



**LOW TEMPERATURE HEATING SYSTEMS**  
INCREASED ENERGY EFFICIENCY AND IMPROVED COMFORT



# LOW TEMPERATURE HEATING SYSTEMS INCREASED ENERGY EFFICIENCY AND IMPROVED COMFORT

Low temperature heating systems or high temperature cooling systems that are suitable for office buildings, service buildings and residential buildings, can use a variety of fuels and renewable energy sources. These systems use energy efficiently while providing a comfortable indoor climate.

## WHAT IS A LOW TEMPERATURE HEATING SYSTEM?

In a low temperature system the distributing temperature of the water or air in the system is close to room temperature where as in the traditional radiator distribution system, the temperature of the circulating water is between +50–+80°C. If the heat distribution is managed using a low temperature under-floor heating system the temperature of the water is only about +25–+35°C. When the heat is distributed through the whole floor area, the temperature of the water can be much lower than that required in normal radiators.

The heat carrier in a normal cooling system is cooled to approximately +10°C. In a low temperature system this temperature can remain as high as +20°C, which is close to the desired room temperature.

Low temperature systems successfully combine both traditional and innovative new approaches to heating. Usually the heat is transferred into the room through air or liquid circulation systems and the same system can often be used for both heating and cooling.

## A SUSTAINABLE AND FLEXIBLE APPROACH TO HEATING

It is widely accepted that buildings of the future will need to be built in a more sustainable and environmentally friendly way. Low temperature heating and cooling systems represent a sustainable choice as they are energy efficient, can utilise renewable energy sources and provide a comfortable and healthy indoor climate.

Low temperature heating systems are sustainable because they are flexible. These systems are not bound to any one energy source and fuel switching does not entail excessive cost. Low temperature systems can utilise a variety of sources of heat including district heat, biofuel, solar energy, gas, oil or electricity, and so the user is not constrained by choices made in the planning phase.

## A HEALTHY COMFORTABLE AND SAFE LIVING ENVIRONMENT

Research shows that people living in houses with low temperature heating systems are very satisfied with ambient indoor air quality. In particular, thermal comfort levels are considered to be higher than in houses with a



IEA Research Project on low temperature heating systems, Annex 37. Eleven countries participate.

traditional heating system. Residents also experienced a reduction in draughts and dust, and reported fresher air in houses with low temperature heating systems.

Under floor heating systems distribute heat more equally, and offer higher comfort levels than systems which transfer heat through air. By using low temperature heating systems the room temperature can be decreased by a few degrees, which is more energy efficient and healthier for occupants. Low temperature heating systems do not require radiators, which can be unsightly and hard to clean. This offers the additional advantages of increased living space and more flexibility in terms of interior design. The absence of radiators also provides a safer environment for children during the heating season.

## ECONOMICALLY EFFICIENT HEATING SYSTEMS

Thorough planning and expert implementation are prerequisites for an appropriate and functional system. System flexibility will be dependent on the choice of appliances and overall system design, which can be difficult and expensive to change after installation.

The life cycle costs of a low temperature heating system are about the same as of a traditional system. Although the initial investment might be slightly higher the system offers increased flexibility in terms of fuel choice and increased energy efficiency, for example the efficiency in solar heating is considerably higher in a low temperature heating system than in a traditional one.

## CENTRE FOR SUSTAINABLE BUILDING – KASSEL, GERMANY

The low energy office of the Centre for Sustainable Building is a project demonstrating the implementation of a new low temperature hydronic heating and cooling system.

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Pipes are embedded in the concrete slabs and floor construction. A ground heat exchanger (pipes in the basement slab) facilitates utilisation of the coolness of the underlying ground, thus using a renewable energy source. The ZUB office building is an example of how new low temperature heating/cooling systems and new environmentally friendly building materials can be used. This case study illustrates the practical implementation of these approaches to building projects.

The new three storey building (net floor area 1732 m<sup>2</sup>) is attached to an existing preserved building and consists of three different areas; an exhibition space; a venue for events; offices and a separate area for experimental research into innovative building technologies and services.

To achieve a very low energy demand (calculated annual heating demand is 16.5 kWh/m<sup>2</sup>), special measures have been adopted. The U-value of the exterior walls is 0.11 W/m<sup>2</sup>K. Triple glazed windows with a U-value of 0.6 W/m<sup>2</sup>K, have been chosen for the mainly south facing large window area,

minimising heat loss and maximising solar gain.

The minimal frame-fraction of the wooden facade construction helps to reduce heat losses. Careful planning of all joints has minimised thermal bridging.

To save electricity, use of natural lighting has been optimised and ventilation strategies have been implemented.

A good level of comfort has been reported by occupants. This was a high priority for the building owner.

An important aspect of the overall concept is the use of sustainable building materials. A clay wall, made from unbaked clay bricks, stands in the centre of the building. This wall, has great heat retention capacity and by dampening fluctuations in humidity, works as a climate wall.

To monitor the aims of this project and verify its achievements, an intensive research programme "Solar Optimised Building" funded by the German Ministry of Economic and Technology is currently being run.

## LYCÉE LÉONARD DE VINCI – CALAIS, FRANCE

The lycée Léonard de Vinci-Calais, France is a demonstration project for the French High Environmental Quality (HEQ) approach.

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This case study involved the application of a wide variety of environmentally sound measures to the building of a school. These measures included selection of reusable or local building materials and double-flux ventilation (heat recovery on air exchange). Solar collectors with a heat pump are used for water heating for the kitchens and 75 m<sup>2</sup> of PV cells were fitted to generate electricity for security lighting and alarms. A combination of construction techniques, technical devices and energy efficient architecture have realised a 30% energy saving.

The gas-fueled combined heat and power generation system produces heat for the heating system and electricity for other uses. Electricity is also produced using a wind generator which was installed at the beginning of the construction phase. Even when

electricity supply and demand are not simultaneous, a balance is achieved on an annual basis. Electricity produced during the summer months when the school is closed is sold back to the national grid.

Use of natural daylight has been optimised in class rooms and corridors and although some overheating occurred in May and June during the first year window blinds were installed and the problem has been solved.





## CARISVEN - HEERLEN, THE NETHERLANDS

"Carisven" is a demonstration project for the Dutch sustainable and low-energy building programme. It is comprised of 54 semi-detached houses, and is situated in the city of Heerlen.

The Carisven project was developed by Corio Vastu bv, Heerlen, in close co-operation with the municipality of Heerlen. The project has been extensively monitored by Novem (the Netherlands Agency for Energy and the Environment) within the framework of the Market Introduction Programme for Low Temperature Heating Systems. This Programme was conducted by Novem on behalf of the Dutch Ministries of Economical Affairs and Housing, Spatial Planning and the Environment.

There are two types of dwellings. The A/B-type has an unheated south facing sun lounge overlooking the garden. The C/D-type has an unheated south facing sun lounge overlooking the street. Individual dwellings can have customised floor plans.

All dwellings have wall heating. A solar collector preheats the water for central heating and domestic hot water. A built-in gas boiler is used for additional heating. PV-cells are used for electricity generation and rain water is stored in an underground tank for reuse.

All dwellings have a high efficiency solar boiler for space heating as well as for domestic hot water supply. A solar collector preheats the water in the storage tank. When necessary, a natural gas boiler heats water for domestic hot water supply and use in the central heating system.

A wall heating system has been installed with a maximum design supply temperature of 50°C and a design return temperature of 40°C. The houses are ventilated naturally.

A survey amongst occupants showed a very high level of satisfaction with thermal comfort and indoor air quality. Occupants indicated that they were very pleased with the Low Temperature Heating System and that they would recommend it to others.

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## IDIC RESEARCH CENTRE - IWATE, JAPAN

Chilled Radiators for Radiant Cooling and Dehumidification.

The IDIC Research Centre is situated in the North-eastern part of Japan, where winter temperatures fall well below freezing point and summer temperatures reach 30°C or more with high humidity.

This building utilises room radiators for heating and cooling as well as for dehumidification of the indoor air. In addition, the south facing glass façade effectively utilises deciduous trees, which provide shade in summer and allow solar gain in winter to reduce space cooling and heating requirements. Continuous operation of radiators at relatively high temperature for cooling in summer season, and low temperature for heating in winter season provides a low energy system and high levels of comfort. Both heating and cooling energy are extracted from groundwater at 12°C.

Water temperature operated below dew point facilitates the dehumidification of the air. The large surface area of the radiators, mainly designed for cooling of the building, allow the use of heat pumps at high efficiency with water temperatures of 30–40 °C during the heating season.

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## THE LABORATORY BUILDING "LA CASA INTELLIGENTE" – ROME, ITALY

La casa intelligente is located in the ENEA centre in Casaccia, Rome, in Italy. Many energy efficient technologies and national programmes are developed here for the residential sector.

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This laboratory building, was funded within the framework of the MICA-ENEA programme (MICA is the Italian Ministry for Industry, ENEA is the Italian Committee for Energy and Environment). This case study presents the application of systems and technological devices suitable for adoption in the medium term for everyday use in the construction industry.

This two storey detached building has an area of 900 m<sup>3</sup> and is quite traditional, but the brickwork consists of alveolater bricks. These bricks are manufactured with a mass of small air cavities diffused throughout, making the brick lighter and giving better thermal insulation characteristics to the walls. The windows are equipped with electro-chromic insulating glass featuring electronically adjustable light and power transmission allowing regulation of the amount of light and heat passing through the window.

A radiant floor panel system has been installed which circulates water at low temperatures for heating and higher temperatures for cooling, to reduce energy consumption. This involves the use of more

modern heaters, which work at lower temperatures and have more sophisticated controls. A direct expansion ventilation system has also been installed, using an environmentally friendly gas instead of water as a thermovector, unlike traditional apparatus.

This heating system is connected to the security system, shutters, lighting, programming of internal devices and technological systems. The kitchen appliances interact to minimize energy consumption and the refrigerator has the added capability of being equipped to remind the user of the expiry date of food by reading the relevant bar codes. All of these instructions are given using a small user-friendly touch pad. An experimental programme is underway to look at the issue of humidity, which in the Italian climate, is an important parameter to consider in relation to masonry. Tests showed doors to be quite air tight and the thermal comfort levels of the building in winter demonstrated the success of the building envelope design.

## VILLA WÄHLIN – STOCKSUND, SWEDEN

The Villa Wählin is a demonstration project for STEP, the new, lighter structure building system. The exterior walls consist of large polystyrene block elements that are connected to each other with U-shaped shield metal profiles.

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This two storey residential building has large south facing windows. A balanced ventilation airhandling unit is installed in the heated crawl space beneath the building. This combination supplies the building with fresh air and heat.

The crawl space is heated, insulated and radon tight at ground level. The air supply is from a balanced ventilation source with an air/air heat pump that works by using the heat from the returned air to preheat the

supply air. Warm air is supplied to the crawl space, heating the floor, and flows through a gap at the edge of the floor into the rooms above. However it was found that heating of the two remaining floors was insufficient and additional heating was required.





Photo: Per Wählin

## THE SIBELIUS HALL - LAHTI, FINLAND

Sibelius Hall is the largest wooden building constructed in Finland for over one hundred years.

The complex which is nearly 90,000 m<sup>3</sup> is a conference centre and concert venue. Facilities include a main hall with 1250 seats, the forest hall which is a 1000 m<sup>2</sup> lobby, a renovated carpentry factory which acts as a 1400 m<sup>2</sup> exhibition space, and meeting and lecture rooms.

In Finland wood has always been a popular building material, both inside and outside. The Sibelius Hall represents the further development of timber construction technology. The building contains many special wooden elements and uses new innovative approaches and solutions. For example, the facades of the conference centre and concert hall are made of sand filled wooden structures and glass. Recent research in Finland has shown that use of wood impacts positively on indoor climate and comfort.

The building is heated and cooled with a ThermoNet® system, with district heating and cooling networks supplying energy to the Hall. Cooling is achieved by utilizing the local industry process water via absorption chillers. Waste heat from the system is recovered by return to the district heating system.

In a venue of this sort it was essential to give due consideration to the acoustics of the main hall. The materials and even the furniture have all been chosen with this in mind. In this kind of environment it is also essential that the cooling system is silent. The echo chambers at the sides of the hall, along with the doors and curtains, allow for adjustments to the acoustics of the hall when required.

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## THE AALTOALVARI WATER SPORT CENTRE - JYVÄSKYLÄ, FINLAND

The AaltoAlvari is a water sport centre originally designed by the world famous Finnish architect Alvar Aalto.

The centre has a total area of 64,900 m<sup>3</sup> and offers excellent swimming and water sports facilities as well as a modern spa.

Between 1998 and 2000 a major reconstruction and renovation programme was undertaken in the AaltoAlvari. A ThermoNet® low temperature system was installed. After renovation, the heat energy demand was reduced by 20% and the indoor climate and comfort levels have been improved considerably.

Due to the nature of indoor swimming pools and spas, the heat energy requirements, and electricity and water consumption,

are much greater than in other types of buildings. The evaporation of water from the pools consumes a substantial amount of the energy. An essential task for the building service system is to manage the moisture load.

The ThermoNet®-Indoor swimming hall system is an integrated system, where the different demands of pool areas, dressing rooms and shower areas have been taken into account. The system is flexible and functions according to users' needs. Lifecycle costs are optimised and the environmental impact is minimised.

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### MORE INFORMATION ABOUT THE PROGRAMME:

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

[www.vtt.fi/rte/projects/annex37](http://www.vtt.fi/rte/projects/annex37)



IEA ECBCS

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### THE LOWEX RESEARCH PROGRAMME

LowEx, the international low temperature heating systems research programme, is part of the International Energy Agency's (IEA) Energy Conservation in Buildings and Community Systems programme (ECBCS).

The aim of the programme is to promote rational use of energy by encouraging the use of more efficient low temperature heating systems for heating and cooling of buildings. The programme will result in the production of a guidebook for designers on low temperature heating systems. It will outline the advantages and constraints of the systems

and components required and provide information on analysis, planning and selection tools. This book will be completed by the end of 2003.

The programme is coordinated by VTT, Finland. The coordinating group consist of a management team which has the following partners: ABB Installaatiot Oy, Are Oy, Development Centre For Finnish Building Services Ltd, The Finnish District Heating Association (FDHA), Tekes the National Technology Agency, Uponor Suomi Oy, VTT Building and transport and YIT.

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