



## Seasonal storage with collective ground source system for low energy apartments



Agentschap NL  
Ministerie van Economische Zaken



### Contribution of the Dutch national project

### Summary

By distributing water at ground source temperature, very energy efficient free cooling is available in all apartments. Individual heat pumps use the same source for the heating and hot water. Hot water is produced at night, when no room heating is required, and stored for use during the day. The low temperature of the two-pipe system avoids thermal distribution losses.

The source consists of several vertical heat exchangers, connected in parallel. The flow of all sources is matched by tuning the flow resistance. Thermal energy from the floor cooling system is fed into the system in the summer, regenerating the source. The heat capacity of the underground will level out variations in the energy balance from year to year. An overall balance is achieved by careful dimensioning of windows and openings.

The system concept consists of:

- Individual heat pump (3.5 kW<sub>th</sub>) and collective vertical ground source system (33 closed loop sources, 120 m depth)
- Floor or wall heating
- Ventilation system with heat recovery 300 m<sup>3</sup>/h

### Building outline for the system concept

- Application: Apartments and high density housing blocks.
- Heat pump 3.5 to 7kW<sub>th</sub>, floor heating, collective vertical closed ground source (water)
- Functions: Heating, cooling, hot water, ventilation
- Identified optimisation potentials: capacity reduction, integration with ventilation system and building
- Costs per apartment € 7.000 (Heat pump, boiler and shared collective source system, distribution system)



## Background

In the EU, all buildings commissioned after January 1<sup>st</sup>, 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.

## 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, if combined with ventilation heat recovery, solar energy and reduction of losses

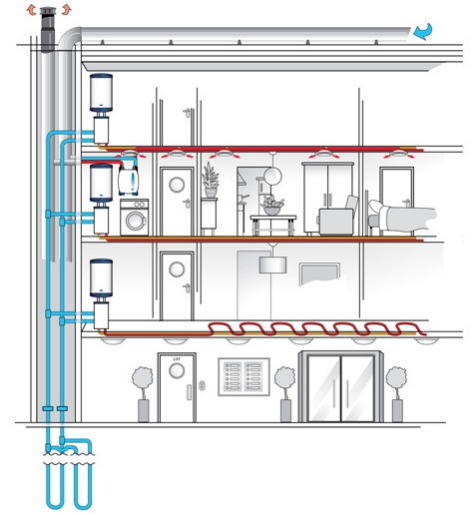
To reduce building costs, and to be able to meet the increasing demands on building performance in the field of energy, acoustic insulation, fire safety and recycling of materials, the building industry switches more and more to prefabricated parts and components. Prefabricated floors and walls can come with a 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).

## State of market introduction

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



Sketch of the system configuration

### Technical data of the unit

- Collective closed ground sources
- Individual heat pump per dwelling for heating, cooling and hot water
- COP approx 6 for heating, COP approx 3 for hot water
- Balanced ventilation with a recovery rate of 95%

**Field monitoring**

**De Tas, Biddinghuizen**

Project: De Tas, Biddinghuizen  
 Type: apartment building for seniors  
 Monitored house:  
 floor area: 54 dwellings each approximately 76 m<sup>2</sup>

Walls	$R_c = 3,0 \text{ m}^2 \cdot \text{K/W}$
Roof	$R_c = 3,0 \text{ m}^2 \cdot \text{K/W}$
Ground floor	$R_c = 3,0 \text{ m}^2 \cdot \text{K/W}$
Glazing	$U_c = 1.2 \text{ W/m}^2 \cdot \text{K}$
Infiltration	$0.625 \text{ l/s} \cdot \text{m}^2$
EPC	$< 0.5$

Number of units monitored: 54

Variables monitored: room temperature, room temperature setting, operating mode, temperature, ground source temperature

Results:

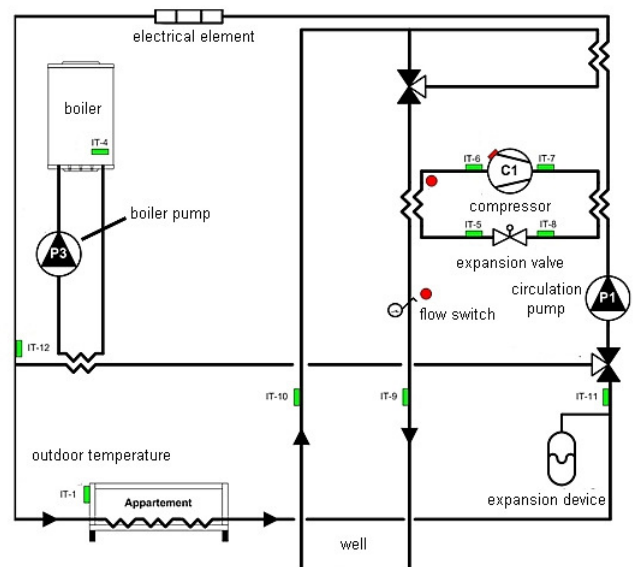
Even after a very cold winter, the ground source temperature at the end of the winter is the same as one year earlier, and starts to build up as early as in March. This can be explained by the oversized ground source system giving an ample peak capacity and thermal regeneration of the sources through heat conduction in the underground from parts further away from the sources. The resulting temperature swing of the extracted water is only 9 degrees Celcius, and the temperature never reaches the freezing point. This also has the advantage that pure water can be used as the medium in the closed sources, avoiding the risk of contamination of the underground in the unlikely event of leaks altogether.

The source system consists of two loops: a ground source loop and a circulation loop, coupled through a mixing box. These systems are regulated separately. Experience shows that source circulation is not necessary in large parts of the year, leading to energy conservation.

Compared to the cost of gas equipment and heating, the system is cost effective, offering lower emissions and increased comfort through the availability of cooling.

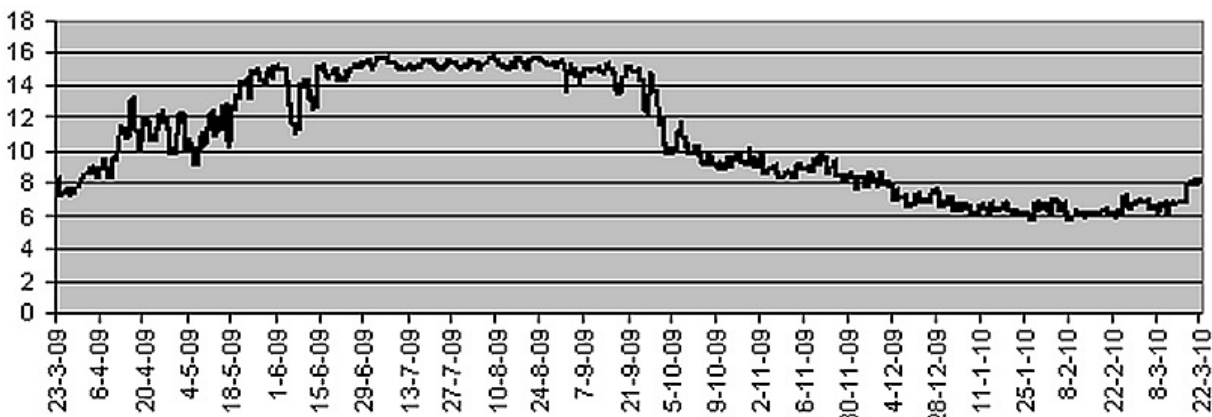


*Evolution of ground source temperatures over one year*



*Hydraulic sketch of the field monitoring plant*

**Groundsource temperature**



*Evolution of ground source temperatures over one year*



**Technical innovations**

In the Netherlands, ground source heat pumps are often used with an individual source, i.e. one or more ground collectors per dwelling. Typically, the ground source has a footprint of approximately 25 to 50m<sup>2</sup>.

For apartment dwellings this is often not possible, as the available area for ground sources is not sufficient. The proposed concept therefore uses a system of parallel ground sources creating one closed loop ground source for a number of apartments. Each apartment has an individual heat pump to supply heating and hot water.

The separate regulation of the collective source system and distribution system leads to energy conservation in the source pump and has simplified the control algorithms and control conflicts. The source system kicks in automatically on the basis of the temperature in the mix box. The circulation pump maintains a constant pressure on the supply side of the distribution system. By using a reverse return system, an equal flow in the parallel branches of the distribution system is realised, without the use of flow restrictions. The individual heat pumps have an intelligent PID-control system.

**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, with a pay back time within 12 years.

Ecology

Heat pump systems are the best performers on CO<sub>2</sub>-emission reduction. This will even improve as more sustainable electricity is fed on the grid. The CO<sub>2</sub>-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 space, but this does not take into account that no stack gas channel and radiators are necessary. The room requirement is actually less than for a conventional system, providing the building is optimised for the heat pump system

Imprint	Literature
<b>Company</b>	Monitoring results will be forthcoming
Oost Flevoland woondiensten, Biddinghuizen Itho systems, Schiedam	
<b>Development</b>	
Itho systems, Schiedam	
<b>Date of System concept sheet: June 2010</b>	

**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>

