International Energy Agency

Implementing Agreement of District Heating and Cooling, including the integration of CHP

IEA DHC|CHP

Annex TS1 | Low Temperature District Heating for Future Energy Systems

SUCCESSFUL IMPLEMENTATION OF INNOVATIVE ENERGY SYSTEMS IN COMMUNITIES

- WITH LOW TEMPERATURE DISTRICT HEATING AND RENEWABLE ENERGY SOURCES

SUCCESSFUL IMPLEMENTATION OF INNOVATIVE ENERGY SYSTEMS IN COMMUNITIES



LOW TEMPERATURE DISTRICT HEATING OFFERS A FAIRLY EASY AND COST EFFECTIVE WAY TO REALIZE A FOSSIL FREE HEATING SYSTEM COMPARED TO SOLUTIONS BASED ON RENEWABLE ENERGY PRODUCTION ON EACH BUILDING

What is low temperature district heating?

Low temperature district heating is a heat supply technology for efficient, environmental friendly and cost effective community supply. Traditionally district heating grids are operated at temperature levels up to 120 °C. In comparison with conventional district heating, in low temperature district heating the network supply temperature is reduced down to required temperature levels of about 50 °C or even less. Simultaneously low temperature district heating coupling with reduced network temperature and well-designed district heating network can reduce heat losses of the grid by up to 75 % comparing to the current system design. To achieve maximum efficiencies, the district heating network, energy conversion process and the end user demand need to be optimized to utilize lower network supply temperatures. When the building systems and district heating supply network are treated as one integrated system, synergies and economies of scale can be optimized on a community scale.

Low temperature district heating is an enabling technology to increase the integration of renewable and waste energy sources for heating and cooling (e.g. from solar thermal, biomass combined heat and power or from heat pumps to use excess electricity from wind power plants). This contributes to meet national and local GHG reduction targets.

COMMUNITY SCALE SYNERGIES CAN BE MAXIMIZED WHEN BUILDING AND BUILDING SUPPLY SYSTEMS ARE TREATED AS INTEGRATED COMPONENTS OF AN ENERGY DELIVERY SYSTEM

A sustainable and flexible approach to the energy supply of communities

Low temperature district heating offers a sustainable and flexible approach to the energy supply of communities. On the buildings' side a number of issues of matching the demand need to be addressed to develop advanced low temperature heating networks. On community scale synergies are maximized, if buildings and building supply systems are regarded as integrated components of an energy supply solution. That is why implementation of solutions based on large shares of renewable energies requires an adaptation of technical and building infrastructure. In contrast to the current standard network design, the low temperature district heating concept pursues a different approach. Starting from end-user thermal comfort, as well as a quality match between energy supply and the energy utilization, the identification of the most efficient and economical way to satisfy the heat demand is through efficient distribution networks. Furthermore, low temperature district heating systems opens up for a GHG emissions free supply systems based on waste heat and renewable energies only.

An economically efficient low temperature heating energy supply

The utilization of low network temperatures is a flexible approach to the heating energy supply of communities and results in economically competitive solutions, because of the easy integration of cheap renewable or waste heating energy into the supply systems. From an economical point of view, relatively high price stability can be expected due to the use of locally available, renewable, or surplus heat energy sources. An additional advantage of this is a lower dependency on fossil fuel supplies. The high overall system performance can be achieved by using innovative low temperature district heating technologies and leads to reduced resource consumption as well as lower costs for fuels.

For this reason, low temperature district heating is seen as an emerging innovative system technology with high potential to

PASSIVE HOUSE BUILDING FAIR - HYVINKÄÄ, FINLAND

Aerial view Building Exhibition - Hyvinkää (Finland) © Rakentaja.fi/jarno Kylmänen

HYVINKÄÄ HOUSING FAIR AREA CONSISTS OF LOW ENERGY SMALL HOUSES CONNECTED TO DISTRICT HEATING

The project at the housing fair area, Hyvinkää is based on the connection of very low energy buildings and so-called passive houses to a district heating system.

The particular goal for this project is to estimate the long term performance of innovative district heating systems. So the long-term goal extends to the year 2020 and beyond. The aim is also to explore in Finnish climate the boundary conditions and opportunities for the district heating solutions for so-called “nearly zero-energy houses”.

Based on the targets a number of new business and service models for district heating in single-family houses are developed and assessed. For the utility companies not only the economic issues are of interest, the short- and long-term variations and power peaks in district heating consumption will be examined to optimize the entire energy system. For this last point the proper sizing of on-site energy production (e.g. solar thermal) for own use in the houses are of interest as well.

The housing fair area in Hyvinkää opened in 2013 and is a place for demonstrations. This location also offers longer term research opportunities to evaluate the use of district heat to supply domestic hot water for laundry, bathing and cleaning in place of electricity. Finally a contribution to the development of national building code is in focus, since the energy consumption dynamics are actually not accounted for in the codes. Here the project is demonstrating compliance with the regulation.

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Planning area - Feldlager (Germany) © City of Kassel

COST-EFFICIENT IMPLEMENTATION OF GROUND HEAT AND SOLAR THERMAL SYSTEMS FOR LOW TEMPERATURE HEAT SUPPLY OF RESIDENTIAL BUILDINGS

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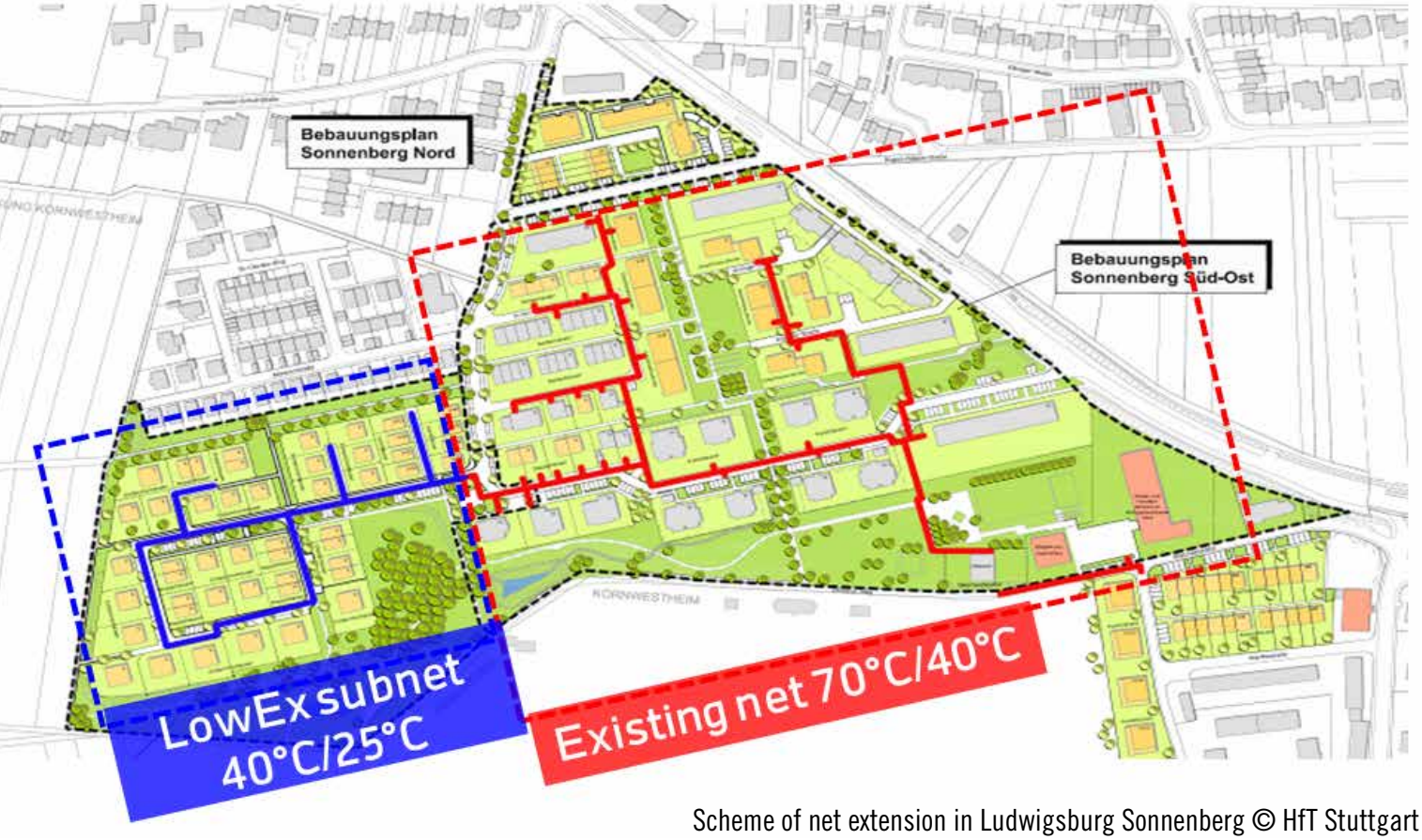
An innovative and economically beneficial heat supply concept for the new housing area „Zum Feldlager“ has been set up which is planned to be erected in Kassel (Germany). The main objectives and challenges are the minimization of primary energy consumption, the reduction of CO_2 emissions, the reduction of transmission heat losses and the usage of a high share of renewable energy sources. To identify the best possible system solution, different supply strategies have been analyzed. Central challenge is the identification of the most promising and efficient technical solutions for practical implementation. Furthermore, aspects of future network management as well as business models are considered.

The innovative heat supply concept has been set up to realize the supply without fossil fuels. For that reason the use of renewable energy sources (e.g. geothermal and solar energy) to supply low-energy buildings has been elaborated. The supply to different houses has been planned to optimize low temperature heat supply in conjunction with intelligent storage systems and thermal load shifting strategies. The area includes approximately 130 low energy residential building which are supplied by a low temperature district heating grid operating at 40 °C supply temperature. The buildings are equipped with floor heating systems or low temperature radiators. To increase the efficiency of the heating systems and to optimize the hydraulic integration of the heat generation systems, the use of smaller water storage tanks in all buildings are intended. A hygienic preparation of domestic hot water is realized by fresh water stations. For the low temperature heat generation a ground coupled (boreholes) central heat pump is chosen. In this case the use of a large heat storage to realize a demand-oriented power generation is foreseen. For the domestic hot water preparation solar thermal systems with an additional electrical backup heater are planned.

„LOWEX“ GRID IN SONNENBERG – LUDWIGSBURG, GERMANY



Scheme of net extension in Ludwigsburg Sonnenberg © HfT Stuttgart

VERY LOW TEMPERATURE HEATING GRID EXTENSION TO SUPPLY NEW BUILT “PASSIVE” HOUSES

The city quarter Sonnenberg of Ludwigsburg is supplied by a low temperature district heating network operated at 70 °C supply and 40-45 °C return temperature. The energy supply unit consist of a gas-fired cogeneration unit (230 kW_{th} and 112 kW_{el}) (CHP), a geothermal driven heat pump (200 kW) and a gas fired condensing boiler (900 kW) for redundancy and peak load coverage. The geothermal heat pump with fifty ground probes set at 115 m deep is intended to cover the first temperature lift from 40-50 °C. The remaining temperature lift is covered by the cogeneration unit. The control of the decentralized heat storages inside the buildings is connected to the central control unit of the heat supply unit. An intelligent control algorithm controls the charging of these storages with the goal to reduce peak loads.

The district extension Sonnenberg-Südwest is planned with single family houses and some smaller multifamily houses. The planned building energy standard is close to passive house. Due to the resulting very low heating energy density of this new district, even the extension of the existing low temperature heating network would result in high energy losses of more than 30 %. Therefore, it is planned to connect this highly energy efficient district to the return line of the low temperature grid of Sonnenberg. This LowEx subnet will be operated at 40 °C supply and 25 °C return temperature. For hot water preparation additional electric heating is required (direct flow heaters or micro heat pumps) to boost the hot water temperatures to 43 °C. Detailed analyses showed that micro heat pumps are only economically viable for the multifamily houses. To decrease the electricity demand for additional hot water, the integration of a solar thermal heating system is planned for the LowEx subnet.

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COLD DISTRICT HEATING GRID– PROJECT ENVISAGE IN WÜSTENROT

Thermal activation of agricultural area as geothermal heat source / sink © doppelacker GmbH

COLD DISTRICT HEATING GRID WITH DECENTRALIZED HEAT PUMPS SUPPLIES HEAT AND COLD FOR RESIDENTIAL NEIGHBORHOOD

Wüstenrot is a rural community with 6,500 inhabitants situated in South-West of Germany. In 2007, the municipal council decided to make Wüstenrot a plus-energy community. Under the lead of Stuttgart University of Applied Sciences (HfT-Stuttgart), the EnVisaGe project is developing transferable strategies for energy efficiency measures and the utilization of local renewable energy sources. A new residential neighborhood is being built in Wüstenrot. This energy-plus-quarter consists of 25 new high energy standard buildings (single family and detached houses). With the sale contract for the ground, the future building owners agree to fulfill the high energy standard requirements, install PV systems of sufficient size (6-10 kWp) and connect to an innovative cold water heating grid.

This grid supplies low temperature heat from a near surface geothermal system to decentralized heat pumps providing heating energy and hot water for the single buildings. The geothermal source is based on a sub-surface underground geothermal (agrothermal) collector. This collector was designed by assuming a heat gain of 28-32 kWh/m²a in a dimension of 1,5 ha. Thus, the heat demand of the settlement of 288 MWh/a is covered while providing additional reserves of about 380 MWh/a for the possible connection of nearby existing buildings. A common intelligent load and storage management system optimizes the PV self-consumption, reduces the peak power supplied in the electricity grid and offers the possibility to use the heat pumps with hot water and electricity storages as controllable electricity sinks for future smart grid applications.

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LOW TEMPERATURE DISTRICT HEATING SUPPLY - LYSTRUP, DENMARK

Terraced low energy house in Lystrup © Technical Universitiy of Denmark

THE AREA CONSISTS OF LOW-ENERGY SINGLE FAMILY HOUSES SUPPLIED BY LOW TEMPERATURE DISTRICT HEATING

The concept of low temperature district heating is implemented and evaluated in a pilot project in Lystrup, Aarhus in Denmark. The goal of the project is to examine the technical and economic feasibility to supply low temperature district heating to low energy building areas. The area includes 40 terraced houses with low-energy standard. The network design supply temperature is 55 °C and the return temperature is 25 °C. The area is supplied by supply water from the main medium district heating network mixed with return water from the low temperature district heating network. A booster pump raises the network pressure. To adapt low-temperature operation, new network design strategy and consumer heating installations were designed and implemented.

The network is optimized for application of low temperature district heating. Additionally to the low temperature level high efficiency is achieved by using pre-insulated twin pipes, small pipes diameter and high pressure level.

Two types of substations which include the instantaneous heat exchanger unit and district heating storage tank unit were applied. The layout of the domestic hot water distribution pipes is specially designed in order to reduce the pipe diameter and confine the water volume in the secondary side below 3 liters. In this way, the risk of Legionella can be avoided.

Through long term surveillance and measurement, it was shown that low-temperature district heating can satisfy the consumer thermal comfort and hygienic requirement. The measured network heat loss in a low temperature network is approximately twenty five percent (25%) of the heat loss in a conventional medium temperature network (80/40 C). It is therefore both technically and economically feasible to supply low-temperature district heating to low energy building area.

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LOW TEMPERATURE DISTRICT HEATING IN EXISTING BUILDINGS - DENMARK - SØNDERBY, DENMARK

Sample house with new service pipe at Sønderby © Technical Universitiy of Denmark

LOW-TEMPERATURE DISTRICT HEATING SUPPLY TO EXISTING BUILDINGS

The large scale implementation of low temperature district heating needs to address the feasibility to supply low temperature to existing building areas. The full scale demonstration project at Sønderby aims to examine the feasibility and economic benefit to supply low-temperature district heating to existing building areas.

The low temperature area includes 75 single family houses, which were built from 1997-1998. The buildings are supplied with floor heating. The previous district heating network consisted of old inefficient single district heating pipes. In the project, the old pipes are replaced by efficient twin pipes. The area is mainly supplied by return water from the main medium temperature district heating network at 48 °C. It covers 80 % of total heat supply. This return water mixes with supply water in order to raise the water temperature up to 55 °C to supply the designated area. During summer, return temperature from the main network is higher, which provides 100 % of the heating demand.

The design supply temperature at consumer is 52 °C with 25 °C cooling at consumers.

The annual network heat loss is reduced from 41 % to 13-14 %. The significant heat loss reduction is mainly due to the reduced network temperature, improved pipe insulation and reduced dimension of pipes by using high network pressure. During operation, it was found that network return temperature is close to 40 °C. This high return temperature is due to large bypass flow rates in incorrectly set control valves. Another reason is due to consumers who forgot to close valves for the heating system during summer. The unclosed valves for the heating system in summer should be avoided by installing the return temperature limiter on the space heating heat exchanger in the future work.

The demonstration project has shown great energy saving potential by providing low temperature heating. The low supply temperature works for existing buildings with floor heating system.

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FJORDVARME, FJORD DISTRICT HEATING – ULSTEIN, NORWAY

Fjord district heating © Øyvind Amdam, Ulstein municipality

FREE SEA HEAT FOR DISTRICT HEATING SYSTEM BASED ON DECENTRALIZED HEAT PUMPS

Fjord district heating is based on utilization of the "free" heat from the sea by using decentralized heat pumps. A common heat exchanger is utilized to take the heat from the sea. The sea heat with low temperature is then distributed to energy substations. Both heating and cooling are distributed by using the same pipe network without insulation. Low water temperature gives low heat losses and low operation cost. The local energy substation could be used for one or few buildings. This solution with utilization of sea heat and decentralized heat pumps is suitable for places located at the coast. The current project at the Ulstein municipality is based on the well developed and proven solution in the Eid municipality, Norway. In Ulstein project, the sea water temperature was measured to be between 4-9 °C over the year at the depth of 42 m. In total, about 15 energy substations will be included in the system.

The plan for the customers development is as follows: at the beginning 20 % of the costumers are included, after five years up to 60 %, so that after 10 years 100 % of the capacity will be utilized.

Additional capacity of 20 % as reserve is assumed to be utilized within 20 years. The total heat capacity delivered by the district heating system will be higher than 10 MW within five years. The total investment within the first 10 years is about 75 mil. NOK and 85 mil. NOK within 20 years. Including the reserve capacity the plant should deliver about 20 GWh heating and 5 GWh cooling. It was assumed that the heating and cooling price will be about 0.7 NOK/kWh.

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GREENWATT WAY - SLOUGH, UNITED KINGDOM


Greenwatt Way © SSE Enterprise

A 'ZERO CARBON' HOMES DEVELOPMENT WITH LOW TEMPERATURE DISTRICT HEATING

This project focuses on the evaluation of the energy consumption within nearly zero carbon houses, on furthering the understanding of the interaction of the users with the house and demonstrating construction methods that may be deployed to build nearly zero carbon houses.

The demand of the site for electricity and heat is met by renewable technologies. Photovoltaic panels provide electricity whilst an innovative low temperature district heating system provides low carbon heating and hot water to the houses.

With regard to the energy production, the energy center is comprised of a selection of renewable technologies (biomass boiler, air source and ground source heat pumps and solar thermal) together with a thermal store. Each technology (apart from the solar thermal) was sized in order to meet the full heat requirement of the site and is able to run independently.

Therefore, testing of different combination of heat supply is possible. Heat and electricity supply has been met with a combination of photovoltaic panels and either one of the renewable heat technologies. One of the main challenges faced was the optimization of the design and operation of the energy center with the district heating scheme.

The stratified hot water tank increases flexibility and efficiency of the renewable heating plant operation by shaving the peak demand and improving the efficiency of the heat pumps by allowing a staged heating cycle.

The district heating supply temperature varies between 50-55 °C. Each house is equipped with a hydraulic interface unit serving one single large radiator in the open plan lounge/kitchen and towel rails in bathrooms and showers. Domestic hot water is supplied at 43 °C via an instantaneous heat exchanger.

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THE LOW TEMPERATURE DISTRICT HEATING RESEARCH PROGRAM

The IEA DHC Annex TS1 aims to identify holistic and innovative approaches to communal low temperature heat supply by using district heating. It is a framework that promotes the discussion of future but also existing heating networks with an international group of experts.

The goal is to obtain a common development direction for the wide application of low temperature district heating systems in the near future. District cooling can also be integrated into the activities but is not the focus. The gathered research which is going to be collected within this Annex should contribute to establishing DH as a significant factor for the development of 100% renewable energy based communal energy systems in practice.

By connecting the demand side (community/building stock) and the generation side (different energy sources which are suitable to be fed in the DH grids), this technology provides benefits and challenges at various levels.

The activities are strongly targeted at DH technologies and the economic boundary conditions of this field of technology.

MORE INFORMATION ABOUT THE PROGRAM:

Up to date information about the participants and the progress of the research program is available on the web page:

www.iea-dhc.org

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The participating countries are:

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- Germany
- Norway
- South Korea
- United Kingdom

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