An option is to transport low-temperature heat from the converter station to Bramming before heat pumps increase the temperature to district heating network levels around 68 °C. A second option is to increase the temperature directly at the converter station and then transport the heat to Bramming. Which option is chosen largely depends on the actual costs and transmission losses. A high-level COP is obtainable due to a relatively high exit-temperature from the converter station. Estimates suggest a COP-factor above 6.0. The costs of establishing the project is currently unknown, but heating production costs will probably be lowered compared to the existing natural gas-fired units.

Facts about this case

Heat source: Excess heat from a converter station (35 °C).
Heat pump COP: Expected above 6.0
Temperatures: Surplus temperature from the converter station is expected to be 35 °C.
Period: Expected to be finished in 2019

District heating network: 2500 consumers
Link to web page: https://energinet.dk/ http://www.brammingfjernvarme.dk/

Contact information:
Steen Thøgersen, Bramming Fjernvarme, post@brammingfjernvarme.dk

Source: Energinet

13 Heat recovery from the London Underground in Islington, UK

An expansion of Bunhill Energy Centre in Islington is a part of a project to capture waste heat from London Underground tunnels. Heat recovered is used to warm local homes and lower the energy bills.

Description

Temperatures in London's tubes can get high and currently most of this energy is discharged through ventilation systems all over London. Most of this heat is produced by the train system, of which a great part is form braking losses, mechanical losses and drivetrain. Only a small part of the heat is produced by passengers. Currently, most of the heat is absorbed in the tunnel walls and approximately 10 % of the heat is removed by mechanical ventilation.

The EU-funded CELSIUS-project, a platform of networking and knowledge-sharing regarding barriers to district heating and cooling solutions, aims to demonstrate heat recovery from London Underground's ventilation system through an electric heat pump system. Hereby, energy is extracted and used to produce local district heating. The Bunhill Energy Centre already through a previously project in 2012 created a local district heating system to warm two leisure centres, three communally heated council houses and one private housing development, covering 805 units in total. The existing system consist of a 1.9 MW CHP gas engine and 115 m^3 thermal storage with 1.5 km of district heating pipework.

The CELSIUS-project aim to expand this network with 454 homes and include excess energy from London Underground, potentially further supplying 1000 homes. Removing heating from the tunnel system in winter, when it is mostly needed above ground, can help cool surrounding walls and hereby lower overall temperatures during summer. Heat extraction during winter enables more absorption capacity for the tunnel walls during summer.

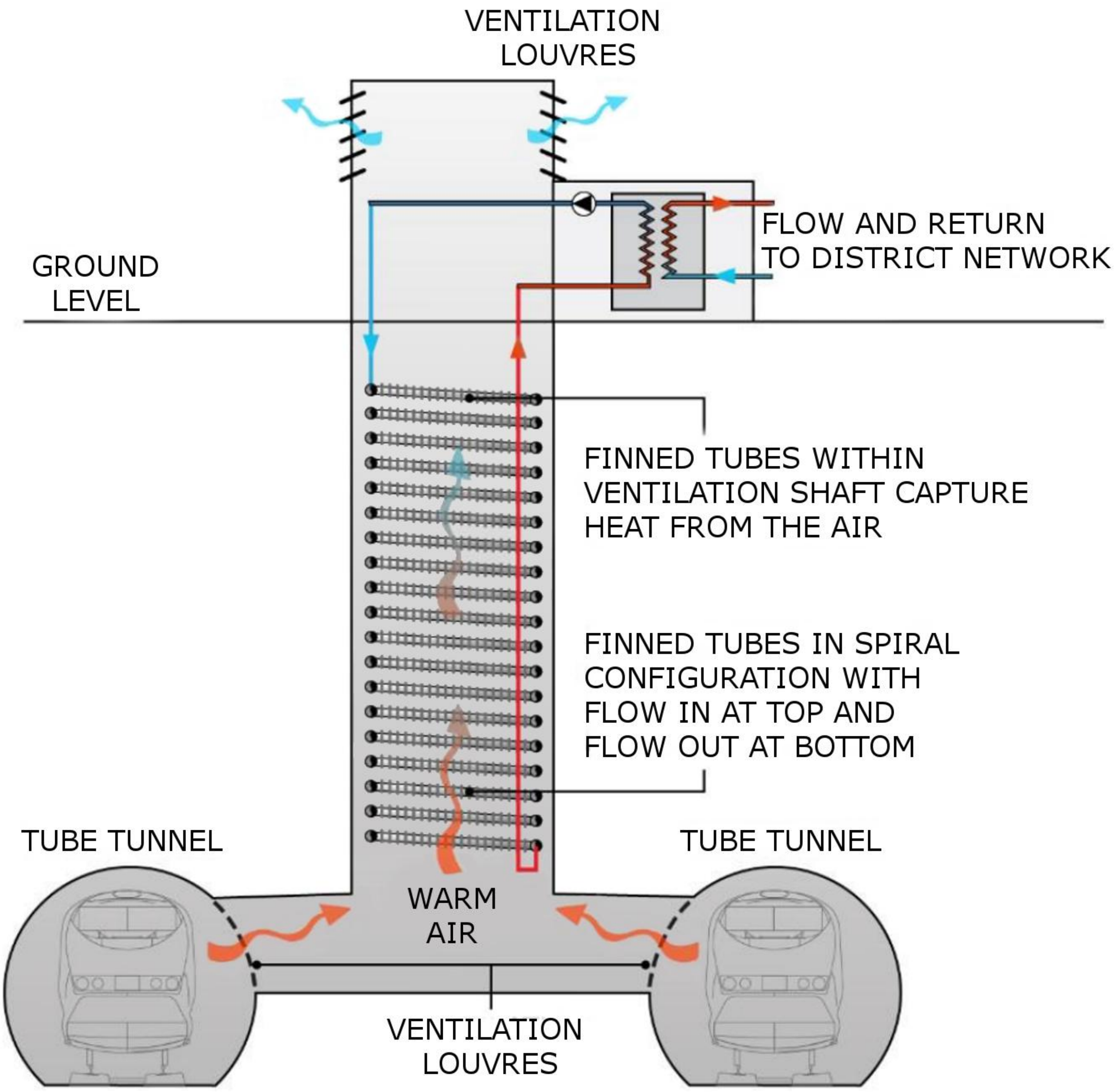
Finned tubes within the ventilation shaft capture heat from the air. The ventilation shaft expels exhaust air at a rate of 30 m^3/s with a temperature of 22 °C in winter and 28 °C in summer. A feasibility study found that the heat capacity of the ventilation shaft would be approximately 400 kW. By increasing fax expelling air rate to 70 m^3/s the heat capacity would be increased to 1000 kW. Hereby, low-grade waste heat is recovered from the ventilation shafts through a air-to-water heat pump. Two 237 kW CHP gas engines, which produce electricity, can power the heat pumps when electricity prices are high. The heat pump can accordingly operate without connection to the national electric grid, when both heat pump and CHP's are operating. The CHP's can further operate without the heat pumps, hereby exporting electricity to the national grid.

Facts about this case

Installed heat capacity: 1 MW heat pump and 2 x 237 kW CHP gas engines.
Heat source: Excess heat from London Underground ventilation system (22-28 °C)
Potential: 10 % of heat losses from the London Underground is from ventilation.

Support: FP7-supported CELSIUS-project
Organization: Islington Council
District heating network: +1000 units
Link to web page: http://celsiuscity.eu/

Contact information:
CELSIUS-project



Source: Greater London Authority

14 Sewage water demonstrators in Cologne, Germany

Three demonstrators in Cologne in the areas Mülheim, Nippes and Wahn, aim to utilize heat recovery from waste water. Heat is used to warm schools in a decentralized local heating network. More than 84 % of the EU population is connected to a sewage network and it is assumed, that 5 % of the total heat demand in cities and towns could be covered with heat recovered from sewage systems.

Description

The three demonstrators are a part of the EU-funded CELSIUS-project, a platform of networking and knowledge-sharing regarding barriers to district heating and cooling solutions. All sites utilize sewage pipelines as source for heat recovery through heat pumps. The overall system at the three demonstrators is composed of heat exchangers, water-to-water heat pumps, additional gas boilers for peak-loads and heat buffer tanks to increase heat production flexibility. At the two sites Mülheim and Wahn, the heat exchanger is installed inside the sewage pipe, making the heat exchange technique unique. At Nippes, the heat extraction is directly with sewage water, meaning that a part of the sewage water is withdrawn from the pipeline and pumped directly into the evaporator of the heat pumps.

The CELSIUS project found, that sewage temperatures of at least 12 °C are necessary to ensure economic feasibility. If low district heating supply temperatures are sufficient, high COP-factors can be obtained. There is accordingly a need of a relatively high heat demand above 150 kW to pay off the investment costs, and the sewage solution is most applicable in new construction or major refurbishment of buildings with a substantial heat demand. Further, there should be a short distance between the sewerage piping system and the building and the sewage pipeline should have an adequate size and flow.

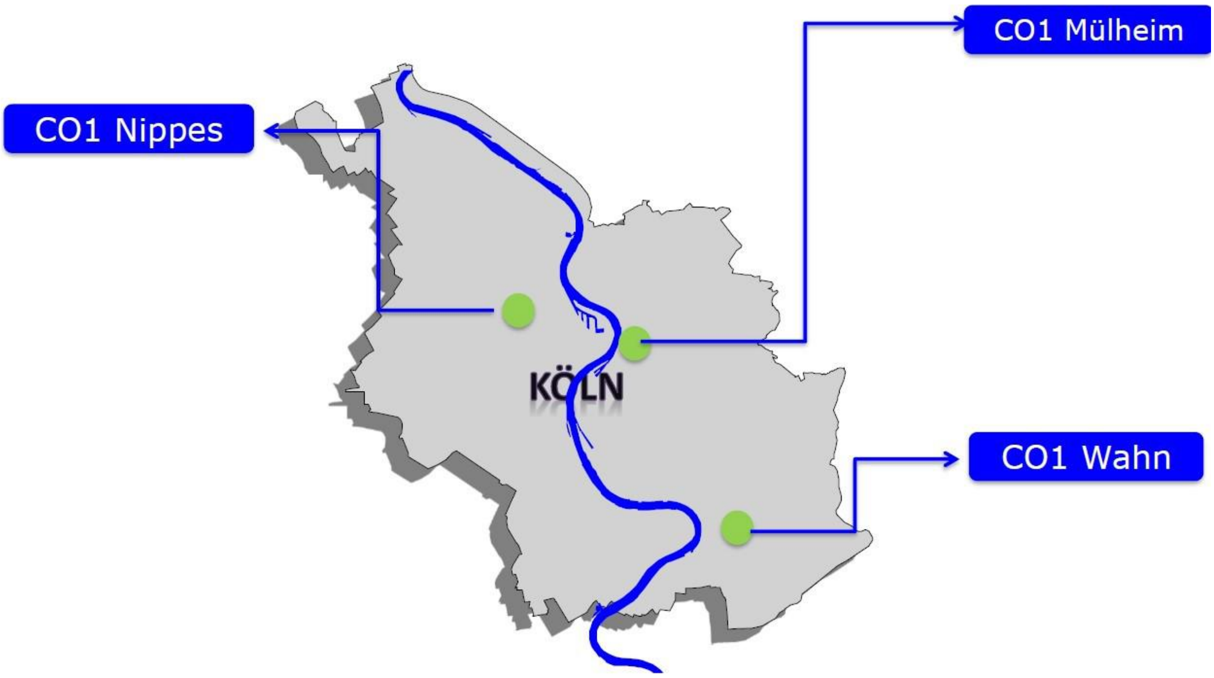
In general, the CELSIUS demonstrators have showed, that the technical dimensioning must be optimal if the sewage heat recovery is to be economically durable. Further, the heat customer must be convinced, that a sustainable solution is better than the alternative, which in Europe often is natural gas boilers.

Facts about this case

Annual thermal energy provided: 1109 MWh (Wahn) and 762 MWh (Mülheim)
Heat source: Excess heat from sewage water (at least 12 °C)
Energy efficiency: 116 % in Wahn and 128 % in Mülheim
Annual greenhouse gas savings: 214 tonCO_2e in Wahn and 150 tonCO_2e in Mülheim

Period: From 2012 to 2016
Support: FP7-supported CELSIUS-project
Link to web page: http://celsiuscity.eu/

Contact information:
CELSIUS project: Rhein Energie, Fachhochschule Köln, D'Appolonia



Source: CELSIUS

15 Excess heat from lignite mining in Bergheim, Germany

The thermal potential of sump water from open pit mining is used to supply heat to nearby communities through district heating networks. A high-temperature heat pump utilizes geothermal energy from lignite mining in Bergheim.

Description

The city of Bergheim is located left of the Rhine river near Cologne, right at the centre of a mayor lignite open pit mining district. In Bergheim, approximately ten public facilities are supplied with thermal heat through the communal district heating network. Sump water is a by-product of lignite mining, as groundwater needs to be drained from the open pit mine. The sump water contains a large geothermal potential, with temperatures up to 27 °C. Sump water is accordingly drained through pipes and transferred approximately 400 m to a heat generation station. Here, temperatures are raised in a heat pump to approximately 85 °C, and heat is send through the local district heating network to supply local consumers such as sport centres and schools.

The heat pump has a heat capacity of 865 kW and is driven by CO_2 hereby enabling high-temperature delivery. It is supplemented by a 400 kW CHP natural gas engine, a heat storage and two existing natural gas boilers of 1860 kW and 2300 kW, functioning as peak load units. Electricity produced in the gas-powered CHP unit is, in combination with sump water, used in the heat pump. Hereby energy from the open pit groundwater is extracted and utilized. If the CHP unit produce more electricity than the heat pump demands, it is supplied to the national grid. The heat pump operates with a COP of approximately 3.0. The total CHP and heat pump system has an efficiency of 167 % and as electricity is supplied directly to the heat pump, the unit corresponds to a high-efficient natural gas boiler.

The system is supplemented by an energy storage tank with a volume of approximately 25 m^3. The buffer tank increases flexibility of the overall system and is able to supply the heating network for several hours. Hereby, the system can deliver heat in periods when the sump water supply is limited due to maintenance or other events.

The heat pump system reduces the fossil fuel demand by 26 % and reduce the CO_2-emissions by 32 % compared to the previous system without utilization of excess heat. It lowers the heat prices in the community and is a reliable source of energy, as two sources, electricity and gas, are used. By extracting energy from the lignite mine, groundwater temperatures are decreased which derive environmental benefits.

Facts about this case

Installed heat capacity: 865 kW (heat pump) and 314 kW (CHP unit)
Heat source: Excess heat from open pit mining (27 °C)
Heat pump COP: 3.04
Temperatures: 27 °C sump water is cooled to 21 °C. District heating intake temperature is 45 °C and delivered at 85 °C.

Overall system efficiency: 167 %
Period: Finished in December 2014
Organization: Stadtwerke Bergheim GmbH

Contact information:
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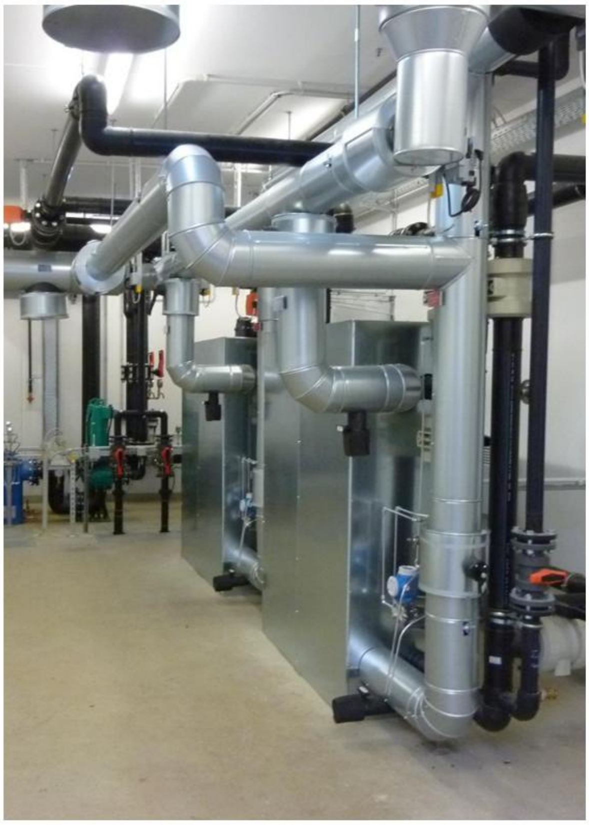
GESA mbH – Ingenieurgesellschaft für Technische Gesamtplanung, koelnbonn@gesa-ingenieure.de, Cologne



Source: Dürr Thermea GmbH

16 Datacentre supplies local heating in Mäntsälä, Finland

The city of Mäntsälä located approximately 55 km north of the Finish capital Helsinki, installed a heat pump capable of supplying 1500 homes with heating. The heat pump extracts heat from a nearby data centre.

Description

Hot air from data centres holds a huge potential for energy recovery. By removing the air and utilizing the excess heat it can be used in local district heating networks. In 2015 Mäntsälä installed a 4.0 MW heat pump which utilize the excess heat from the local Yandex data centre.

Heat exchangers extract hot air from the data centre servers at temperatures of approximately 40 °C. This is used in the heat pump, where the temperature is increased to approximately 85 °C. The heat pumps are optimized to achieve high temperatures hereby having a high COP, which potentially can be above 4.0. The heat pump does not affect the design of the data centre, as energy is harvested from the outgoing airstream. Extra fan-power is merely added to the building to extract the heat from servers.

By extracting waste heat from the computing centre, 75 % of the energy originally used can be reused. Further, the excess heat replaces natural gas heating and hereby reduce the annual CO_2-emission with approximately 4000 ton CO_2 in the first years, which later can be up to 11,000 ton CO_2. Currently the heat pump can supply 1500 homes with heating through the district heating network. Later, as the district heating network is to be expanded, this number can rise to about 4000 homes.

Source: Celefa

Facts about this case

Installed heat capacity: 4.0 MW
Heat source: Cooling of data centre (40 °C)
Heat pump COP: 4.0
Temperatures: Air exhaust from datacenter is approximately 40 °C and the heat pump deliver to the district heating network at approximately 85 °C

CO_2-reduction: 11,000 ton CO_2 annually
Period: June to December 2014
Link to web page: https://www.nivos.fi/

Contact information:
Nivos Energia, Mäntsälän Sähko OY,
asiakaspalvelu@nivos.fi

Source: Calefa

17 Heat pumps using waste water in Gothenburg, Sweden

Four heat pumps at Rya Värmepumpverk in Gothenburg, Sweden, extracts heat from a waste water treatment plant. The excess heat is delivered to the local district heating network.

Description

A great amount of the heating produced in the district heating system of Gothenburg is from excess heat. However, during winter, it is necessary to operate other production facilities such as biomass and natural gas boilers and CHP units. To contribute with environmentally friendly heating, the city of Gothenburg established Rya Värmepumpverk, a local heat pump facility with four heat pump units. The heat pump plant was established in 1985 with multiple heat pump units. The units extract heat from the local waste water treatment plant. The total heating capacity for the heat pumps is 160 MW, divided upon two 30 MW heat pumps and two 50 MW heat pumps. All heat pumps are compressor driven and supplied with electricity from the Swedish grid.

As the heat pumps are greatly flexible they operate as peak-loads. The heat pumps accordingly act as support for the baseload in Gothernburg consisting of waste incineration and waste heat recovery from a local refinery. The waste water has temperatures of approximately 12 °C, which is cooled to approximately 3 °C through the heat pump. The heating delivered to the district heating network is between 75 and 85 °C, depending on season and district heating water is returned at 45 °C.

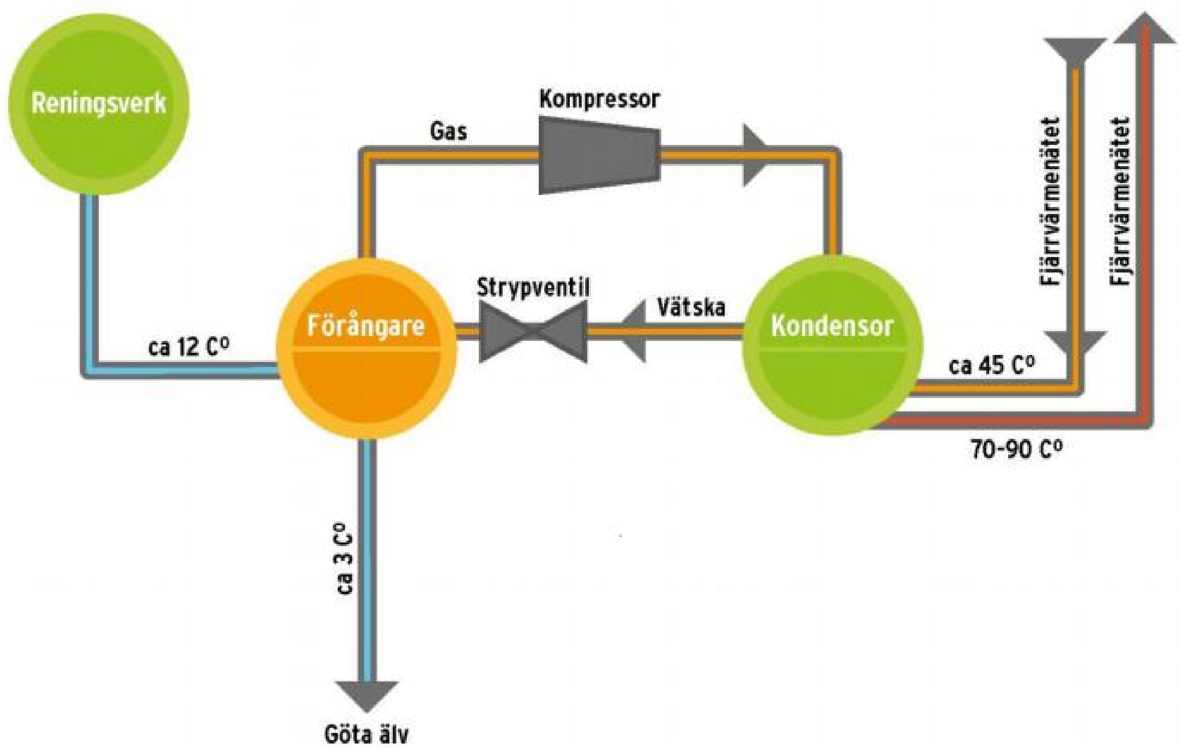
All four heat pumps contain approximately 100 ton of the refrigerant R134a. The greatest environmental effects from the heat pumps are accordingly potential leakages of this, as 1 ton of R134a corresponds to 1430 CO_2 equivalents. However, such leakages are uncommon. In 2013, the four heat pumps had a 11,496 operation hours, producing a total of 443.0 GWh of heating. All heat pumps operate with a COP just above 3.0.

Facts about this case

Installed heat capacity: 160 MW divided upon four heat pumps (2 x 30 MW and 2 x 50 MW).
Heat source: Waste water (12 °C)
Heat pump COP: 3.0
Temperatures: Waste water is cooled from 12 to 3 °C. District heating water is heated from 45 to 75-85 °C

Operation hours: 11,496 in 2013, divided upon the four heat pumps
Period: Established in 1985
Link to web page: https://www.goteborgenergi.se

Contact information:
Jonas Cognell, Göteborg Energi,
Jonas.cognell@goteborgenergi.se



Source: Göteborg Energi

18 Open District Heating in Stockholm, Sweden

Open District Heating is a unique offering for data centres, supermarkets and other businesses that generate excess heat to sell heat at an open marketplace. Currently, more than 30 data centres in Stockholm are connected to the district heating and cooling networks.

Description

The aim for Open District Heating is to improve the efficiency of heating and cooling plants by enabling energy transfers from industries with surplus heat to the local district heating network. A district cooling network is further included, to make supplying both heating and cooling possible. Open District Heating was launched in 2014 and have since experienced a growing number of excess heat producers connected to the system. The concept increases overall energy efficiency but also results in economic gains for companies through sustainable urban heat recovery solutions. It is operated and administered by the district heating supplier Fortum Värme in Stockholm.

One example is the delivery of heat from Banhof Thule, a data centre company with three data halls in Stockholm. Fortum Värme and Banhof have incorporated the synergies between industry and district heating network through a highly flexible heating and cooling system composed of three series of heat pumps. Energy is harnessed from the data halls and from the district cooling network return pipeline. During normal operation, the total cooling output is nearly 1.2 MW corresponding to district cooling temperatures of approximately 5.5 °C and district heating at temperature of approximately 68 °C. The corresponding heat output is approximately 1.6 MW.

The heat pumps can operate independently from the data halls hereby working as a backup for the district heating and cooling systems. Banhof has invested a total of € 0.53 M in the cooling system, including the three heat pumps, pipe installation, electrical work and control equipment, data collection and construction. Fortum Värme have invested a total of € 0.26 M for expansion of the district heating and cooling network.

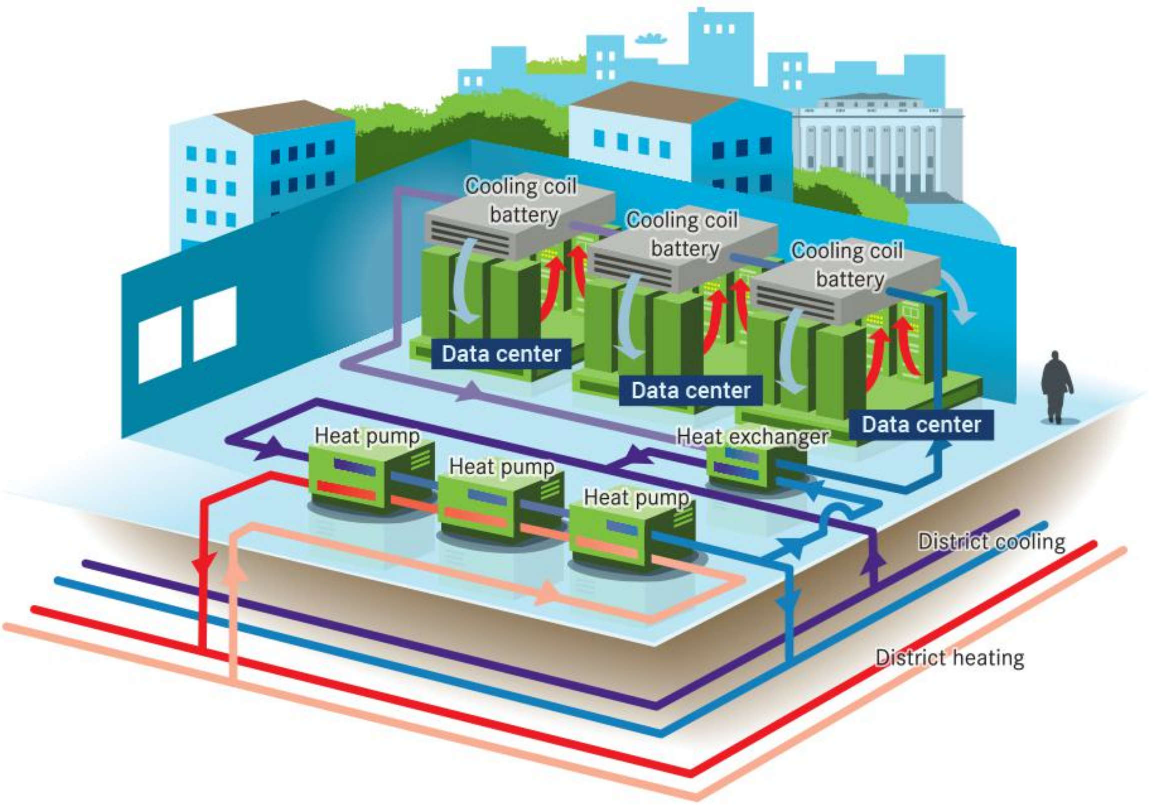
Another mentionable partner of the Open Disitrct Heating network is the fashion retailer H&M, who have decided to build a new data centre in Stockholm with both cooling and heat recovery. The data centre is expected to supply heating for 2500 residential apartments at full load. Further, a new high-efficient data centre by Multigrid Data Centers is prepared to supply the network with 5 MW. Energy costs are expected to be very low for these new data centers, as efficiency is expected to be increased significantly.

Facts about this case

Installed cooling capacity: 1.2 MW
Installed heating capacity: 1.6 MW
Heat source: Cooling of data centre (three data halls)
Heat pump COP: 3.0
Temperatures: District cooling is delivered at approximately 5.5 °C, while district heating is delivered at approximately 68 °C.
Investment costs: € 0.53 M (Banhof Thule) and € 0.26 M (Fortum Värme)

Project: Open District Heating include more than 30 data centres in Stockholm. Further the system includes supermarkets and other businesses with excess heat
Organization: Fortum Värme AB
Link to web page:
www.oppenfjarrvarme.se

Contact information:
Peter Sivengård, Open District Heating,
peter.sviengard@fortum.se



Source: Open District Heating

19 District cooling in Helsingborg, Sweden

At Västhamnsverket in Helsingborg, heat pumps utilize treated water from Helsingborg's sewage system to produce district heating and district cooling. The local district heating company, Öresundskraft is planning to expand the current district cooling grid by enabling an absorption cooling technology to deliver cooling to offices and commercial buildings, hereby replacing individual chillers with centralized cooling.

Description

Öresundskraft begun production and selling district cooling in 1999 and since has the demand grown steadily. Helsingborg have especially found an increased cooling demand from offices and commercial buildings. Öresundskraft have accordingly decided to invest € 2.93 M in an expansion of the current district cooling system and a modernization of production facilities. It is expected, that the fully implemented district heating system can reduce both electricity consumption and environmental emission between 65 and 70 %, compared to traditional and individual refrigeration system. The district cooling capacity is expected to be increased from 16 MW to 30 MW, when the project is fully implemented.

During winter, the district cooling is supplied with sea water to deliver the cooling needed. In summer, an absorption heat pump utilizes excess heat from the district heating network, to transfer energy, and hereby produce cooling for the local offices and buildings. The district cooling option eliminates approximately 1200 ton of CO_2 equivalent emissions annually, as fewer individual chillers reduce the emission of hydrofluorocarbons, which are potent and short-lived greenhouse gasses. The system is built in cooperation with the current Västhamnsverket and construction is expected to begin during fall and winter 2017/2018.

In 2017, the project won a Climate & Clean Air Award for using climate safe and energy-efficient technology to cool down the city of Helsingborg.

Facts about this case

Installed cooling capacity: From 16 MW to 30 MW
Cooling source: Sea water and district heating
Period: Construction is to begin during fall and winter 2017/2018.
Investment costs: € 2.93 M

Payback period: 10 years
Organization: Öresundskraft AB
Link to web page: https://oresundskraft.se/

Contact information:
Jesper Baaring, Öresundskraft,
jesper.baaring@oresundskraft.se

Source: Öresundskraft AB

20 Energy recovered from sewage water in Sandvika, Norway

In 1989 the local district heating company in Sandvika, a suburb to Oslo, started operation of two heat pumps utilizing sewage water for both heating and cooling purposes. The heat pump facility called Sandvika Energisentral have since produced cheap and environmentally friendly energy for the local consumers.

Description

With urban expansion in Sandvika throughout the 1980's came an increased need for district heating. It was decided, that a new heating central was to utilize excess heat from sewage water in two 6.5 MW heat pumps. The system further enabled district cooling, and the project was one of the firsts to combine district heating and district cooling in northern Scandinavia. Since construction, delivery of both heating and cooling have increased. As modern office buildings install more and more data units, the district cooling demand increase. The project further includes defrosting of pavements in winter, which is a popular need in urban northern communities.

The heat pumps are supplied with sewage water from a major waste water channel leading sewage water away from the areas of Olso, Bærum and Asker to a waste water treatment plant. To be near the waste water channel, the heat pumps are placed in a subterranean cavern, excavated from bedrock. As a supplement to the heat pumps, oil burning vessels and a conventional refrigeration unit were integrated in the system. In 2008, a third heat pump of 10 MW was installed. In 2013, approximately 95 % of the production needed came from heat pumps and the remaining 5 % was produced by the peak load units.

With the project comes lowered energy prices and environmental benefits as fossil fuels are not used to produce district heating and -cooling. As the system is optimized, the total amount of refrigerant R134a used in the heat pumps is lowered.

Facts about this case

Installed heating capacity: 23 MW (2 x 6.5 MW from 1988 and 10 MW from 2008)
Installed cooling capacity: 9 MW (2 x 4.5 MW from 1988 and 10 MW from 2008)
Heating source: Sewage water (from 12 °C)
Production: 95 % of district heating is from heat pumps. Additionally, 30,000 m^2 of sidewalk is heated.

Period: Operation begun in 1989
Organization: Oslofjord Varme AS
Link to web page: http://www.oslofjordvarme.no/

Contact information:
Oslofjord Varme,
firmapost@oslofjordvarme.no

Source: Oslofjord Varme

21 Excess heat from data centre in Val d'Europe, France

A new heating system near Val'dEurope outside Paris aims to utilize excess heat from a local data centre. A new local district heating network with a total of 4 km distribution pipelines is to be constructed and heat nearby buildings.

Description

The data centre is in the area Bailly-Romainvilliers, which is a new development zone under construction. A future business park is to be located next to a data centre. The data centre will operate 24 hours a day, all year around and to avoid overheating, the servers are continually cooled using a refrigerator system. Excess heat from the server cooling is recovered and used in heating in nearby buildings. The project to utilize excess heat from the data centre is organized by Dalkia.

The system is composed of two heat exchangers connected to the heat recovery network. Further, a natural gas boiler is used to boost temperatures when needed and act as peak-load in periods of high heat demand. The heat exchangers is capable of providing district heating water temperatures between 48 and 55 °C, corresponding to a total thermal capacity of 7.8 MW which can be extracted from the data centre. It is expected, that the data centre can provide 90 % of the future heat requirements of connected buildings, which include both the current aquatic centre and the future business park. Hereby an annual heating loss of 20,000 MWh is avoided and more than 4000 ton of CO_2-equivalents are saved annually. The probability of the project being fully realized is boosted by this sustainable energy recovery. Hereby, overall heat costs are reduced, and the heat prices are further benefited from a reduced VAT.

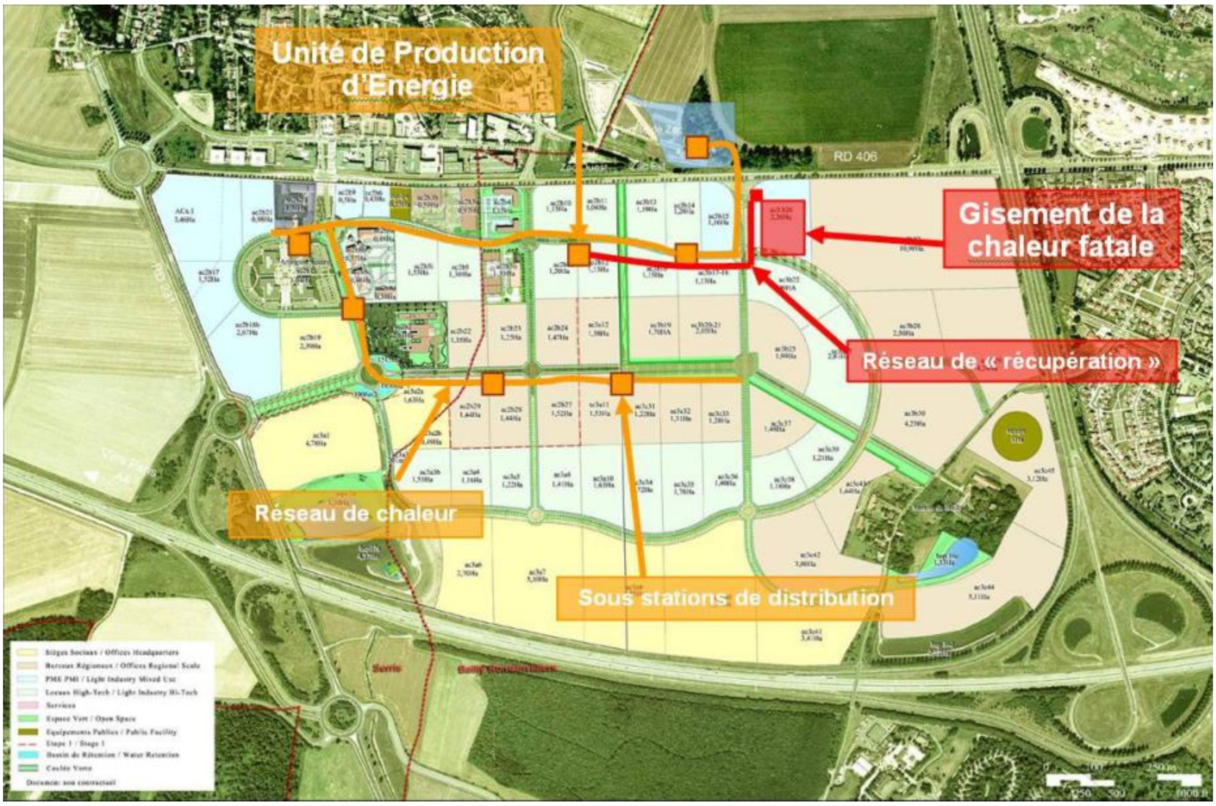
The total project is estimated to cost € 3.46 M, of which the project receive aide from ADEME, the French Environment and Energy Management Agency, of € 1.0 M. The overall project is a decentralized alternative to urban district heating networks with no investment risks to be borne by public actors. The energy recovery is both green and sustainable as it benefits from a local energy source, accordingly reducing the environmental impact. As the data centre operates all year round, the heat prices are low and are expected to be relatively stable.

Facts about this case

Installed heating capacity: 7.8 MW
Heating source: Cooling of data centre
Production: Approximately 20,000 MWh annually. The data centre is operating all year round
Investment costs: € 3.46 M (€ 1.0 M aide from ADEME)

Period: Project begun in 2013
Organization: Dalkia
Link to web page: https://www.dalkia.fr/

Contact information:
Dalkia, Quartier Valmy - Space 21, 33 Rund Square, 92.981 Paris La Défense Cedex



Source: Dalkia

22 District heating in Castelnuovo del Garda, Italy

The municipality of Castelnuovo del Garda near lake Garda in northern Italy received funding in 2012 to establish a district heating system in the town. The district heating network is mainly powered by residual heat from a nearby industry. The first phase of the district heating network was inaugurated in March 2014.

Description

The district heating project desired to exploit residual heat recovered from the local industry Air Liquide. The excess heat is extracted through a heat pump and delivered to a newly established district heating network, supplying both a public school and a sports centre. Air Liquide is a multinational company producing industrial gasses. In Castelnouvo del Garda, the company deliver oxygen for the steel industry. Many of their processes has cooling needs and accordingly produce excess heat, which can be extracted instead of being emitted to ambient air.

The system is composed of two screw compressors and the refrigerant is R134a. Total capacity of the excess heat delivered from Air Liquide is approximately 1.32 MW. District heating network temperatures are increased from the return flow of 40 °C to approximately 63 °C through the heat pump system. Temperatures on the cold side of the heat pump is cooled from 30 to 25 °C. Electricity consumption is approximately 300 kW, meaning that the system can reach a COP of 4.4.

The excess heat is distributed through 3300 m of pipeline, before it reaches the end-users. The main sections of the district heating network are designed with up to five times the capacity which can be taken from Air Liquide. The route of the network is hereby optimized with future expansion possibilities to residential housings in mind. A second phase of the district heating project in Castelnuovo del Garda is to expand the grid with 3500 m of pipeline and construct a biomass power station with cogeneration of heat and electricity. The total scope of the project is to connect a further of 200,000 m^3 of public and private sector buildings.

Heat recovered at Air Liquide will lead to energy savings equivalent to 140 ton of oil every year, corresponding to around 327 ton tons of CO_2-equivalents being saved.

Facts about this case

Installed heating capacity: 1320 kW
Heating source: Low temperature industrial residual heat (30 °C)
Temperatures: Residual heat is cooled from 30 to 25 °C. District heating water is heated from 40 to 63 °C
Funding received: € 1.3 M

Period: 2011-2014
Organization: Hiref
Link to web page: http://hiref.it/

Contact information:
Alessandro Zerbetto, Hiref, (Italian Cooling Solutions)

Source: www.siderweb.com

23 Industrial residual heat and transmission in Leiden, Netherlands

The project Warmtelevering Leidse Regio (WLR) involves transmission of industrial residual heat from the port of Rotterdam to the greater Leiden area. A project agreement was signed in November 2017 which enables a sustainable heating solution to the local community. Low-temperature return flow is used through a heat pump at a nearby local brewery.

Description

The WLR-project is a commitment between the heating transportation company Warmtebedrijf Rotterdam and the energy company Noun. By supplying the greater Leiden area with industrial residual heating from the port of Rotterdam, approximately 13,000 households and 200 companies can potentially be supplied with sustainable heating. The project involves a major transmission line, where a total of 43 km pipeline ensures heat distribution from the port to the town and back again.

The high-temperature residual heat is transported from the port of Rotterdam via a pumping station powered by electricity. The heating is transported to heating centrals in Leiden, where it is dispersed to the already existing district heating network. The return flow still holds a large energy potential, which is harvested at the brewery Heineken. Here the residual low temperature heat from the return flow i used to produce hot steam for brewing processes. This is done through an electrically powered heat pump. Cooled water is returned to the port of Rotterdam, where it again is heated by industrial residual heat in heat exchangers. The heat pump at the brewery is a main part of fully utilizing the potential of excess heat from the port of Rotterdam. By extracting heat from the return flow, the temperature of the returning transmission pipeline is lowered, making room for more energy to be harnessed at the ports. Hereby the overall energy efficiency of the system is optimized. The transmission system is unique and expands across multiple highways in an already existing urban environment. Further, a buffer tank at the heating central supply the brewery and hot water is used for packaging processes.

The transmission system results in immense CO_2- and energy savings, as great amounts of natural gas can be substituted with already existing residual heating. Currently, large amount of energy is lost to the ambient air from industries at the port of Rotterdam. By constructing a transmission system the potential energy can be harvested. A heat alliance between the province Zuid-Holland, Havenbedrijf Rotterdam, Gasunie and Eneco en Warmtebedrijf Rotterdam is planning a larger regional heating system. The goal is to connect 500,000 households and multiple greenhouses in a large regional district heating network, potentially reaching CO_2-savings of 1 million tonnes annually.

Facts about this case

Heating source: High-temperature transmission and low-temperature return flow from industrial residual heat

District heating system: 43 km transmission pipeline deliver heating to the greater Leiden area and the nearby Heineken brewery.

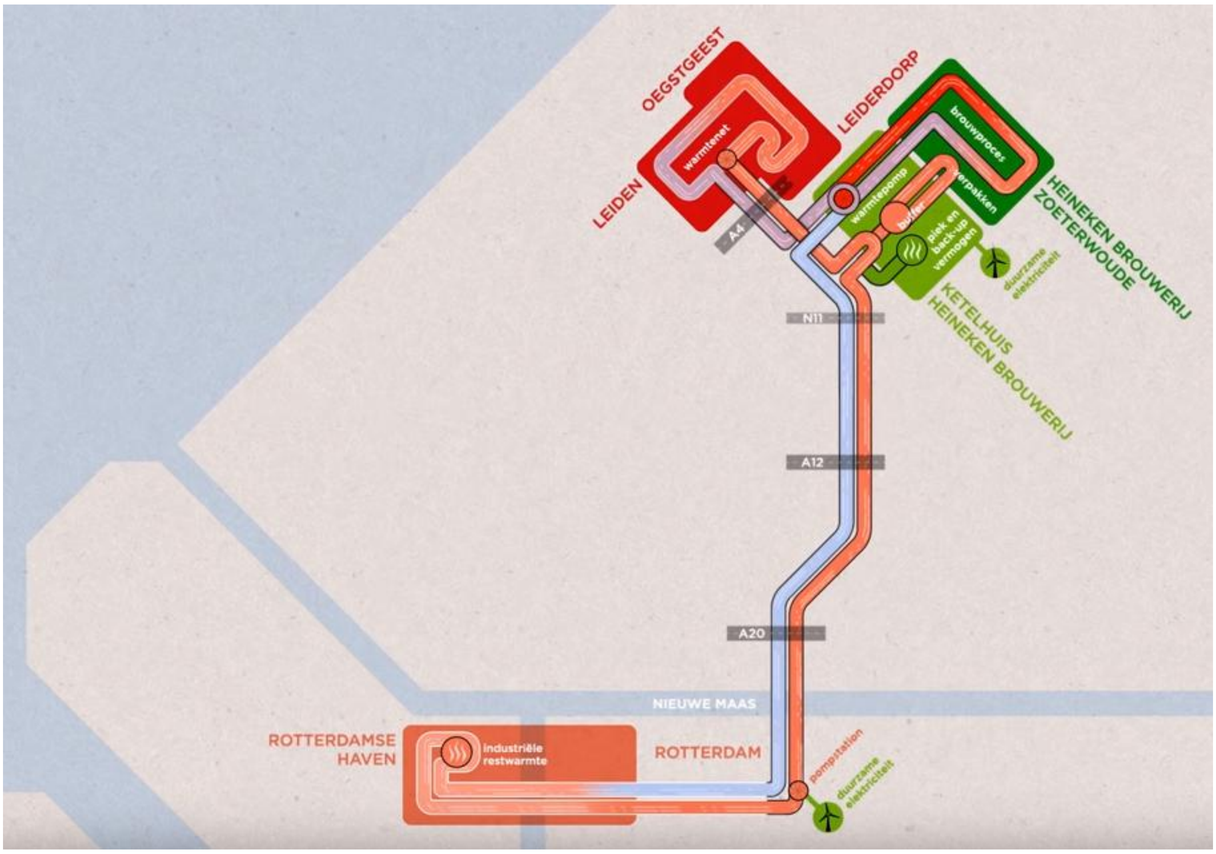
Potential: 13,000 households and 200 companies

Period: Agreement signed November 2017

Organization: Warmtebedrijf Rotterdam and Noun

Link to web page: http://www.warmtebedrijfrotterdam.nl/

Contact information:
Warmtebedrijf Rotterdam, info@warmtebedrijfrotterdam.nl, and Noun



Source: Provincie Zuid-Holland

24 Heat recovery at hospital in Budapest, Hungary

At the military hospital in Budapest, waste water from the sewage system is used for both heating and cooling purposes. The stable sewage water temperatures and a heat pump system ensure a steady and sustainable heating deliverance to the hospital.

Description

The project of using heat recovered from the sewage system was inaugurated in October 2014. The heating and cooling extracted from the sewage water is used internally at the military hospital. The heat pump system is developed by Thermowatt with a total cost of approximately € 2.5 M. Energy savings can however reduce the annual operation costs for heating and cooling purposes with approximately € 340.000.

The sewage water temperature is between 10 and 20 °C throughout the year. The military hospital is a relatively large building complex that requires heating and cooling for 40,000 m^2. Therefore, the heat pump system has a heating capacity of 3.8 MW and a cooling capacity of 3.3 MW. There is installed two approximately equally-sized water-to-water heat pumps. When sewage water is used as a heat source, a filtration unit is required to cleanse the water, before it is send to the heat pump units. Approximately 11,000 m^3 of sewage water pass the system every day. The total system is placed in an underground car park and occupies approximately 210 m^2. The heating and cooling is delivered through air handling units composed of large heat exchangers. Hereby low operation temperatures of approximately 32 °C is reached. A system-COP between 6.5 and 7.1 is accordingly reached.

Facts about this case

Heating source: Sewage waste water 10-20 °C
Heating capacity: 3.8 MW
Cooling capacity: 3.3 MW
Heat pump COP: 6.5-7.1
Temperatures: Sewage water at 10 to 20 °C is heated to 32 °C. Cooling is delivered at 6 °C

Period: Finished in 2014
Organization: Thermowatt
Link to web page: http://www.thermowatt-global.com

Contact information:
Thermowatt, info@thermowatt.hu

Source: Thermowatt

25 Excess heat from sewage in Hamburg and Singen, Germany

Multiple heat recovery projects from sewage water exist in Germany. Waste water flowing in the sewage pipelines contains an often unused heating potential, which can be harnessed using low-tech piping and heat pump solutions. Heating can accordingly be supplied to small-scale internal district heating systems and heat local housings, apartments and larger buildings.

Description

Energy from sewage pipelines is typically extracted using electrically powered heat pumps. The sewage water typically has temperatures between 12 and 20 °C which is raised to higher temperatures up to 70 °C. The solutions are often combined with a natural gas boiler or CHP to ensure a high security of supply and potentially produce electricity, which can be used directly in the heat pump. Heat exchangers are either integrated in the bottom of the sewer or installed in the drain of a waste water treatment plant. The solutions are accordingly particularly favourable near large sewers or waste water treatment plants. In the following, two examples are presented.

Pilot project at Hasteststraße, Hamburg
Waste water produced by the households at Hasteststraße in Hamburg flows into the waste water pipeline system with an unused potential of heat. The local water company, Hamburg Wasser and a construction association in Hamburg, EBV, realized a pilot project that harnesses this heating potential. Since 2009 and 2010, 215 residential units have been supplied with excess heating from the sewage system.

A 100 m heat exchanger in the sewage pipeline extracts the warmth that is still in the waste water. The extracted energy is utilized using four gas absorptions heat pumps supplying approximately 2000 MWh of energy annually. The total system cost was € 700,000, and it reduces carbon emissions by 75 % compared to the pre-existing system.

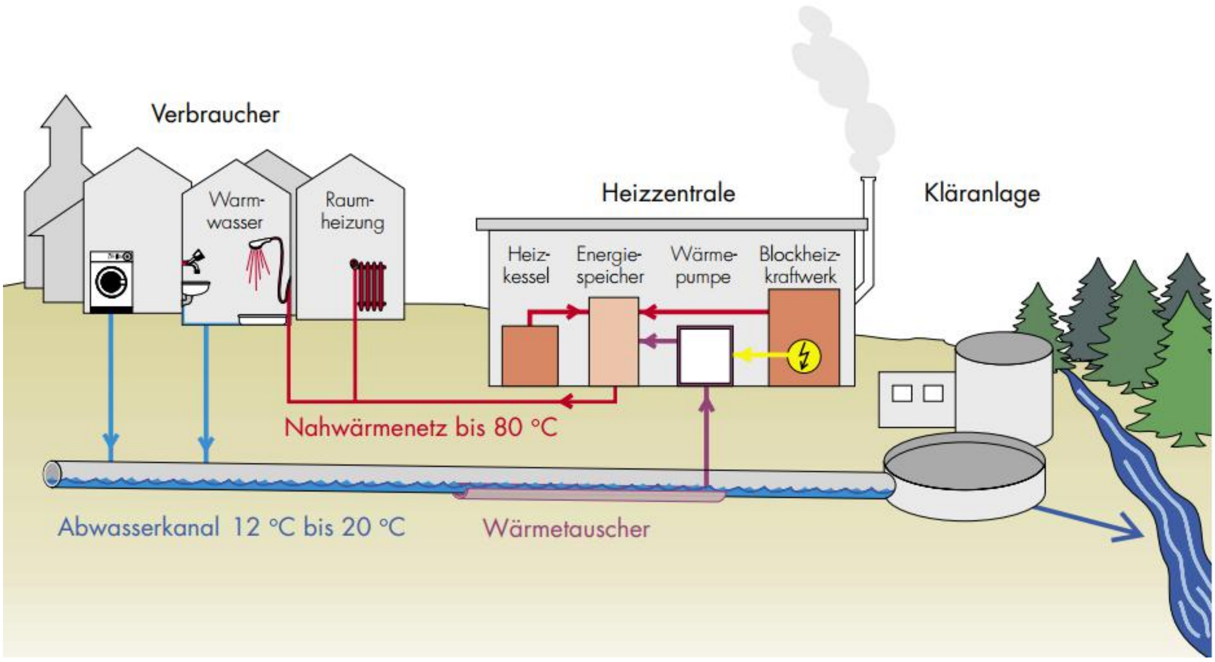
Office building, Singen
The office building in SinTec Technology Park in Singen have been supplied with waste water energy since 2004. The waste water energy is extracted with a 80 m heat exchanger directly in the sewage pipelines and via an electrically powered heat pump unit, that produce heating during winter and cooling during summer. The annual waste water temperature is approximately 15 °C and the heat pump has an annual COP of 3.9. The heat pump annually produces 240 MWh of cooling and 660 MWh of heat with a cooling capacity of 200 kW and a heating capacity of 243 kW. The annual costs are lowered 5 % compared to alternative gas systems and carbon emissions are reduced by approximately 28 %.

Facts about this case

Sewage projects: Multiple projects harnessing energy from sewage- and waste water exist in Germany
Heating capacity: 243 kW (Singen)
Cooling capacity: 200 kW (Singen)
Heat pump COP: 3.9 (Singen)
Temperatures: Waste water temperature is typically 15 °C

Period: Operation since 2004 (Singen)
Organization: GVV Städtische Wohnbaugesellschaft mbH

Contact information:
Hamburg Wasser, www.hamburgwasser.de
GVV Städtische Wohnbaugesellschaft mbH, info@gvv-singen.de



Source: Institut Energie in Infrastrukturanlagen, Bundesverband WärmePumpe (BWP) e.V