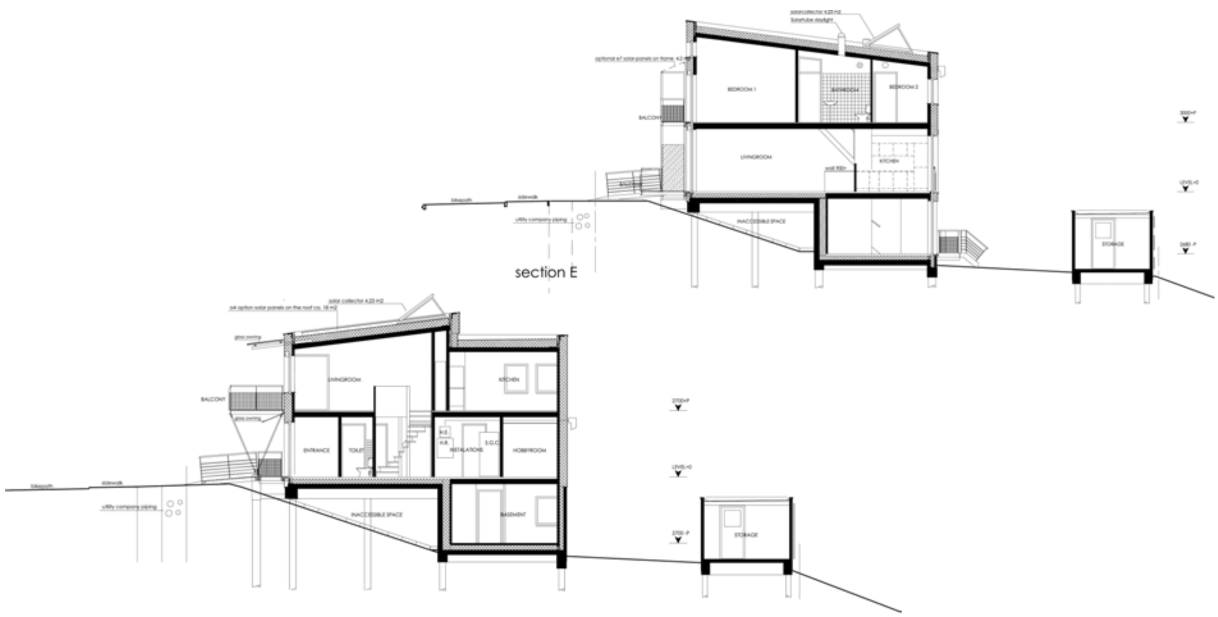
Rivierdijk, Sliedrecht
The Netherlands

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing



The project
Six houses (Types D/E) out of twelve solar houses in three types (A, D en E) have been built against the inner slope of a river dike in Sliedrecht, the Netherlands, (20 km east of Rotterdam). This row of single-family houses was realized for the local housing market, as part of a small project consisting of 23 houses (12 solar houses and 11 conventional, traditional houses) and 1 small additional office space.
The 12 solar houses were built on the principals of passive house technology and were developed by the architect himself. He created, especially for this reason, a company called Archidome Holland BV.

Objectives, goals
One of the main objectives of this solar project was to prove that solar houses, designed and based on passive house technology, can compete in the housing market in Holland on price, quality and comfort - especially if the owners of the houses understand the purpose and the quality of the technology involved. In this way prospective buyers will start to recognize the additional value in sustainability, comfort and quality.
These houses are – as compared to Dutch traditional standards – an innovative solution for the near future of sustainable housing in the Netherlands.
Ingenious new improvements in building detailing – triple glazing, super insulation, the lack of thermal bridges and good airtightness – together with a smart heating and ventilating systems (high performance DHW systems with thermal solar collecting and efficient heat recovery air systems) reduce energy consumption and at the same time both improves the indoor climate conditions substantially and makes a fundamental contribution to protecting the environment.
Some of the additional energy demand can be generated – as an optional feature – by a few photo-voltaic panels (5 m² house type E), which the owner can put on top of the balcony frame at the front of his solar house.

Building construction
As a result of the fact that this project is built in the body of the dike which is constructed on more than 15 m of soft peat ground below sea level, and because of the pressure on the dike caused by heavy rainfall upstream on the rivers Rhine and Meuse, it was necessary to make the concrete pile foundations extremely heavy.
For that reason, the total basement is made of monolite reinforced concrete; the upper level structures of these dike houses are mainly made of light weight (1700 kg/m³) prefabricated concrete wall elements and slab concrete floors. The roofs are also made of prefab concrete hollow roof elements. In order to avoid thermal bridges, the total house-bearing construction is built on the load-bearing thermal insulation Purenite (layer of light Pu recycling foam, 0,7 – 1,8 N/mm²; x = 0,075/0,105 W/mk). The whole structure – ground floor, facade, roof – is covered by 30 cm of polystirol insulation; excluding the basement, which has 15 cm rigid resol foam insulation and an exterior wall of brick masonry. The upper part of the house facades are completely covered with mineral plaster.
The overall foundation/wall/roof construction achieves a calculated U-value of 0,138 W/m²K (basement floor), 0,124 W/m²K (basement facade), 0,116 (upper façade), 0,116 (roof). Special care was given to reduce the remaining thermal bridges.

All east, south and west-facing windows and balcony terrace doors have integrated sun-shading systems. The wooden window frames and isolated doors (U= 0,93 W/m²K) have triple glazing (selective surface and filled with Argon gas U-value 0,6 W/m²K).

Design Data	Type E	Type A
·net floor area	125,4 m²	132 m²
·heating volume	348 m³	336m³
·building volume	486 m³	524 m³

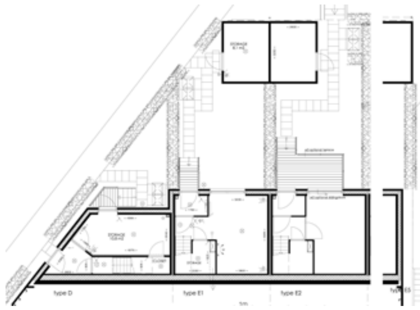
Technical systems
Controlled air supply and extraction with heat recovery: the heat recovery unit (WHR 950 J.E.STORKAIR with 100% bypass, 88% efficiency, PHI-Zertifikat), together with the F7 air filter box, the water-to-air supply air-heater unit and the gas-burning DHW system (high performance Solar Gas Comb II ATAG), combined with the solar hot water storage tank (200 litters, 80 l DHW + 120 l solar part storage), connected to 4,23 m² flat plate thermal solar collector on the roof and F7 air filtration.
The excellent air tightness of the houses is one of the essential pre-conditions for passive houses. During the erection of these solar houses, the main concrete construction and the connection with window and door frames were heavily taped shut to achieve the necessary air-tightness, which is also crucial for passive houses in the (windy) Dutch climate.

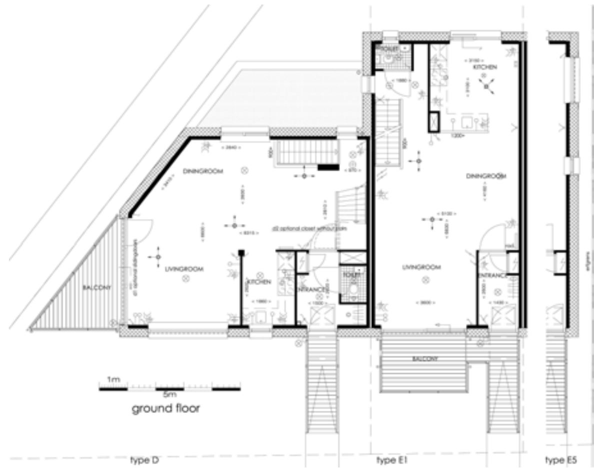
Energy performance
Primary energy consumption for heating and lighting. According to the Dutch standard NEN 5128 the primary energy consumption is : the total energy consumption of fossil fuels per year in MJ.

The energy consumption for the heating is thus defined as primary energy consumption, during a certain period of time, needed to cover the heating demand of a building including the losses of the service installations. This energy consumption will be expressed in MJ per year.

Note:
The energy consumed by heating can be influenced in the calculation of the energy performance of buildings by a number of measures, for example better insulation, heating of ventilation systems with higher efficiency or the use of passive or active solar systems.
The result of the energy performance calculation can be seen as a reference value. The real energy consumption for the heating will be strongly affected by users or residents and can therefore differ from the calculated energy demand given as the result of the calculation of the energy performance.
The primary energy consumption for lighting Qprim;vl of a fimily home is defined as the standard value per m² of the surface area of the building. This energy consumption is calculated according following equation:

$$Q_{prim,vl} = 22 \times A_{g,verwz} / \eta_{el} \text{ [MJ]}$$





The calculation value for the lighting per m^2 of the surface area is 6 kWh/m^2 per year. This is approximately 22 when converted to MJ en rounded off. This value can be found in the equation above.
The energy consumption of home appliances such as TV's and washing machines is not taken into account in this value. The electric energy efficiency according to the Dutch standard NEN 5128 is $\eta_{el} = 0.39$.

Note:
The real energy consumption for the lighting can differ from the predicted energy consumption for the building's energy performance as a whole. For example, the use of energy-saving lamps can affect it. The energy performance of any new Dutch house has to conform to the Dutch building standards for energy efficiency in the building environment. This means that the design of each new house, according to the national building code, must have a calculated energy efficiency performance coefficient (EPC) of 1.

Reference calculations Type E based on the EPC calculations, including assumption appliances:

EPC 1,0 (NL)

- Heating of space and ventilation air	87,6 kWh/m^2a
- Domestic hot water	42,1
- HFns and pumps	14,9
- Lighting and appliances	50,9
Ttotal primary energy demand	195,5kWh/m^2a

The design of these solar demonstration houses reaches an EPC of 0,42, this is an improvement of 58%.

EPC 0,42 (NL)
The annual primary energy demand based on EPC calculating:

- Heating of space and ventilation air	10,9 kWh/m^2a
- Domestic hot water	20,1
- Fans and pumps	14,9
- Lighting and appliances (assumption)	50,9
Total primary energy demand	96,8kWh/m^2a

PHPP (D)
The following calculations are based on the spread sheet calculation test for the Passive House Planning Package (PHPP). These very detailed calculations and assumptions from the PH Institute in Darmstadt are more in harmony with this passive house technology for very low energy consumption and the annual energy demand:

-heating of space and ventilation air	15kWh/m^2a
-domestic hot water (solar energy covers 55% of the demand)	21,9
-fans and pumps	15,1
-lighting	11,5
-appliances	53,6
Total primary energy demand	117,1kWh/m^2a

Costs and benefits
The calculated building costs turned out to be € 1.285,- / m^2 for the 12 solar houses. After the restricted tender, the real building contract was closed at € 1.153,- / m^2; this means: the real costs € 132,- /m^2 for the 12 solar houses were more than 10% less than calculated. The calculating costs for the traditional Dutch reference houses were € 1.089,- / m^2 ; after the tender, the contract costs were € 1.101,-; so the 11 conventional houses + € 12,- / m^2 , which is a little bit (1%) higher than calculated.

Conclusion
The first careful conclusions show us that in this project the building costs of these 12 passive solar houses are 4,7% higher compared to the Dutch standard building costs for the 11 conventional houses in Sliedrecht built on the same site at the same time in the same housing project.

Marketing strategy
To market this project, no special information was given about the high performance of the 12 solar houses. Just the usability of the plan, the location in the dike (more privacy), the living conditions and the good price/quality relation convinced the new owners to buy all these 12 solar houses, which were sold before the completion date. The only information, given in the prospectus, was about the 'zonhuis' quality:
-no traditional radiator heating system, but a controlled hybrid heating system by ventilation air and, in reserve, 3 small radiators in the sun-missing basement, the bathroom (extra comfort) and the living room.

Summary
The comfortable indoor living conditions, in combination with low-operating costs for heating consumption, makes these houses ready for the future; they are user-friendly, have a positive performance in their building environment, and protect the quality of their and others' environment by using appropriate technology in combination with good architecture.

Information and Contactperson

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Building, serv.,techn.	- Consultant installations and building physics J.P.v.der Weele BV, Groningen - Brouwer Energy Consultant BV, Apeldoorn - Ingenieurbüro Morhenne GbR, Büro für umweltverträgliche Energiesysteme, Wuppertal - Foundation Passive House Holland, Bruchem
Stimulation, funding	- NOVEM, national institute for energy and environment, mr.dr.L.Brouwer, Utrecht

List of publications

·Passive House Holland Foundation stimulates innovative building technology; Bouwwereld nr. 4 (febr. 2001), pag. 36 – 39
·Solar home, good practice and smart building; 10 owners about energy saving and comfort, NOVEM jan. 2003, pag. 34 – 35