The International District Energy Climate Awards 2011:

Very-Low-Temperature District Heating for Low-Energy Buildings in Small Communities

Showcase Larch Garden II, Lystrup, DENMARK

Boligforeningen Ringgården

Owner: Boligforening Ringården

A Danish Building Association

Dybedalen 1A

DK - 8210 Aarhus V

www.bf-ringgaarden.dk

Applicant: Palle Jørgensen, Managing Director

pj@bf-ringaarden.dk

Jayen P. VEERAPEN
International Energy Agency
9, rue de la Fédération
75739 Paris Cedex 15
France
jayen.veerapen@iea.org

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District Energy Awards 2011: Very-Low-Temperature District Heating for Low-Energy Buildings - Small Community Larch Garden II

Housing Association Ringgaarden has built 122 sustainable climate friendly public houses in Lystrup near Aarhus, Denmark. The vision of this project is to combine best of European architecture with latest advances in sustainability. Houses are distributed on three building complexes differing from architectural and sustainable elements. For Lystrup and Aarhus this means new housings area saving environmentally app. 100 tons of CO_2 emission/year compared with complexes built according to standard of Danish Building Code Requirements.

This application concerns Larch Garden II complex consisting of 40 single-storey terraced low-energy houses. This is the first world-wide project to test a new very-low-temperature district heating concept for low-energy buildings. Future keen requirements on energy performance buildings necessitate innovative thinking in case of profitable district heating in low-energy buildings. The low temperature concept, developed by a group of research institutes, consultants, manufacturers and users[1], meet challenges by using effective twin pipes in small sizes and new types of building substations allowing supplying district heating to buildings with a supply temperature of just 50°C without additional re-heating.

This construction was finished in April 2010 and first results proved to be very promising, i.e. district energy consumption of each of the 40 houses turned out to be about 5.8 MWh with direct heat loss from distribution network of only 1.2 MWh per house. Taking into account primary energy factors this will lead to very low primary energy consumption pathing the way for district heating in new building areas - now and in future.

Best Regards,

Palle Jørgensen, Managing Director
Boligforeningen Ringgården

[1]) Consortium: Danfoss, Logstor, COWI, DTU-Byg, Energitjenesten, Danish Technological Institute, Kampstrup, Boligforeningen Ringgården, Ribe Jernidustri

Summary

A key challenge for optimum and competitive district heating systems of today and future is to reduce heat loss in network. Today building regulations demand reduction of heat consumption and thus ratio between network heat loss and heat consumption in buildings is a main issue. To address this challenge, low-temperature district heating (LTDH) concept is analysed, implemented and evaluated in real scale. The Larch Garden - II project represents the first world-wide demonstration of a new concept of an efficient district heating system for low-energy buildings. The goal is to reduce district heating temperature delivered to consumers to 50°C. No reheating is applied - neither at consumer site nor at district heating site. For this project, two types of low-temperature district heating substations and new district heating twin pipes with reduced diameter were developed and tested. The project showed that DH can be used even in areas with low energy demand with good economy and high comfort level for users. Overall heat loss from network was reduced to a quarter (¼) compared to traditional district heating system designed with temperatures of 80/40°C. Besides good economy, reduced heat loss there is a contribution of savings equal to 21 tons of CO_2/a just supplying 40 houses with DH network. Further benefits of LTDH can be seen from earlier implementation of renewables being one of the main goals of European Union Energy Policy. LTDH concept has recently been investigated also to include existing buildings representing much larger perspectives for its application than buildings newly built.

Very-Low-Temperature District Heating for Low-Energy Buildings in Small Communities

Introduction

Energy demand and environmental impact caused by using fossil fuels are growing worldwide. Roughly 40% of all energy is consumed in building stock and thus reduction of energy in building sector is one of the main issues in future. EU energy policy is focused on energy savings, security of supply and fossil-free future. Denmark aims at 100% renewable energy sources in 2050 and DH is one of the solutions how to achieve these goals. Requirements to energy performance of buildings are introduced generally. Heat demand of buildings is decreased by applying improved building envelopes and more efficient heat recovery for ventilation systems, and thus heat losses from DH network become a key issue for DH in future. A way to achieve reduced heat loss from DH network is to reduce supply temperature as much as possible, i.e. use Low-temperature DH (LTDH). LTDH system usually means DH system with a supply temperature of 65°C, but our concept goes even further, i.e. a supply water temperature slightly above 50°C without need of additional heating on side of DH or customer side [1].

Reduced temperature level results besides reduced heat losses from DH network in many benefits as e.g. exploiting of renewable sources of energy with higher efficiency and thus easier introduces more fossil-free sources, but on the other hand in some challenges connected mainly to domestic hot water (DHW) preparation.

Described concept of very-low-temperature district heating in combination with no re-heating of the DH or domestic hot water at consumer site, is a so far an unseen realised and thus its realisation in Lærkehaven in Lystrup, Denmark makes this project outstanding.

Demonstration

The progressive Danish housing association 'Boligforeningen Ringgården' has during the recent years built a number of new low-energy buildings and chose for a new project in Lystrup, Denmark, low-temperature district heating as a heat supply. The project in Lystrup involves 7 row houses with totally 40 flats. Two sizes of flats are available: 89 m^2 and 109m^2 (gross area) with design heat demands for space heating of 2.2 kW and 2.6 kW respectively. All rooms - except bathrooms - have low-temperature radiators that are designed for flow temperature of 50°C and return temperature of 25°C – the bathrooms are supplied with floor heating. District heating water is supplied directly with no heat exchanger between building heating system and district heating system.

The district heating network is designed according to the 'low-energy district heating for low-energy buildings' concept presented in [2]. A sketch of the network is shown in figure 1. The DH pipe length is approx. 800m. The local district heating utility, 'Lystrup fjernvarme', is supplying heat to a central spot (yellow line) where a mixing shunt is lowering the supply temperature to about 55°C and a booster pump is raising the pressure dependent on the available pressure difference at the critical consumer (green circle) in the distribution network (black lines). The DH pipe design basis is Alu-flex twin pipes, in as small dimensions as possible to reduce heat losses from the network.

Figure 1: The basic DH net lay supplying 40 flats with very-low-temperature District Heating

Two different types of low-temperature district heating substations are developed and installed for supply temperature slightly above 50°C. The substations are characterized by producing DHW with a plate heat exchanger (instantaneous water heater), but are based on two very different principles. One type has a 120 liter storage tank on the primary side (DH side) and is designed for equalizing the heat demand for DHW over the time in order to reduce dimensions of pipes in district heating network as much as possible. The second type is a more traditional heat exchanger unit (HEU) with normal load requirements. The both concepts are described in [3].

The residents in Larch Garden II are mainly older people and families with small children, who are somehow expected to be more sensitive to thermal comfort and enough of DHW. During the system operation we didn't hear any complains about thermal comfort or problems with temperature or flow of domestic hot water, even the last winter was really cold.

For the objective evaluation of the system performance an extensive measuring system is installed in DH substation in every house. Moreover measured data are used for further improvement of the concept and for definition of new simultaneity factor for low-temperature district heating. Based on the measurements, we can conclude that domestic hot water is delivered with desired temperature level 40-45°C and average temperature in rooms is 22°C. The annual heat consumption per dwelling was estimated to approx. 5.8 MWh for a reference year, corresponding to a measured heat density of 0.3 MWh/m network line and 14 kWh/m^2 field. The results also show that it is possible to supply customers with temperature just above 50°C, with a DH supply temperature to the area of approx. 56 °C. Detailed measurements show that the domestic hot water can be produced at temperature of just 3 °C below the primary supply temperature, e.g. 47 °C at a DH supply temperature of 50 °C.

The measured heat loss for the entire network is very low, but in line with expected heat loss calculated in the design phase. Estimated heat losses in this low temperature network are approx. 50,000 kWh / year. Had the same network been laid out with a traditional design with single pipes and a temperature set of 80/40°C, the corresponding calculated heat loss would be approx. 200,000 kWh. This means that heat loss compared to a conventional network is reduced to approx. ¼. On the other hand, this gives a smaller increase in electricity consumption for booster pumping estimated at approx. 2,600 kWh per year. Heat loss is annually around. 1.2 MWh per dwelling corresponding to approx. 17% of the energy supplied to the area.

Research

The two main research challenges were to design district heating network with low heat loss and design new in-house district heating substations operating efficiently with supply temperature 50°C.

For Lystrup project, two types of low-temperature DH substations were designed, tested and implemented. Since the supply temperature is bellow 50°C, concept of traditionally used DH substation with storage of DHW can't be used anymore because of risk of Legionella. Nevertheless traditional concept of storage tank is very beneficial for DH network because allows reduce diameter of DH network and thus new unit with buffer tank for DH water on primary side was developed [4]. The unit is called District Heating Storage Unit (DHSU). Developed DHSU has 120L buffer tank for DH water which was chosen as optimal size between DHW draw of profile and charging flow rate from DH network. The second type of unit is traditionally used DH substation with once passed heat exchanger (HEU).

Moreover, reduction of supply temperature to 50°C means need to use highly efficient heat exchanger which can heat domestic hot water to temperature over 45°C while keeping low return temperature. Such a heat exchanger was developed specially for this project and was implemented into both types of low-temperature DH substations. The heat exchanger (Danfoss XB37H) is able to operate at very low temperature differences at low pressure drops. The design temperatures for producing domestic hot water for the substations at primary side are 50/17°C, and at secondary side 10/45°C at 32kW draw off.

Besides this, special focus was on high level of insulation. The measured results for heat loss from the substations are 81W for the storage tank substation and 26W for the heat exchanger substation. These levels are low and acceptable for low energy class 1 buildings.

The heat loss from DH network was reduced by use of pipes with reduced diameter. Reduced diameter results in lower heat loss from DH network but on the other hand increased pressure loss in the network lead for need of using booster pump. Many people doesn't believed in this concept, but results clearly documented that primary energy for pumping is 6500 kWh per year which is only 5.5% of energy saved on heat loss (primary factors: electricity 2.5, district heating 0.8). The DH network is built from Alu-flex pipes with diffusion barriers on inner as well as on outer side of insulation. This feature effectively prevents the ageing of the insulation capacity well-known from traditional pipe design. Insulation material is ultra fine cell PUR foam expanded with Cyclopentane (CP). Heat conductivity (λ) of the material is 0,022W/mK at 50°C. Moreover a new type of district heating twin pipe, Aluflex 14/14/110 with inner diameter 10 mm was developed specially for the project to be used as branch pipe for substations with buffer tank on primary side because recently used pipes were too big. The desired pipe diameter was lower, but recently it is not possible produce pipes with smaller diameter.

Environmental impact

With the vision of fossil free future the alternatives for supply of areas with low heat demand are individual heat pumps or low-temperature district heating using multiple heat sources based on renewable energy. Based on the previous project [5] the low-temperature district heating solution is economically fully competitive to solution with individual heat pumps even in areas with low-energy houses.

The annual heat loss from Lystrup low-temperature district heating network is 50 000kWh/year which is ¼ of heat loss 200 000kWh/year calculated for traditional design, i.e. if network was build with single pipes and operated with 80/40°C supply and return temperature. Recalculation of 150 000kWh heat saved by reduction of heat loss to CO_2 emissions means saved 21 tons of CO_2 each year.

The directly seen environmental impact of low-temperature district heating in Lystrup is not presenting astonishing numbers of CO_2 savings as e.g. change of traditionally coal-fired boiler in heating plant with boiler for biomass, but it should be considered that the reduction is in case of Lystrup made only by change of network supplying area of 40 houses. For application in bigger area, CO_2 saving will be higher and additional reduction can be added on top by possible improvement of heat source. Even more important feature in relation to environmental impact and security of supply is the possibility of leaving fossil fuels and operate network with low temperature supplied by renewable sources of energy as e.g. geothermal heat plan, biomass or with waste heat from industrial processes, which will be with recently used temperatures uneconomical.

Community benefits

Recently a benefit for the community is cheap, reliable and environmentally friendly heat supply of the houses, but the main benefit should be seen in perspective of the future. Based on the "Heat Plan Denmark", 70% of heat demand in Denmark will be in 2050 supplied by district heating with 100% share of renewable energy. This transition will mean reduction in supply temperature of district heating networks as much as possible resulting in installations of new in-house substations and refurbishment of district heating networks. In Lystrup, all necessary steps were already done and thus there is no need of additional investments for the future.

Financing

The project was invested and financed by the building association Ringgården. Besides this, the technical analysis and development of the concept including appropriate components were supported by the Danish Energy Authority project "Development and Demonstration of Low-Energy District Heating for Low-Energy Buildings", EFP2007, and the Danish Energy Authority supported project "CO2-reductions in Low-Energy Buildings and Communities by implementing Low-temperature district heating systems. Demonstration cases in EnergyFlexHouse and Boligforeningen Ringgården" EUDP 2009.

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Lærkehaven II

Slut med at fyre for regnormene
– koncept for lavtemperaturfjernvarme

No more heating for the earthworms
– Concept for low temperature district heating

40 et-plans rækkehuse
Lavenergiklasse 1

Boligstørrelser:
3-rums boliger 100 m²
4-rumsboliger 110 m²

Færdigopført april 2010

Arkitekt: schmidt hammer lassen architects

40 single-storey terraced houses
Low-energy class 1

Size of dwellings:
3-room dwellings 100 m²
4-room dwellings 110 m²

Construction finished April 2010

Architect: schmidt hammer lassen architects

" Bækken pibler af sted lige uden for hoveddøren og forleden gik der et par rådyr på marken. Ja, omgivelserne og udsigten er fantastisk.

Beboer i Lærkehaven II

The creek trickles just outside the main door, and the other day there were a couple of deer in the field. Yes, the surroundings and the view are fantastic.

Resident in the Larch Garden II

Nyt fjernvarmekoncept til lavenergiboliger

New district heating concept for low energy dwellings

Slut med at fyre for regnorme

Lærkehaven II er den første bebyggelse i Danmark, hvor et nyt fjernvarmekoncept til lavenergiboliger afprøves: "slut med at fyre for regnormene".
Fjernvarme forsyner 1,5 millioner danske boliger og udgør 60 procent af Danmarks varmeforsyning, men de skrappe krav til bygningers energiforbrug betyder, at der skal tænkes nyt, hvis det skal kunne betale sig at bruge fjernvarme i lavenergibebyggelser.
Fjernevarmeprojektets første fase, der blev udført i et testlaboratorium på Teknologisk Institut, pegede på, at der kan spares både energi og penge på det nye fjernvarmekoncept til lavenergihuse. Blandt andet reduceres varmetabet i jorden ved at bruge twinrør som har en særlig isoleringskappe. Hertil kommer lave temperaturer på 50 grader i fjernvarmeforsyningen.
Projektets næste fase er at afprøve fjernvarmekonceptet i praksis. I Lærkehaven II er der installeret lavtemperatur fjernvarme i halvdelen af boligerne, så forskerne kan sætte fokus på den praktiske drift af fjernvarmekonceptet og måle det virkelige varmebehov og varmetab i moderne lavenergiboliger.

No more heating for the earthworms

The Larch Garden II is the first project in Denmark to test a new district heating concept for low energy dwellings "No more heating for the earth-worms".
District heating supplies 1.8 million Danish dwellings and constitute 60 percent of Denmark's heating supply, but the tough requirements on the energy consumption of houses mean that innovative thinking is necessary if district heating shall be profitable in low energy buildings.
The first phase of the district heating project which was performed in a test laboratory at the Danish Technological Institute indicated that it is possible to save both energy and money on the new district heating concept for low energy houses. Among other things through reduction of the heat loss in the earth by using twin pipes which have a special insulation jacket. Add to that low temperature of 50 degrees in the district heating supply. The next phase of the project is to test the district heating concept in practice. In the Larch Garden II low temperature district heating is installed in half of the dwellings so that the researchers can focus on the practical operation of the district heating concept and measure the real heating needs and heat loss in modern low energy dwellings.

Strategi for bæredygtighed

- Lavenergiklasse 1 – forventet energiforbrug på 47,3 kWh/m^2/pr. år
- Højeffektiv isolering og tæthed. Gennemsnitligt ca. 450 mm. i tag, 335 mm. i ydervægge og 300 mm. i terrændæk
- Lavenergivinduer og døre: U-værdi inkl. rammer 1,1 W/m^{2}K
- Store vinduer mod syd giver tilskud af passiv solvarme
- Balanceret ventilation med varmegenvinding
- Konstruktion uden kuldebroer (tæthed og kuldebroeliminering kontrolleres ved termofotografering og blower door tests)
- Alle kendte vandbesparende foranstaltninger
- Lavtemperaturfjernvarme
- FSC certificeret træ

Strategy for sustainability

- Low Energy Class 1 – expected energy consumption on 47,3 kWh/m^2/year
- Highly efficient insulation and tightness. On average app. 450 mm in roof, 335 mm in outer walls and 300 mm in ground floor
- Low-energy windows and doors: U-value incl. frames 1.1 W/m^{2}K
- Large windows facing south contributes with passive solar heat
- Balanced ventilation with heat recovery
- Construction without cold bridges (tightness and cold bridge elimination controlled by thermo photography and blower door tests)
- All known water saving measures
- Low temperature district heating
- FSC certified wood