CADDET renewable energy IEA OECD

A Zero-energy House in the Netherlands

Summary

A Dutch energy consultant has developed and demonstrated a house designed to produce as much energy as it consumes. The energy consumption was reduced by insulation, minimising the surface/volume ratio, reducing the window surface area and by the use of energy-efficient equipment.

The roof of the house carries 3.4 kWp in photovoltaic cells, connected to the public grid, and a 12 m^2 active (thermal) solar collector. A measurement programme in 1995 showed that the house meets the designer's "zero-energy" target. Between 31 December 1994 and 1 January 1996, the energy consumption of 1,070 m^3 natural gas equivalent (nge) was almost balanced by the energy production of 1,146 m^3 nge.

Highlights

- **Active (thermal) solar water heating**
- **Energy-efficient architecture used in house design**
- **Energy consumption balanced by production**
- **Photovoltaic cells connected to the grid**

The zero-energy house in Woubrugge.

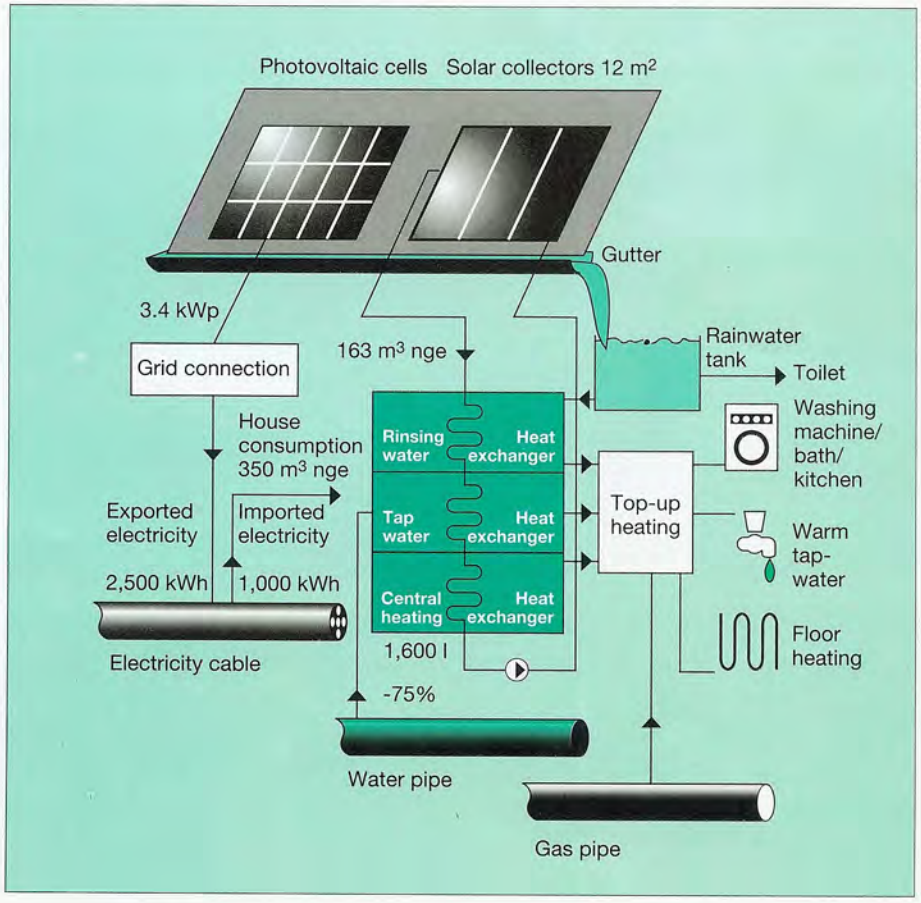
Project Background

Within its policy to stimulate the use of renewable energy sources, the Dutch government started the National Research Programme Solar Energy (NOZ). One part of the programme concerns photovoltaic energy. The purpose of the NOZ-pv programme is to stimulate the development of photovoltaic cells towards an independent, competitive place in the energy market for the next century.

Introducing photovoltaics successfully requires experience of applications, both in the laboratory and in the field. Within the NOZ-pv programme, a learning programme "Photovoltaics in the Built Environment" is designed to provide this experience. As part of this programme, a subsidy was granted to an energy expert to develop and build a dwelling which, on a yearly basis, produces as much energy as it consumes. The general principle has been titled the "zero-energy concept".

The zero-energy house is also a demonstration project within the IEA task "Solar Heating and Cooling". The purpose is to gain experience with the integration of grid-connected photovoltaic modules and to collect the data necessary for the further development of integration technologies.

Schematic of the photovoltaic and active (thermal) solar heating systems.



Source: Metaal and Techniek

Project Description

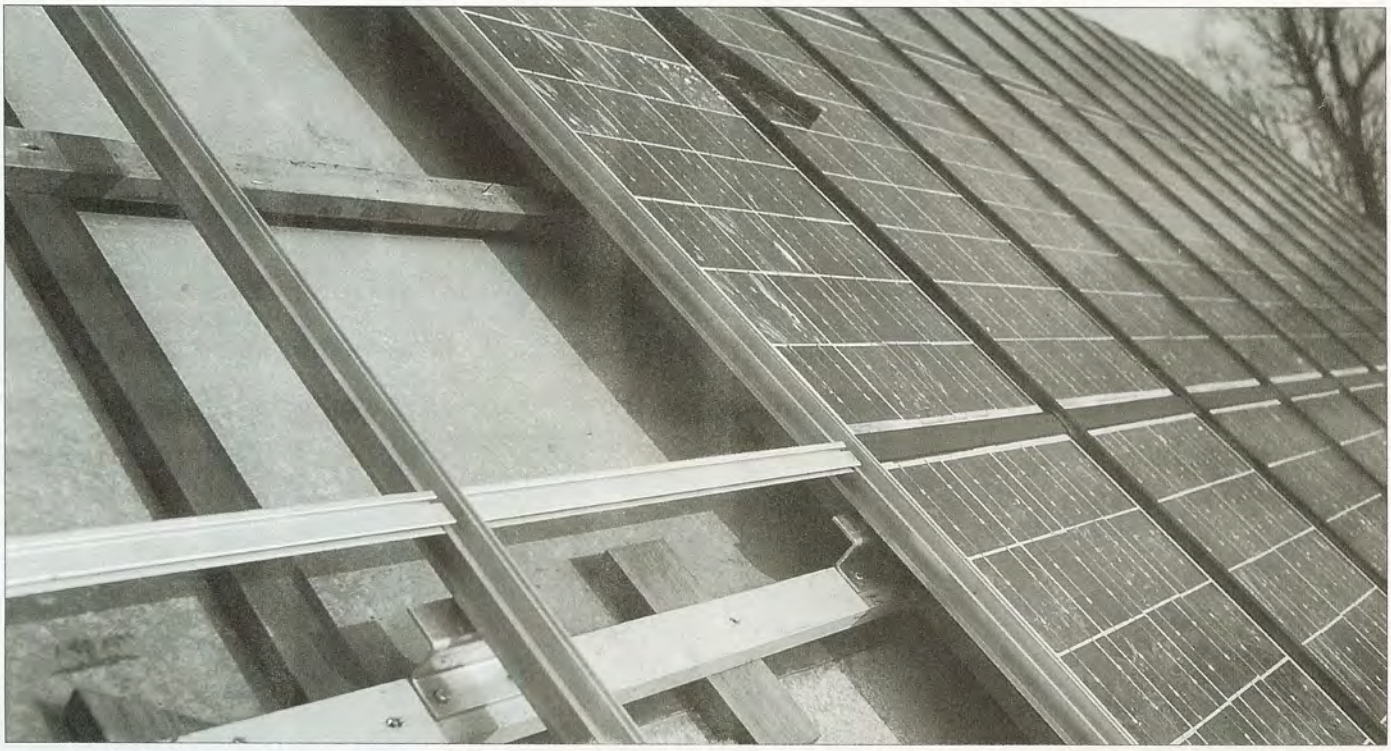
Although energy production and energy saving techniques are usually developed separately, a much better result can be obtained from a combined approach. This idea was the starting point for the design of the zero-energy home built in the Dutch village of Woubrugge. The first ideas were developed around 1985; construction began in 1991 and was completed in 1993. The house, at present inhabited by the initiator and his family, was designed to meet the following demands:

- average annual energy production equal to the energy consumption;
- minimum consumption of water from the mains supply;
- maximum use of environmentally friendly materials;
- an aesthetically-acceptable design;
- standard of living comfort maintained or improved.

In the Woubrugge project, the annual energy consumption of the 400 m^3 house (floor area: 160 m^2) is balanced by energy production from solar collectors and photovoltaic cells installed as part of the roof.

The solar thermal system consists of 12 m^2 of collectors integrated into the roof. They are connected to a 1.6 m^3 hot water tank. This thermal system provides about 62% of the hot tap-water demand and 25% of the heat demand.

The photovoltaic generator consists of 76 modules of 45 Wp each,



Detail of the mounting of the photovoltaic panels.

giving an installed power in the house of about 3.4 kWp. The system is divided into 3 sub-arrays, each of them containing 5 to 9 strings of 4 modules. Every sub-array is connected to a 1 kW inverter; the inverters operate in parallel and are connected to the public grid.

The roof itself has an unusual shape in order to minimise the surface/volume ratio. The south side consists of four surfaces: three of these are occupied by the photovoltaic system and the fourth carries the solar collector. The frameless photovoltaic modules are mounted in a support construction fitted as part of the roof. In this way, the photovoltaic system forms part of the water-tight shell of the house. A cavity beneath the cells keeps their temperature within acceptable limits and reduces condensation problems. Roof integration proved to be successful but labour-intensive. The design of the aluminium profiles has since been improved.

The energy consumption of the house has been minimised by the use of:

- 200 mm-thick foam glass insulation;
- low-energy-transmission glass in the windows;
- window surfaces as small as possible, within the limits of comfort and aesthetics;
- switches to avoid stand-by losses of electrical equipment;
- a sun lounge to provide passive solar heat;
- efficient lighting;
- a wood stove;
- filtered rainwater for sanitary purposes.

Performance

Measurements in the spring of 1995 showed that the overall energy production of the previous twelve months almost equalled the energy consumption in the same period. The grid-connected photovoltaic system functioned well. The inverters, despite showing a high efficiency, proved to be unreliable and incapable of coping with peak loads at full irradiation. This led to a revision of the power control system, after which the inverters performed better.

The Table overleaf shows the house's energy balance over a year. The energy consumption and production are expressed in m^3 of natural gas equivalent (nge); 1 m^3 nge is equivalent to about 31.65 MJ.

Table: Energy balance between 31 December 1994 and 1 January 1996

Consumption of:	m^3 nge	Production from:	m^3 nge
Gas	274	Photovoltaic units	968
Wood	289	Collectors	178
Collectors	178		
Electric energy	329		
Totals	1,070		1,146

nge= natural gas equivalent

The figures are based on the following assumptions:

- efficiency of hot water production 62.5%
- efficiency of the heating system 85%
- efficiency of the central electricity supply 31% (including transport losses)
- Calorific value of wood: 3 kg/m^3 nge.

The measurements show that the house's energy production exceeded its consumption by 76 m^3 nge.

Economics

The investment for the photovoltaic system amounted to NLG115,000, (where NLG is the Dutch guilder). The annual yield of 2,905 kWh at a rate of NLG0.25/kWh, gives an income of NLG726. This does not lead to a realistic pay-back period. However, the purpose of the project was to demonstrate the technical feasibility of the zero-energy concept. Soon, the required equipment will become cheaper and energy prices will rise to the point were the zero-energy concept becomes economically feasible.

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International Energy Agency
The International Energy Agency (IEA) is an autonomous body which was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

CADDET
CADDET was set up in 1988 as an IEA Centre for the Analysis and Dissemination of Demonstrated Energy Technologies. Today, there are two CADDET operations: one is for energy-efficient technologies and the other for renewable energy technologies. The Centres co-operate with member countries in the exchange of high quality information on energy technologies.

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