Netherlands

The Passive House

National Publication

What is a Passive House?

*In this age of **increased energy prices** and **emission excesses**, efficient energy use is becoming more and more important. This is no longer solely an environmental consideration, but increasingly also a financial one. Some **40% of our annual energy consumption** is used in buildings. The Passive House concept primarily focuses on residential buildings, though these principles are applicable in other building types as well. As the numbers show, **energy-wise**, there is **much to be gained in buildings**. For this reason, more and more building professionals have recognized the Passive House approach as the sensible way forward.*

The Passive House is a residence that has been optimally designed to retain energy. Much attention is paid to performance of the materials and components with respect to **indoor climate**. The advantage being that temperatures inside the residence have very few fluctuations, resulting in **notably higher indoor comfort.**

The **Passive House concept** applies **established techniques** and **solid design principles** to realize a residence that utilizes it's energy optimally.

By **reducing heat losses** to a minimum through optimal insulation and heat recovery techniques and **maximizing passive heat gains**, the Passive House is so efficient that it no longer requires a conventional heating system.

This means that the **cost savings** for the heating system can, in part, compensate for the higher cost of high performance building components.

Moreover, by using less energy over its lifetime, a Passive House not only generates a **smaller environmental impact**, it also incurs **lower energy costs** during use. In addition, a Passive House decreases the financial impact on occupants that rising energy prises may bring.

Introduction

What is PEP?

PEP, which stands for **'Promotion of European Passive Houses'** is a consortium of European partners, supported by the **European Commission**, Dictorate General for Energy and Transport.

Why Promotion of European Passive Houses?

It is generally recognized that, within the housing sector in Europe, **many building activities** can be expected over the coming decades. The old building stock will need to be refurbished or, in many cases, even demolished and new buildings erected. The existing housing stock is responsible for a **large share of our total energy consumption**, and therefore many **energy savings** can be accomplished in these upcoming reconstruction activities. As previous demonstration projects (such as CEPHEUS) have demonstrated, the **reduction of non-renewable energy demand** by a **factor 4** (compared to contemporary national standards) is not only **possible** but also **realistic**. The Passive House concept is a **sound** and relatively **low-cost method** to achieve these energy savings. To spread this knowledge throughout the professional building community, beyond the select group of specialists, PEP has set out to spread the experience gained throughout Europe on the Passive House concept.

What does PEP do?

Goal of P.E.P. is to promote regional economic activities, especially for SMEs (which perform a significant part of the work in the housing industry) in order to induce a substitution of expenses for energy use during the lifetime of houses with investment in the building envelope.

To achieve this goal, the consortium intends to:

- communicate the passive house concept and specific solutions in different European regions and climates

Introduction

- adapt the existing Passive House design tool (PHPP, Passive House Planning Package) to meet the demand of architects and planners in different countries
- develop practical information packages, such as building product documentation, design guides, research results, calculation methods and quality assurance activities to assist building professionals throughout Europe in the development of Passive Houses
- set up a certification program for Passive House buildings and technologies and a link to the national Energy Performance Certification system according to the EU building directive
- organize national workshops and the annual international Passive House Conference
- Create national Passive House websites for continuous up-to-date information provision

How can I find out more?

For more information, please contact:

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Passive House a definition

The term **Passive House** refers to a specific construction standard for residential buildings with good interior comfort conditions during winter and summer, without traditional heating systems and without active cooling. Typically this includes very good insulation levels, very good air- tightness of the building, whilst a good indoor air quality is guaranteed by a mechanical ventilation system with highly efficient heat recovery.

Thereby the design heat load is limited to the load that can be transported by the minimum required ventilation air. However space heating does not have to be carried through the ventilation system. For 40° - 60° Northern latitudes, under conditions specified in the PHPP calculation model[1]:

- the total energy demand for **space heating and cooling** is limited to **15 kWh/m² treated floor area**[2];
- the total **primary energy use** for all appliances, domestic hot water and space heating and cooling is limited to **120 kWh/m² treated floor area**[2]

A passive house has a **high level of insulation** with **minimal thermal bridges**, **low infiltration**, and utilizes **passive solar gains** and **heat recovery** to accomplish these characteristics. Consequently **renewable energy** sources can be used to meet the resulting energy demand.

The Passive House Concept illustrated: Passive (thermos) versus Active (stove)
Source:Informations-Gemeinschaft Passivhaus Deutschland

1 *Passive House Planning Package, Passiv Haus Institut*
2 *According to the Dutch NEN 2580 norm, the treated floor area is determined by the heated 'use-area' (gebruiksoppervlakte, A_g); the floor area of a building that is heated (when needed) excluding: Load bearing exterior & load bearing interior walls; Stairwells, open areas of mezzanine floors & elevator shafts – if > 4 m²; Freestanding structural elements (except staircases) and piping shafts – if > 0.5 m²; Building related exterior areas; Areas with a ceiling height below 1.5 m, except the areas under staircases and ramps.*

Passive House measures

Measure/ solution	*Passive House standard*
1. Super Insulation	
Insulation walls	U ≤ 0,15 W/(m^{2}K)
Insulation roof	U ≤ 0,15 W/(m^{2}K)
Insulation floor	U ≤ 0,15 W/(m^{2}K)
Window casing, doors	U ≤ 0,8 W/(m^{2}K)
Window glazing	U ≤ 0,8 W/(m^{2}K)
Thermal bridges	linear heat coeff ψ ≤ 0,01W/(mK)
Air tightness	n50 ≤ 0,6 h-1
Minimal Shape Factor (Area TFA/ Volume TV)	
2. Heat Recovery/ IAQ	
Ventilation counter flow air to air heat exchanger	heat recovery ηHR ≥ 75 %
Ventilation air sub-soil heat exchanger	air outlet after sub-soil heat exchanger above frost temperature
Ventilation ducts insulated	
Other heat recovery (e.g. ventilation & DHW return pipes)	
DHW heat recovery	
DHW pipes insulated	
Minimal space heating	postheater ventilation air/ low temperature heating
Efficient small capacity heating syst.	biomass, heat pump, gas, co-generation (e.g. district heating), etc.
Air Quality through ventilation rate	min. 0,4 ach^{-1} or 30 m^3/pers/h or national regulation if higher
3. Passive (Solar) Gain	
Window glazing	solar energy transmittance g ≥ 50 %
DHW (solar) heater	
Thermal mass within envelope	
Solar orientation	
Night-time shutters	
Shading factor [%] (East & West)	

Measure/ solution	*Passive House standard*
4. Electric Efficiency	
Energy labeled household appliances [Labeling A - G]	Energy reduction 50% of common practice
Hot water connections washing machines/ dishwashers	
Compact Fluorescent lighting	
Regular maintenance ventilation filters	
Direct Current motor ventilation	
Efficient fans: SFP (Specific Fan Power)	≤ 0,45 W/(m3/h) (transported air)
5. On-site Renewables	
Wind turbine	
Photo Voltaics	
Solar thermal energy	
Biomass system	
Other	
	=basic measure/ solution
	=often applied optional measure/solution
	=other optional measure/ solution

Passive House barriers/publications

Barriers to build passive houses

Barriers to build passive houses in the Netherlands will be largely market related;

•Changing the traditional 'cavity-wall'
•Coordinated interdisciplinary building development

The main envelope construction is a cavity wall with brick stones, constructed as described above. Lower U-values for walls will be obtained with more thermal insulation, resulting in thicker walls. To avoid extremely thick walls other finishing materials and construction will be preferable.

Moreover the Dutch housing market is a push-market. Many large development projects are yearly developed by real estate developers. The occupants/sellers of houses buy what they can buy, without much interest and knowledge of (passive) houses.

National Publications regarding Passive Houses

- Information of a few passive houses is shown at www.archidome.nl. One project information sheets of Archidome is shown at: http://www.iea-shc.org/task28/final_reps/Netherland_Rivierdijk.pdf
- Goed bekeken, slim gebouwd. NOVEM 2003 (this brochure regarding energysaving in 10 example houses can be viewed at: http://www.vrom.nl/get.asp?file=Docs/bouwen_ en_wonen/Goedslim_brochure1.pdf)

Overview building stock

The existing building stock in the Netherlands is around 6.7 million houses, with yearly around 75.000 new housing developments.

The percentage of different types of houses that make up the existing building stock is shown in the table below.

Type of house	Existing building stock
Single family, row house	41%
Semi-detached	11%
Detached	16%
Apartment/flat	21%
Other	11%
# Passive houses/ year	0

Typical Dutch house, new construction

Netherlands climate

The Netherlands has a moderate maritime climate. The climate in the Netherlands is determined by its position by the sea. The closer to the sea, the lower the temperature fluctuations. However, the wind rates increase closer to the sea. Generally, the wind comes from the southwest.

In June and July, the highest temperatures occur, with an average daily maximum of 22°C in De Bilt. During the period of December until February, the temperatures are the lowest, with an average daily minimum that lies just below freezing. The minimum/maximum design temperature is –10°C for winter and 28°C for summer. The temperature, humidity and solar radiation are given per month in the next graph.

longitude	5°11’
latitude	52°06’
altitude	+2m

Netherlands best practice example

Type of dwelling: One-family dike-dwelling on piles in Dalem, the Netherlands with 2 storeys.

Occupancy: Building Occupancy is 3 persons for this dwelling.

Overall Measurements

Treated floor area	127 m^2
Average ceiling height	2.55 m

Sources: www.passivhausprojekte.de
IEA (International Energy Agency) – SCH Task 28 / ECBCS Annex 38: Sustainable Solar Housing;
Novem – Goed bekeken, slim gebouwd, 2003
Initiative of “Stichting Passief Huis Holland”.www.passiefhuis.nl
Architect:Franke Architekten B.V.

Netherlands best practice example

Thermal mass: This detached dike-residence can be considered high thermal mass.
The exterior walls consist of a 120 mm light weight concrete structure, covered with 300 mm EPS insulation, and finished with plaster. Floor is a slab of 280 mm monolithic reinforced concrete, also covered with 300 mm EPS insulation. The roof consist of 170 mm semi-prefabricated reinforced concrete slab, covered with 300 mm EPS insulation.

Compared to typical construction:
The typical Dutch house is designated "medium" thermal mass.
Exterior walls: inner leaf is brick masonry – high thermal mass.
Interior (separation) walls: wood frame – low thermal mass.
Floors: prefabricated concrete – high thermal mass.

Air tightness Dalem House	$n_{50} = 1,2\ h^{-1}$
Air tightness typical Netherlands	$n_{50} = 2,32\ h^{-1}$

Thermal insulation

	Dalem House	*Typical House Netherlands*
Envelope component	**U-value [W/m²K]**	
Facade	0,115	*0,32*
Roof	0,116	*0,32*
Floor	0,113	*0,31*
Doors	0,68	*3,45*
Window frame	0,68	*2,4*
Windows	0,6 /Triple Pane	*1,8 /Dual Pane*

Netherlands best practice example

Equipment/ installations

Through a horizontal earth heat exchanger of about 30 meters in the dike, fresh air flows into the ventilation and heating system.
A system with heat recovery and auxiliary space heating using a water to air heat exchanger is applied to the fresh air intake. Also, use is made of renewable solar energy for domestic hot water heating demands.
A special, insulated body shaped, bath lowers the demand for domestic hot water energy, that is mainly collected by 4,23 m2 of flat solar collectors on the roof. There are only two small radiators, one in the basement and one in the north west facing bathroom.

Compared to typical new construction:
The most common heating system in Dutch dwellings is central heating with radiators and/or under floor heating. The heating fluid is water, which is heated by a gas heater. Applied ventilation systems in dwellings are natural air supply with mechanical exhaust or mechanical ventilation with heat recovery.

Heating	Heat generator Heating fluid Heating system	Solar thermal collectors + gas boiler combination, earth heat exchanger Air/ water (from solar collectors) Ventilation system + 2 radiators (low temperature heating)
Domestic hot water	Heating Energy source	Solar thermal collectors + gas boiler combination Solar energy, gas
Ventilation	System Heat recovery	Mechanical ventilation system (supply and exhaust) preheating the fresh air with an earth to air heat exchanger, consequently with an air to air heat exchanger from the exhaust air and finally water to air heat exchanger from the solar thermal collectors, supplemented with heat from the gas boiler. Recovery rate is 90%.

Heating	Heat generator Heating fluid Temp. control Heating system	Gas heater Water Thermostat Central/radiators
Domestic hot water	Heating Energy source	Instantaneous Gas
Ventilation	System Heat recovery Ventilation Rate	Mech. supply and exhaust Yes, up to 95% ~0,9/hr

Netherlands best practice example

Energy Use (calculated with PHPP)

Annual heat requirement = 20 kWh/m²a for space heating.

Primary energy requirement = 118 kWh/m²a including space heating, DHW, auxiliary electricity and electricity for household appliances.

Monitoring results 2001-2004:
Heating demand = 31 kWh/m²

Compared to new build detached residence:

*Based on the EPC-calculation for the Dalem House if it were to be built merely according to current code (NPR 5129 V1.2 from 2003, EPC 1,0), the energy requirement for space heating has been calculated. The energy requirement for heating of an identical residence according to code would be: 95 kWh/m²: 4,75 times the space heating requirement of the Dalem Residence.**

* Source: Franke Architekten B.V

Typical new build semi-detached construction in 2006:

Based on the Building Code requirement in 2006 (EPC 0,8) the energy use of a semi-detached dwelling is calculated. The energy use for heating is 66 kWh/m². The energy use for Domestic Hot Water (DHW) is 37 kWh/m². Both sources for this energy use are gas. The total electricity use for a semi-detached dwelling is around 3664 kWh= 27 kWh/m² (~70 kWh_{prim}/m²).

Netherlands best practice example

Type of dwelling: Family house in Heerhugowaard. This demonstration house is called the IsoZero-house. Besides good thermal envelope, this house has a full PV system roof. The concept of this best Dutch practice example is that the combination of a good thermal envelope, air-heating system with a heat-pump and a PV system results in net-zero (off-site) energy use. This demonstration house is part of a larger development in the "City of the Sun" in Heerhugowaard.

Occupancy: Building occupancy is approximately 4 persons for this dwelling type.

Construction: To make the builder aware of the energy-related consequences of certain tasks, specific quality cards have been developed. Each task has a quality card containing a brief explanation with many demonstration pictures. Especially pictures of infiltration-measurements and infrared pictures proved to have significant impact on awareness of the parties involved.

Source: www.isozero.nl

Netherlands best practice example

Thermal mass: This IsoZero-house can be designated as "medium" thermal mass.
Exterior walls are wood frame construction with mineral wool insulation and brick facade.
Separation walls between residences are concrete.
Interior walls are made of Autoclaved Aerated Concrete blocks (70cm).

Compared to typical new construction:
The typical Dutch house is designated "medium" thermal mass.
Exterior walls: inner leaf is brick masonry – high thermal mass.
Interior (separation) walls: wood frame – low thermal mass.
Floors: prefabricated concrete – high thermal mass.

Air tightness IsoZero-house	Qv;10 = 20 dm^3/s Qv;50 ~1.8 h^{-1}
Air tightness typical Netherlands	*n_{50} = 2,32 h^{-1}*

Thermal insulation

	IsoZero-house	*Typical House Netherlands*
Envelope component	**U-value [W/m²K]**	
Facade	0,25	*0,32*
Roof	0,25	*0,32*
Floor	0,40	*0,31*
Doors	n.a.	*3,45*
Window frame	1,2	*2,4*
Windows	n.a.	*1,8 /Dual Pane*

Equipment/ installations

The IsoZero-house is heated through the low temperature ventilation system, which is equipped with a high level of heat recovery. The heat source is a heat-pump with subterranean heat storage. The heat pump runs partly on electricity from the 30 m^2 of PV panels on the roof (~3400 kWh/ year).

Heating	Heat generator Heating system	Heat pump Ventilation system and low temperature air heating
Domestic hot water	Heating Energy source	Heat pump Geothermal heat, electricity from PV-panels
Ventilation	System Heat recovery	Central ventilation system, preheating the fresh air yes

Compared to typical new construction:
The most common heating system in Dutch dwellings is central heating with radiators and/or under floor heating. The heating fluid is water, which is heated by a gas heater. Applied ventilation systems in dwellings are natural air supply with mechanical exhaust or mechanical ventilation with heat recovery.

Heating	Heat generator Heating fluid Temp. control Heating system	Gas heater Water Thermostat Central/radiators
Domestic hot water	Heating Energy source	Instantaneous Gas
Ventilation	System Heat recovery Ventilation Rate	Mech. supply and exhaust Yes, up to 95% ~0,9/hr

Netherlands best practice example

Energy Use IsoZero-house

The IsoZero-house is a further development of the ISO++ concept by Vos' Projectdevelopment in Alkmaar. The gas use for heating the ISO++ is 350 m^3/residence (3402 kWh, for an average semi-detached house this means around ~23 kWh/m^2)
Gas use for DHW = 400 m^3/residence (3888 kWh, for an average semi-detached house this means around 26 kWh/m^2)

Measured gas use ISO++-house 2002—2004

Compared to typical new build construction in 2006:

Based on the Building Code requirement in 2006 (EPC 0,8) the energy use of a semi-detached dwelling is calculated. The energy use for heating is 66 kWh/m^2. The energy use for Domestic Hot Water (DHW) is 37 kWh/m^2. Both sources for this energy use are gas. The total electricity use for a semi-detached dwelling is around 3664 kWh= 27 kWh/m^2 (~70 kWh_{prim}/m^2).

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Intelligent Energy Europe

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