System concept

IEA HPP Annex 32

Economical heating and cooling systems for low energy houses

Seasonal storage and solar collector integrated heat pump concept with individual ground sources for the application in low energy homes

Agentschap NL
Ministerie van Economische Zaken

q:p
innovatie
communicatie

Contribution of the Dutch national project

Summary

Individual seasonal storage systems can be effective in low energy houses, even in densely populated areas, because of the availability of very energy efficient cooling and the integration with solar thermal energy systems, offering a seasonal performance based on primary energy of 2.5 and better.

The system concept consists of:

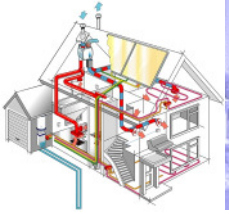
- Individual heat pump (7-9 kW_{th}) and vertical ground sources (brine or water, 150 m)
- Solar collector 2.8 m^2 with 150 l storage tank
- Floor or wall heating
- Ventilation system with heat recovery 300 m^3/h

Building outline for the system concept

Application:
Single family homes, detached and semi-detached houses, apartments, where heating and space cooling is required. Homes adapted to people with allergies or respiratory diseases, homes for the elderly, homes in smog risk areas.

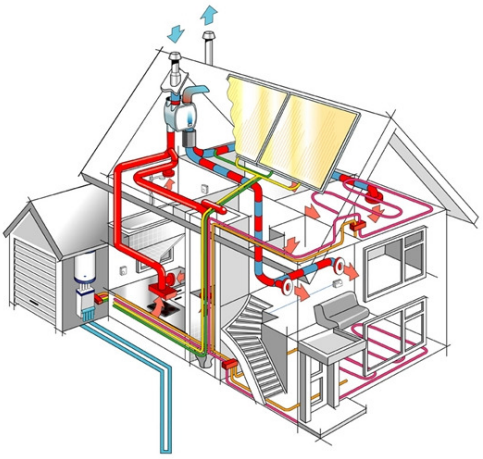
- Heat pump 3.5 to 9 kW_{th}, floor heating, solar collector 2.8 m^2, vertical closed ground source (brine or water)
- Functions: Heating, cooling, hot water, dehumidification, ventilation
- SPF on primary energy: 2.5 (heating and hot water)
- Identified optimisation potentials: capacity reduction, integration with ventilation system and building
- Costs € 18.000 (2003 prices for heat pump and source, solar boiler, ventilation with heat recovery)

International Energy Agency
Heat Pump Programme


Background

In the EU, all buildings commissioned after January 1st, 2019 will be required to be net zero, meaning that a building's carbon emissions are offset by the generation of energy through non-carbon-emitting means. In the Netherlands some local goals are more ambitious and are set to reach net zero for projects commissioned after 2015 or even 2010, for a part of the volume. In 2011, the national energy performance requirement for dwellings will be changed from the present 0.8 to 0.6, comparable to passive house level plus 50%, bringing it to an effective low energy level. This includes room heating, cooling, hot water, lighting, ventilation and auxiliary energy, but not the energy consumption for consumer appliances such as washing, drying, computers and audio/video equipment.
While not obligatory, several parties have already developed and built projects with an energy performance that meets the low energy level. This performance is obtained by a combination of improved insulation quality of the building, south orientation and an efficient energy system, at least partly based on sustainable energy and thermal storage.
Thermal storage in the underground or in aquifers can be considered a standard technique in the Netherlands and is widely applied for utility buildings. Several collective heat pump systems are operational in the housing sector. Also a limited number of projects using individual heat pumps are operational. Proposed new low energy housing projects frequently use individual heat pumps.



Concept with integrated solar collector

Technical concept

Heat pump systems are still relatively new to the Dutch housing market, the standard technology being natural gas heating with condensing boilers. The higher cost of heat pump systems has slowed down the market penetration.
The next change in the energy performance requirement can still be met by gas systems, combined with ventilation heat recovery, solar energy and reduction of losses.
To reduce building costs, and to be able to meet the increasing demands on building performance in the field of energy, acoustic insulation, fire safety and recycling of materials, the building industry switches more and more to prefabricated parts and components. Prefabricated floors and walls can come a with low temperature heating system already built in.
A closed ground heat exchanger offers good working conditions for a heat pump in heating mode. The relatively cold water from the ground source can be used directly for cooling and dehumidification in summer, with only very little auxiliary energy consumption.
Balanced ventilation systems offer the possibility to effectively use the heat from the exhaust air to heat the incoming air through a ventilation heat exchanger, with a recovery rate of up to 95%, leading to a reduction in energy demand for room heating (and in principle, cooling). A solar collector of 2.8 m2 with a storage tank will normally produce all the hot water needed for a family during the summer months and for regenerating the ground source, in addition to the heat obtained by the cooling system. In colder and less sunny periods, the heat pump will process the water further the required temperature.
A solar collector is used for both hot water production on sunny days and for ground source regeneration on colder days. This way, the solar panel has the highest possible performance: even with an outside temperature of 10 degrees and lower the solar panel are used to regenerate the ground source.

Technical data of the unit

Heat pump	**2 compressors 3kW+5kW**
COP	**6 (heating) 3 (hot water)**
Storage tank	**150 l hot water**
Refrigerant	**R134A**
Elec. backup	**5 kW**
Noise	**45 dB(A)**
Storage volume	**2 m^3**
Ventilation	**300m^3/hr 95% recovery**

Figures apply to current units

State of market introduction

The technology has been applied in several low energy projects and is actively co-marketed by producers and project developers.
Market state
The technology has been applied in several projects and is actively co-marketed by Itho and project developers.

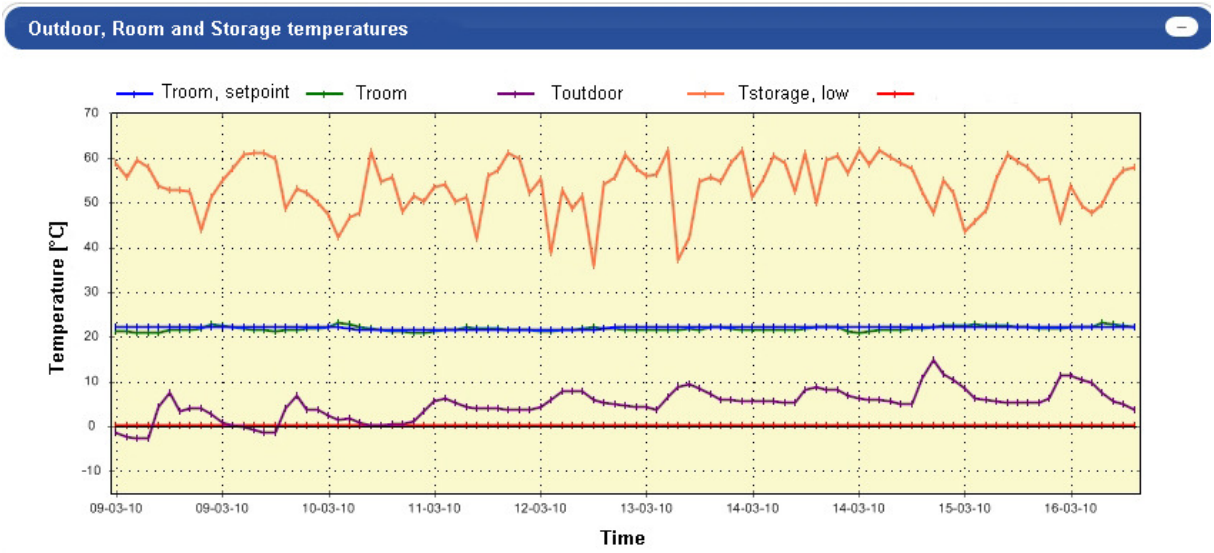
Field monitoring

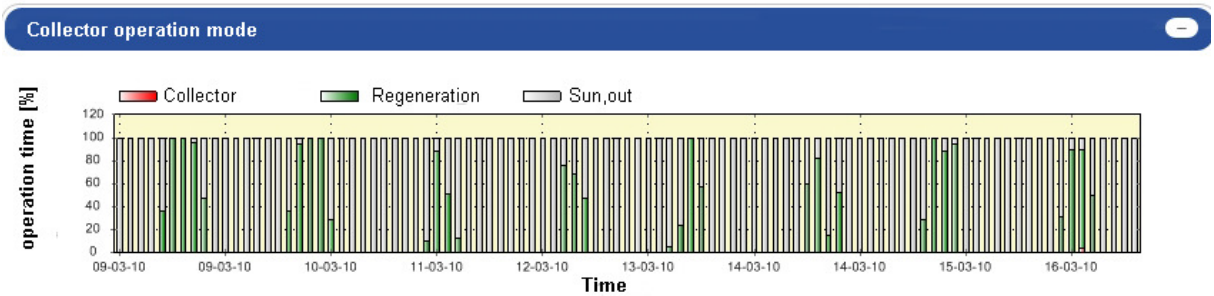
Project: Carré, Delfgauw
(ground source heat pump, balanced ventilation, solar collector)

Location:	Delfgauw, near Delft
Type:	single family terraced (row-)houses
Monitored house:	floor area: 90 m^2
Walls	R_c = 3.5 m^2·K/W
Roof	R_c = 4.0 m^2·K/W
Ground floor	R_c = 3.5 m^2·K/W
Glazing	U_c = 1.2 W/m^2·K
Infiltration	0.625 l/s·m^2
EPC	0.6

Number of units monitored: 1
Variables monitored: inside/outside temperature, solar regeneration, floor temperature
Occupant influence: the occupants use large quantities of hot water, approx double the expected volume

Results:
Energy consumption: system runs on approximately 5 kW_{th} on cold days, 40% lower than expected. This can be explained by the regeneration of the source by the solar collector. The ground source temperature has risen 5° C, including the cold winter of 2009/2010, after 5 years.
The solar panel contributes even at exterior temperatures below 10°C. While contribution of the collector to the hot water production under these circumstances is limited to a few hours per day, the temperature outside these hours will still be enough to store the energy in the (closed) ground source. The higher source temperature leads to better heating-COP of the heat pump.





Field monitoring values of the described system concept

Technical innovations in system concepts

The presented system was used in dwellings designed in 2001 and built in 2002. Thanks to improved isolation quality, the solar panels are no longer necessary in this concept. The power necessary for room heating, and the energy supplied by the ground source, currently are 40% lower than in 2002. Therefore the solar panel, which is an expensive component to produce and install, is not used in current projects.

In Eindhoven, Berckelbosch, Ballast Nedam is developing energy neutral (net-zero) single family terraced houses with the described concept without the solar panel.

Monitoring of these heat pumps has not started, yet.

Economy, Ecology and Costs

A heat pump with ground source will produce heating, cooling and hot water. A gas boiler can only produce heating and hot water. To achieve cooling, an additional investment is necessary and operating costs will occur. When this and the lower energy bill is taken into account, a ground source heat pump is an attractive option.

Ecology

Heat pump systems are the best performers on CO_2-emission reduction. This will even improve as more sustainable electricity is fed on the grid. The CO_2-emission can be reduced further by integrating sustainable energy systems such as a solar collector or photovoltaic cells.

Other environmental benefit

In homes, the internal space is important. Heat pump systems can appear to take a lot of room, but this does not take into account that no smoke channel and radiators are necessary. The room requirement is actually less than for a conventional system, providing the building is optimized for the heat pump system.

Imprint

Company
Woningcorporatie Rondom Wonen, Delfgauw
Energy concept: Itho, Schiedam
Consultans: W/E Adviseurs, Utrecht

Development
Itho, Schiedam

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Literature

Evaluation report available through AgentschapNL

IEA HPP Annex 32

IEA HPP Annex 32 is a corporate research project on technical building systems with heat pumps for the application in low energy houses.
The project is accomplished in the Heat Pump Programme (HPP) of the International Energy Agency (IEA).

Internet: http://www.annex32.net