IEA-SHC Task 28/ECBCS Annex 38

Sustainable Solar Housing

Exemplary
Sustainable Solar Houses

A Set of 40 Brochures

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

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Exemplary Sustainable Solar Houses - a Set of 40 Brochures:-

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Passivhouse in

Gaspoltshofen, Austria

International Energy Agency

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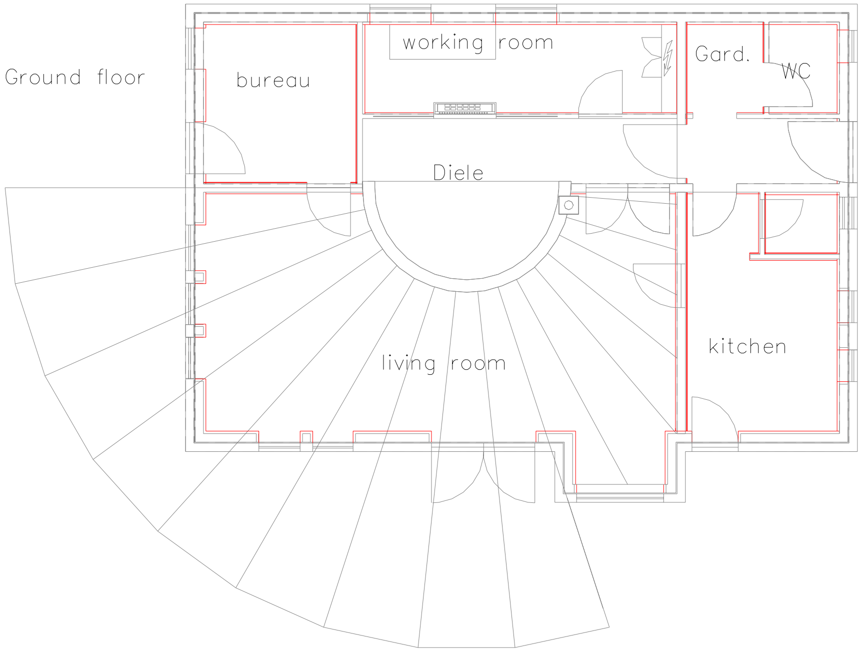


The project

This single family house has been constructing as a privat built-house and will be finished in 2004.

Objectives - Goals

The main goal was to construct a low energy house in respect to economic and ecologic issues.

In addition a further supposition of the owners was an attractive and appealing outfit.

Of course sustainability and the use of material of the region was granted.

(e.g.: lambswool for insulation and timbers of spruce and larch came close to the location)

Marketing strategy

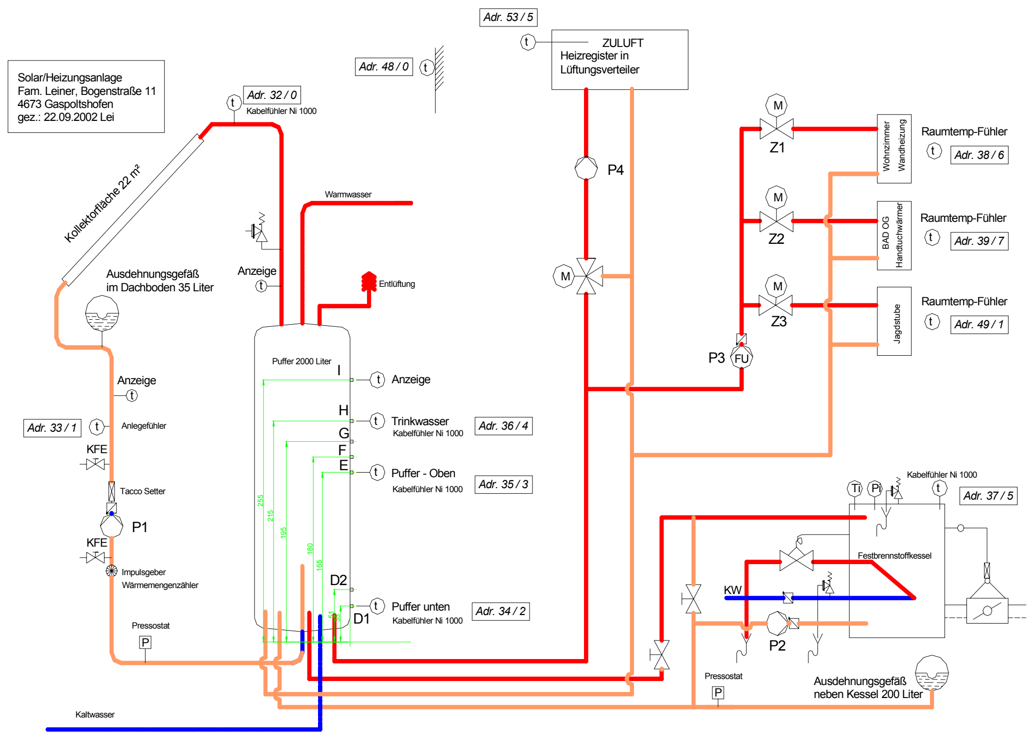
none

Building construction

Most parts constructed as prefabricated segments moveable by crane only

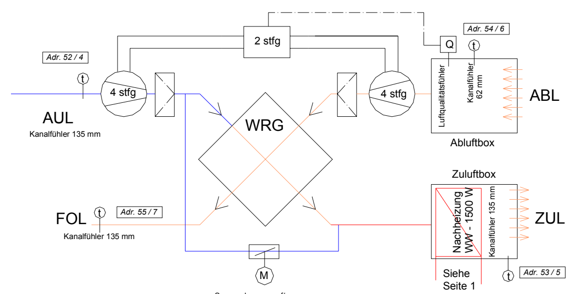
Construction type and material use, U-values, innovative elements.

Construction	Material	U-value
Wall	Timber, lambswool, cellulose	0,11
Ceiling	Timber, cellulose	0,09
Windows	Timber, cork, 3-layer-glass	0,78



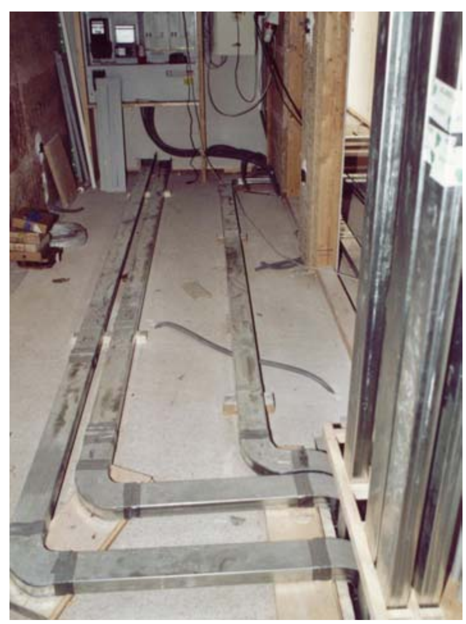
Technical systems

- PV – supply 2,8 kW
- Thermal collector 22 m²
- storage tank 2000 liter
- bio mass – boiler
- ventilation system
- rain water storage equipment
- EIB control



Energy performance (demand per year and m²)

	Reference building (standard house 2004)	House Leiner Monitored (m) Calculated (c)
Heating of space and Ventilation air	80 kWh/m²a	14 kWh/m²a (m + c)
Domestic hot water	25 kWh/m²a (4 persons)	2,5 kWh/m²a (c)
Solar pump		0,5 kWh/m²a (m +c)
Lighting	7 kWh/m²a	3 kWh/m²a (c)
Electrical appliances	12 kWh/m²a	5 kWh/a (c)



Ventilation pipes

Planning tools for LCA, energy performance, solar energy design and more

The over all performance (electricity, heating, domestic watersupply,..) was calculated by the PHPP of Dr. Feist (Darmstadt).

Costs and benefits

	Standard house (in k€)	**House Leiner (in k€)**	**benefits**
Building, incl. Wintergarden, PV, all technical equipment (e.g. PV, Solarthermal appl., rainwater facility,..) , cellar	350	400	Extraordinary space klimate due to Plaster made of loam, loambricks, lambswool, timber, ... Energy savings in fact due to wintergarden and heating/cooling system by air

Innovative products

Windows and doors	Cork-insulated frames and 3-layer-Glasses
Ventilation and cooling	Heat recovering by interchanging and cooling with bypass and 40 m pipe digged in earth
Controls	All systems are controlled electronically by one system (programmable control panel)
Domestic appliances	Low energy lamps and refrigerator, washing-machine with warmwater supply by solarthermal equipment
Space heating and domestic hot water	Solar thermal collector 22 m² and bio-mass-oven. Distribution of heat by air.
Electricity	Roof-integrated Solar PV: 2,8 kW

Other information

PROJECT OWNER	Ing. Maximilian and Erni Leiner
Financer and contact person	e.leiner@eduhi.at
Architect	Dr. Wiesmayr
Tecnical issues and coordination	Ing. Maximilian Leiner
Awards	Winner 2002 solar award www.eurosolar.at/solarpreis_2002.html

Plus Energy House in

Thening, Austria

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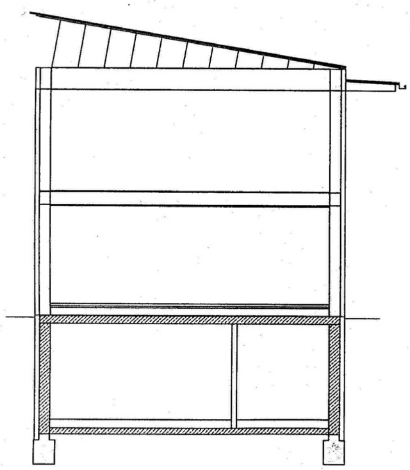
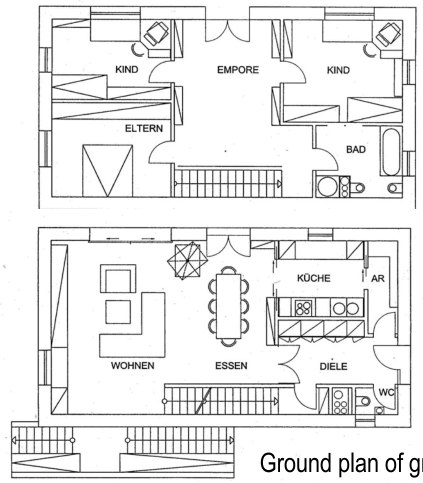


Section of "Plus Energy House"



Ground plan of ground floor

and first floor

The project

It took only 6 months to build this cozy home for one family back in 2001. It is of the ecological Passive-house type and is made of pre-fabricated wooden components.

The building structure is compact and opens to the south. The northern part of the facade shows only the window for the toilet.

The open, horizontally fixed timbering made of larch wood, hides a perfect thermal insulation assembly.

DWD board, cellulose insulation and OSB board complete this wooden construction.

Building construction

Basement:
Floor surface: floor tiles 10mm
Screed: 60 mm
PAE Sheet
45/42 TSDP
Polystyrene: 100mm
Impermeable Concrete: 100mm
Gravel layer: 300 mm

Composition of ceiling:
Board made from wooden material: 22 mm
Ceiling beams made of bonded plywood: 320 mm
Inter-layer of Stone wool as thermal insulator 100 mm
PAE Vapor-barrier sheet
open form work: 24mm
Fiber reinforced Gypsum core board: 15 mm

Windows
Wood frame windows for passive house with 3-pane-glazing (manufactured by Sigg)

Wall construction
GKPL (Fermacell): 15 mm
Intermediate Installation level with 6 cm Flax insulation
Vapor barrier (Eco vapor barrier)OSB Board: 15 mm
TJI Carrier: 300 mm with intermediate Isocell thermal insulation (Cellulose)DWD
BoardVentilation gap: 50mm

Composition of roof:
Rubber sheet
RHEIN ZINK® Sheetmetal
Lining sheet for dew drainage (open to diffusion)
Open form workVentilation
gap/rough from work: 24mm
Moisture Insulation of lowerInsulation element with
110 mm wooden board with surface dressing
Wooden board 16 mm
Ceiling beams: Ply-wood board ,
with intermediate insulation 400 mm
PAE sheet as Vapor barrier
Open form work: 24 mm
Fiber reinforced Gypsum core board: 15 mm

The living area is
equipped with energy
saving lamps (CFL)
Total load for lighting: 460W

Inlet for living rooms,
exhaust outlet and
technical services

Technical systems

Modern technical services incorporate tested technologies, resulting in a well functioning Plus Energy house

The two-storey structure is fitted with a 17m² façade collector in the ground floor for the generation of warm water.

Mechanical ventilation with heat exchanger (efficiency: 85%) supplies perfectly filtered air and cools or heats, depending on the circumstances

Ecological house of wooden construction, built as passive house

Use of rain water for irrigation, toilets and laundry.

10,350 Wp photovoltaic modules which replace the roof are connected to the grid and produce electric energy.

Due to this technology and the design of the house, there is no need for a separate chimney.

The roof is not inclined towards the north as is usually the case, but its highest point is due north, and it has an angle of 10° to the south and thus, the photovoltaic module can be incorporated in the roof surface.

The solar modules from "Solar Fabrik" have a surface of 86m² and come from a CO_2-free production. Consumption of the house is only 1/3 of full capacity, with the surplus being sold to the power utilities and fed into the mains.

Energy performance

The house is heated by a controlled air supply for living areas with 85% thermal efficiency. An earth heat exchanger sucks air of currently 12 degrees centi-grade from the soil. The air is cleaned by 2 filters. It is then blown into the living rooms at a velocity of 0,3 m/sec. Warm air from the kitchen, the bath, and the toilet is sucked away, on the way out passing the heat exchanger.

An electrically driven heat pump heats the preheated incoming air up. Because the entire air of the house is exchanged, there is no need to ventilate the rooms by opening the windows. During summer, the ventilation can be used as air conditioning using the low ground temperatures

Total energy demand: 12,8 kWh/m²
Heating of space and ventilation air: 750 kWh/a
(energy source)
Domestic hot water: 350 kWh/a
(energy source)
Fans and pumps: 320 kWh/a
Lighting and appliances: 220 kWh/a

Transmission values of components

Windows and glazed doors	0,79 W (m²K)
Exterior doors	1,20 W (m²K)
Exterior walls	0,11 W (m²K)
Ceiling of basement	0,11 W (m²K)
Roof	0,11 W (m²K)

Energy demand for heating: 15 kWh/m²a

Team:

Owner:	Karin und Uwe Kroiss
Architect:	Karlsreiter Andreas, Thening
Calculations:	Planungsteam E-PLUS
Energy Concept:	uwe kroiss energiesysteme
Renewable Energy:	uwe kroiss energiesysteme
Kontakt:	www.energiesysteme.at
	www.plusenergiehaus.at

Schöberl & Pöll OEG

Demonstration-project
Passive housing Utendorfgasse 7

Vienna[14], Austria

International Energy Agency

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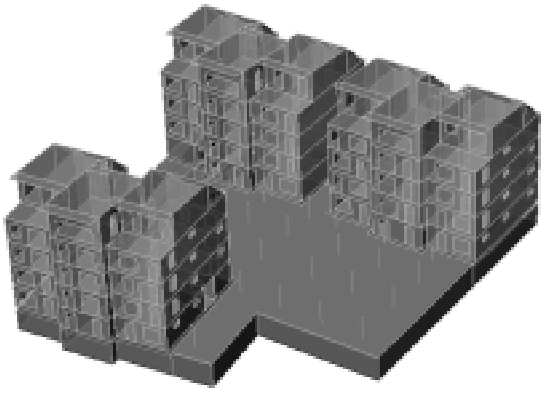
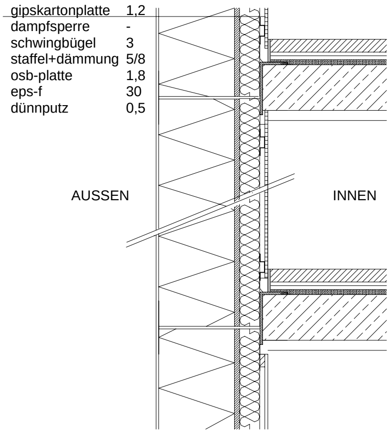


Structural system



Cross section

The project

The demonstration-project “passive housing” Utendorfgasse 7, A-1140 Vienna” was implemented in a research project founded by the Austrian Government (BMVIT). The goal of the research project is the development of a building concept for the employment of passive technology in social housing. The houses are financed by an semi-official housing company. The building project should be finished in 2005/2006. The apartments will be rented.

Architecture and structure

The three building parts cover an underground parking space and 5 floors with 39 flats with an average size of 73 m².

Building construction

The construction concept plans of a building of concrete disks (basic transverse walls). This provides a large use flexibility and is given with high economy. Attention was given to the possibility for a non-load bearing facade system. The thermal decoupling between "cold" underground parking space and the "warm" living area above the garage takes place via a unique twist of the concrete wall.

Objectives - Goals

1. Passive house standard

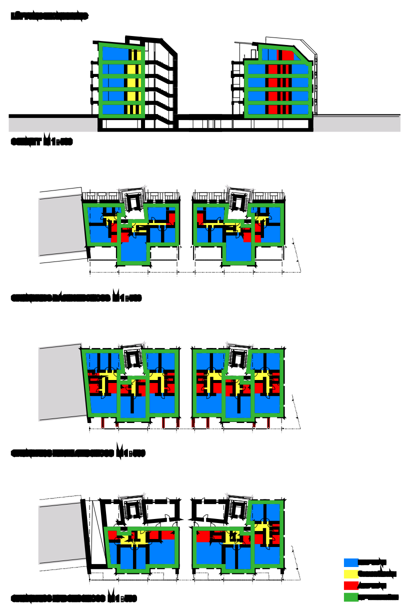
heating energy demand ≤ 15 kWh/mà
air tightness n_{50} ≤ 0,6/h
heating load ≤ 10 W/m2
primary energy demand ≤ 120 kWh/(m²a)

2. Planning objectives

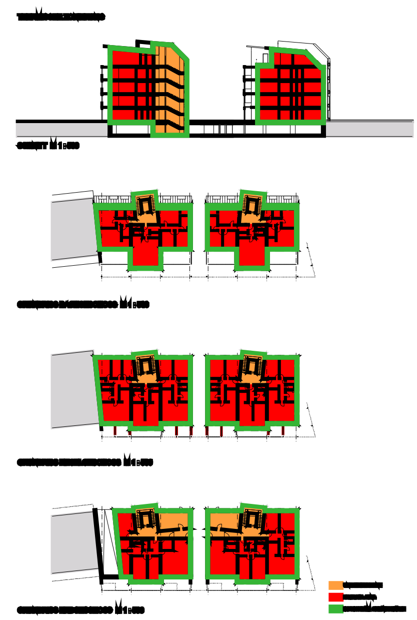
“Specifications for social housing”
defined comfort criteria
e.g. noise level < 25 dB
Minimum sensitiveness to users behaviour
e.g. sensitiveness to unused (cold) flats
Extra costs ≤ 75 Euro/m² effective living area
Construction costs ≤ 1,055, -Euro/m²

Costs

Many investigations were undertaken to specify extra costs and ways for reducing the costs for passive housing elements e.g. for windows, ventilation systems, facade, etc.



Air ventilation zones



Thermal zones

Technical systems

Building equipment and appliances

The concept of a “semi-central” ventilation system is used. The central appliance of the ventilation system consists of a central heat exchanger, air filters, supporting fans and an electric heater battery for frost protection.

The decentralized components (in each flat) are a heating battery and two speed controlled fans. The transport of the fresh air into the sleeping-, living- and children rooms is via long range ducts. From these zones the air is transferred to overflow zones (e.g. corridors) via overflow openings (e.g. openings in door leafs; joints between the walls and the door casings).

The fume extraction hoods are operated with circulating air.

Water heating

For the central heat production a condensing boiler with a hot water tank is used. The boiler is fired with gas and produces the heat for both, the heating water and the hot water.

The distribution of the hot water is made with circulation pipes and a circulation pump, which is controlled with a time switch. The heat for the decentralized heating batteries is supplied by the heating water.

Building physics / building services / simulation

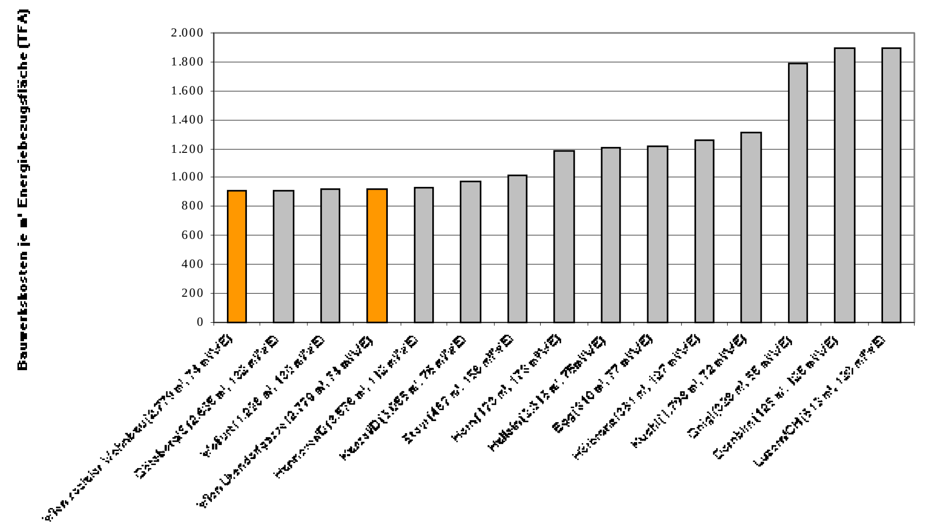
The variant of an external insulation of 30 cm gives the smallest heating energy demand. The staircase is included in the thermal envelope.
In the basic variant a heating load ≤ 9,1 W/m² and an average heating demand of ≤ 14,5 kWh/m²a at a room temperature of 22 °C can be achieved.

Between the flats U-values of less than 0,9 W/m²K according to Viennese building code should be reached. It has been shown that the influence of unoccupied flats can be called insignificant.

Without attenuators the remaining noise in the living room is higher than 25 dB (A), which is higher than the goal for the maximum noise level. If attenuators are used long range jet nozzles can be used for the supply of air in the living room. The noise level in the investigated flat was calculated to 18 dB(A) with the use of attenuators and long range jet nozzles, which is under the limit of 25 dB (A).

Used Planning tools

PHPP - Passive House Planning Package
Buildopt & Simulink – 3D Building



Cost Comparison of CEPHEUS passive house projects with the actual project (Euro per m²)

Project team	
Financer:	Heimat Österreich, Vienna
Project management and Cost control:	Schoeberl & Poell, Vienna
Electrical & ventilation Services :	TB Steininger, Vienna
Building Physics:	ebök engineer's office, Tübingen
Architect:	Kuzmich Franz, Vienna
Statics:	Werkraum ZT OEG
Scientifically accompanied by:	Technical University Vienna, BBB

The research work will be published in German language. It will contain a planning guideline for all involved planning disciplines. You find the complete text under the link www.schoeberlpoell.at .

The Project is supported by

HAUS der Zukunft

BMWA BUNDESMINISTERIUM für WIRTSCHAFT und ARBEIT

bmvit Bundesministerium für Verkehr, Innovation und Technologie

www.schoeberlpoell.at **www.hausderzukunft.at**

Demonstration houses in

Černošice,

the Czech Republic

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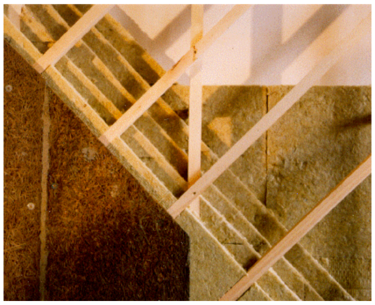
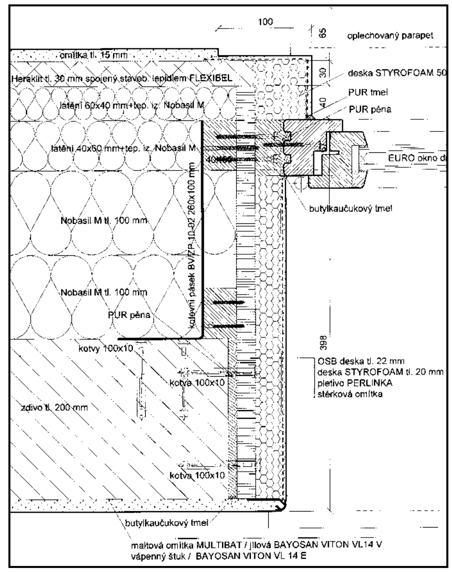




Basic information

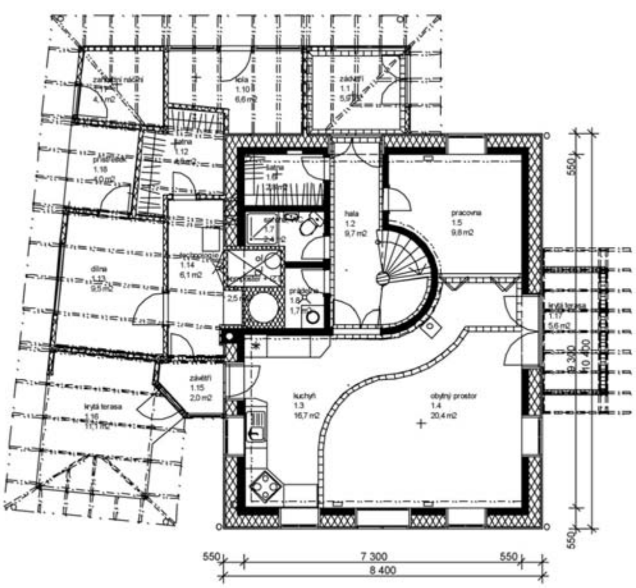
Traditionally shaped, private built, single family house was built in 2003.

A building site for this private built house was set by regulating plans, which do not respect optimal solar orientation (in general: when assigning orientation of building, roof type and other parameters, spatial planning does not consider factors of sustainable housing, mainly optimal solar orientation). Therefore, gables had to be south-north oriented and solar collectors had to be placed on the porch.

The house consists of two functional parts. First one is living heated area of 86 sqm designed for 4 persons. Second one is an auxiliary space of 52 sqm.

The house was finished in December, 2003 and is indwelled since.

1st floor plan



Objectives

An investor desired for a house with a minimal impact on the environment. Hence, except energy performance, also another environmental aspects were considered. For example, composting toilet and rain water storage were set. Investor wished for biomass fire place too, so it was compromised as a small fire-stove.

There was an challenge to build a „common“ brick house of a maximal reduction in energy consumption and not to significantly exceed standard costs.

Building construction

Construction of solid brick (unburnt lime-sand bricks). Insulation 300 mm of mineral wool.

Innovative: minimal dimension of a framework was „compensated“ by maximum of thermal insulation. Special wooden frame was developed for free laid mineral wool.

U-values

External wall	$U = 0{,}122\ Wm^{-2}K^{-1}$
Socle	$U = 0{,}159\ Wm^{-2}K^{-1}$
Roof	$U = 0{,}108\ Wm^{-2}K^{-1}$
Floor	$U = 0{,}272\ Wm^{-2}K^{-1}$
Windows (glazing)	$U = 1{,}100\ Wm^{-2}K^{-1}$

Technical systems

- warm air heating, mechanical ventilation with heat recovery
- earth heat exchanger
- solar collectors 5,0 m^2
- integrated heat storage (IZT) 950 litres
- fire stove 9/5 kW
- central regulation
- lighting tube for staircase
- composting WC

Energy performance

<u>Total energy demand</u>: **29 kWh/m²**

Space heating and ventilation air: **12 kWh/m²**

Energy sources: solar energy, biomass, electricity (low tariff)

<u>Domestic hot water</u>: **34 kWh/m²**

energy sources: biomass, electricity (17 kWh/m²)
solar collectors (17 kWh/m²)

Parameters declared above are calculated. The house is being monitored since January, 2004. System was proved by failure of its active heating part. For about 14 days there was average temperature of 19°C by exterior temperature of – 20°C.

Note: If „super“ windows (and doors) had been used, the passive house standard would has been performed.

Costs

Realization costs were about **4 mio. CZK (ca.123000 EUR)**. There are approximately 0,5 mio.CZK extra costs when comparing with a common house of this standard.

Planning tools

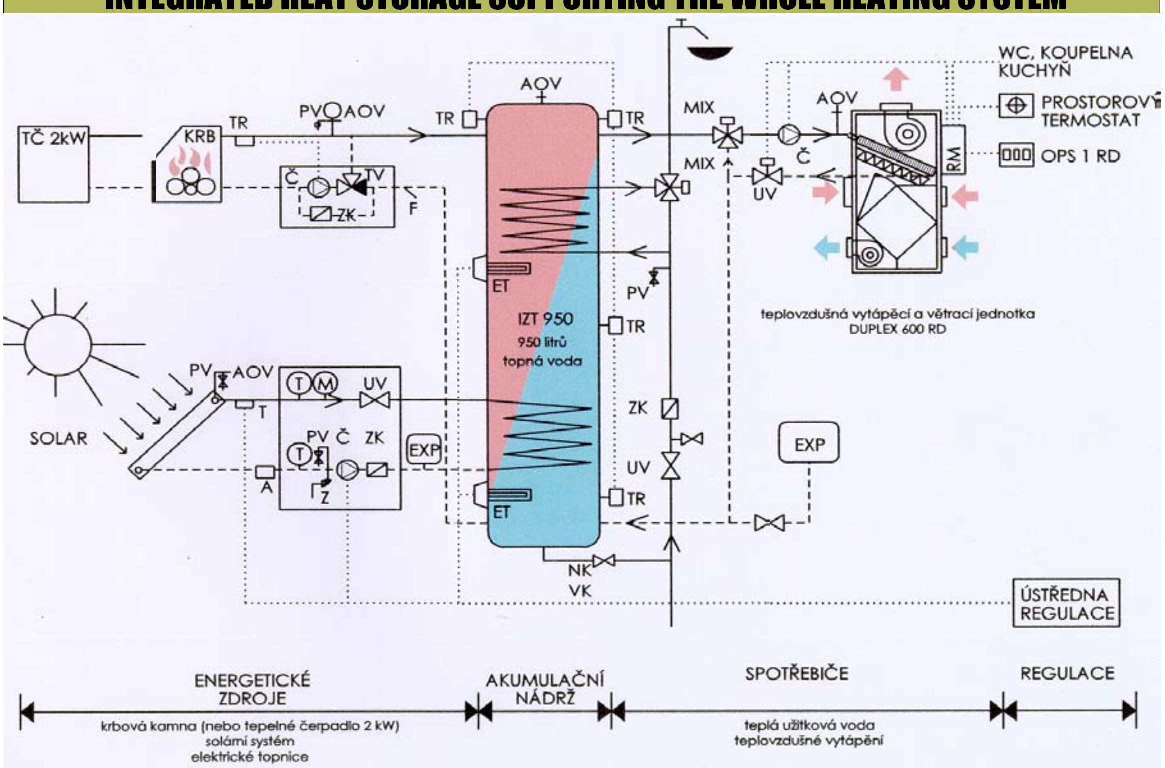
Energy performance of the house comes partly from former experiences of several engineers and architects and partly from a model developed in co-operation with Czech Technical University, Faculty of Civil Engineering.

Marketing strategy

The marketing strategy can not still be based on economical arguments only. Economical pay-back time is playing important role for many investors when making decision on energy parameters, but never plays role when making decision on bay-windows, doorknobs or garages.

Marketing can be based on both environmental and economical parameters. A standard shape and material of such type of house can be an advantage for rather conservative investors.

INTEGRATED HEAT STORAGE SUPPORTING THE WHOLE HEATING SYSTEM



The design principles of the house are published at venues of ECOHOUSE (association for sustainable housing) and discussed at the website. The parameters of energy performance will be monitored in co-operation with investor.

Investor:	Vančák family
Detail planning and energy concept:	Aleš Brotánek, Jan Brotánek
Realization:	ALTERSTAV s.r.o., Vysoké Mýto

LOCALITY
(south-west of Prague)

www.iea-shc.org www.ecbcs.org

House W - demonstration house in the Czech Republic

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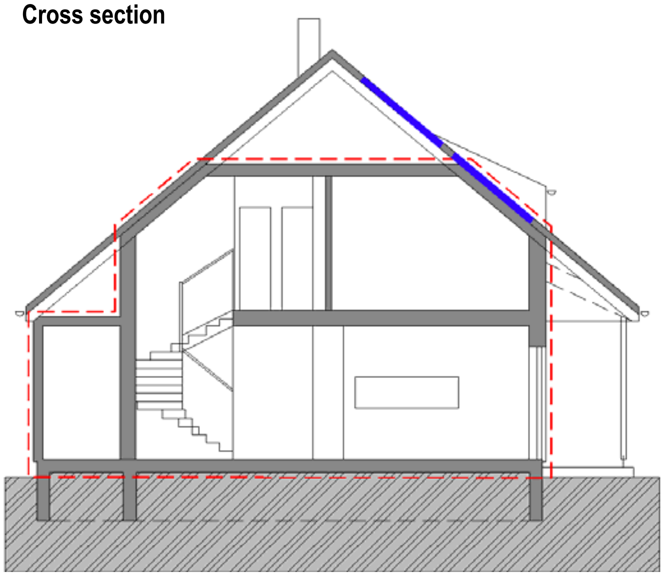
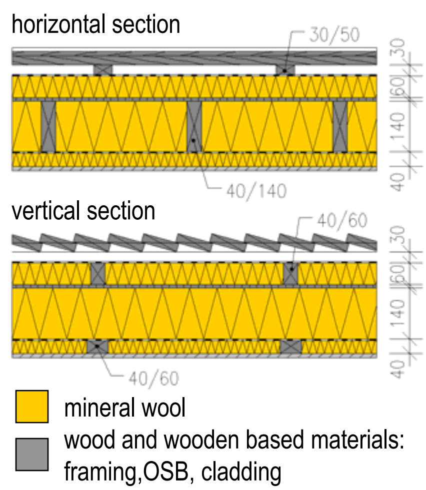
Cross section



External wall



Basic information

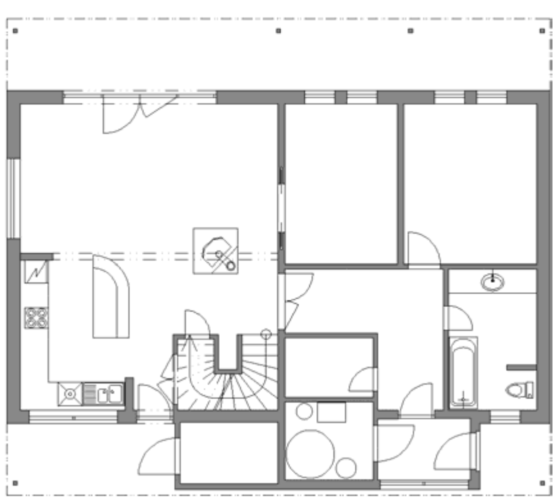
House W is a private built single family wooden-based house, with two floors, without cellar.

Location: 15 km south of Prague, near Velké Popovice

Built-in volume	691,0 m^3
Floor area:	190,4 m^2
Living area:	129,5 m^2

Construction time: June to November 2003

1st floor plan



Objectives

Using a minimum amount of materials and total primary energy from non-renewable sources was the leading idea of the project. The house should reach the low-energy house level with usually accepted costs for standard housing. Both of these facts have led to a wooden-based construction with simple form, energy effective building envelope and use of several components typical for passive houses. The U-values of the building envelope are close to those recommended by ČSN 730540-2 (2002) Thermal Protection of Buildings, Part 2: Requirements.

Building construction

Wooden frame construction was completed with OSB-boards from the exterior site of the framing, thermal insulation from mineral wool and wooden cladding. Polyethylene foil was used as water-vapour barrier. The air-permeability was measured during the constructing period to prevent air leakages.

U-values:

External wall	$U = 0,19\ Wm^{-2}K^{-1}$
Roof	$U = 0,17\ Wm^{-2}K^{-1}$
Ceiling (loft)	$U = 0,14\ Wm^{-2}K^{-1}$
Floor	$U = 0,25\ Wm^{-2}K^{-1}$
Windows	$U = 1,39\text{-}1,68\ Wm^{-2}K^{-1}$ (glazing $1,1\ Wm^{-2}K^{-1}$)

Technical systems

• warm air heating, mechanical ventilation with heat recovery

• earth heat exchanger, 21 m in length, 2 m deep

• roof integrated solar collectors 8,4 m^2

• integrated heat storage (IZT) 950 litres water, heated by solar system and electricity, secures hot water at time of use (no separate hot water storage needed)

• wood stove 7 kW (max.), intermittent operation

Energy performance

Specific (calculated) heat use for heating is 44,4 kWh/(m^2 year) - approximately 1/3 of required value. This value does not include gains from earth heat exchanger.

Boundary conditions for calculation: efficiency of heat recovery 75%, air exchange 150 m3 per hour when taking into account full occupancy by 5 people.

Energy balance

The energy balance (heating+hot water) of a reference building with identical geometry that fulfils the energy requirement (1) and the realised house W (2,3) is shown below. *A* corresponds to heat use for heating, *B* heat use for hot water, *C* represents system losses. Red arrows show non-renewable energy use.

Monitoring

The repeated measurement of air permeability together with infrared thermography was performed. Monitoring of energy parameters in the first two years of operation is in progress. A computer-operated measurement unit was installed in the technical room of the house.

Costs

The investment costs were very close to the costs for standard housing in the region. Additional costs are caused due to larger amount of thermal insulation (35 thousand CZK), for the solar heating system (175 thousand CZK), for the warm air heating system including integrated heat storage, all ducts and installations (250 thousand CZK). The saved costs are for conventional heating: gas ducts, gas boiler, chimney (together 323 thousand CZK).

Finally: the extra costs compared to the virtual reference house in this particular case are only 137 thousand CZK (approximately 4% of total investment costs). The simple pay-back time is about 13 years.

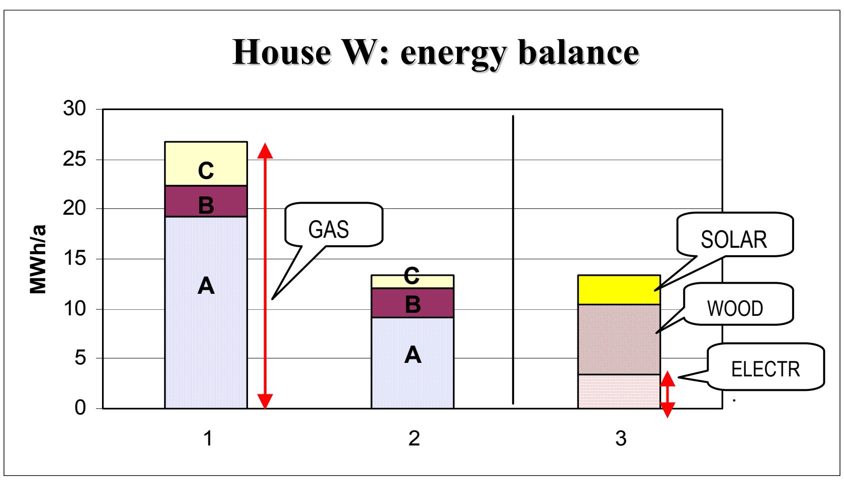
Planning tools

Energy use was calculated according to ČSN EN 832. More detailed computer simulations will be performed later to analyze the measured data, especially to study the real contribution of the solar heating system.

Marketing strategy

The marketing strategy for this type of house might follow the strategy for marketing wooden houses in general.

There is a large potential for the wood house sector in the Czech Republic as a significant capacity for quality timber does exist there. Market penetration depends mainly on to what extent „a wooden concept“ can penetrate regional tradition and mentality.

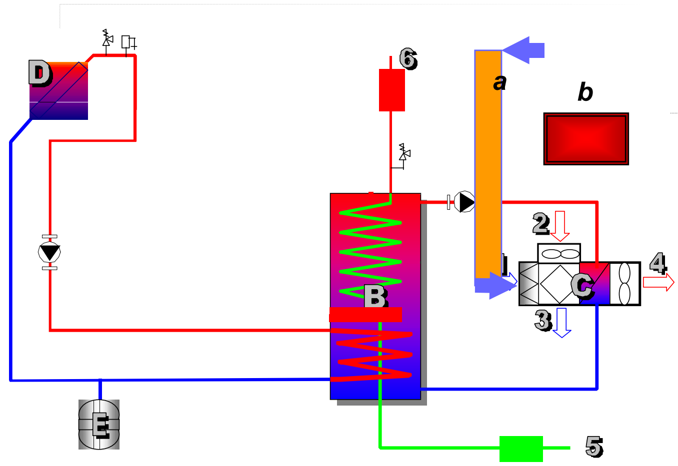


Legend to the scheme:

B integrated heat storage
a earth heat exchanger
C warm air heating with heat recovery
b small wood stove (independent)
D solar collectors (roof integrated)
E expansion vessel

1 fresh air
2 interior air
3 outlet air
4 warmed-up fresh air
5 drinking water
6 hot water

Scheme of energy supply

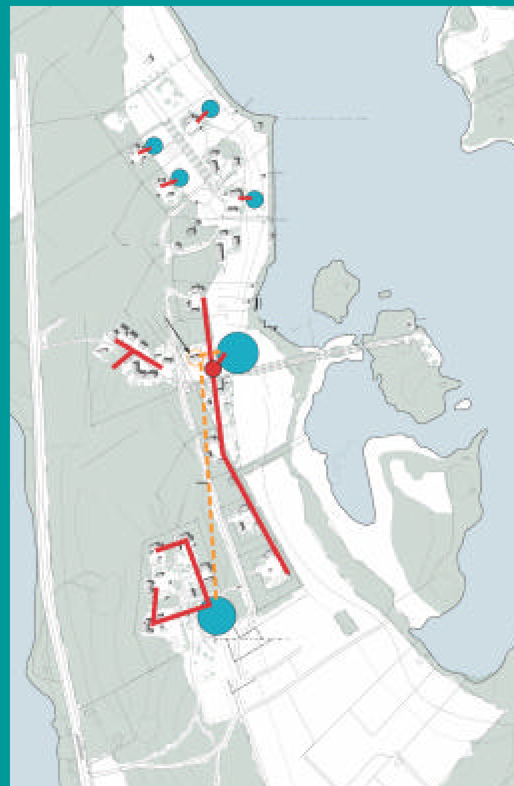


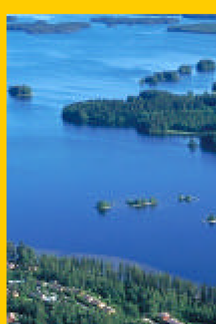
The design principles of the house were published several times (using web and journals), presented and discussed at expert seminars and conferences in 2003-2004.

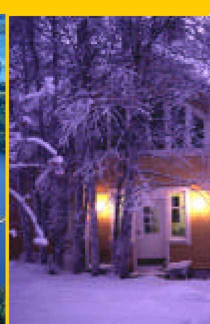
Investor:	Weger Family
Preliminary design study and energy concept:	Jan Tywoniak, Martin Šenberger
Detail planning and realization:	PENATUS s.r.o., Zlatníky
Thermal insulation:	ROCKWOOL, a.s., Praha
Heating/Ventilation:	ATREA, s.r.o., Jablonec n.N.
Solar system:	REFLEX CZ s.r.o. and ATON s.r.o., Praha
Monitoring:	Czech Technical University in Prague, Group for Sustainable Housing (Jan Tywoniak et al.), cooperation AHLBORN CZ. s.r.o., Praha
Information:	www.tzb-info.cz

Demonstration houses in

Tuusniemi, Finland



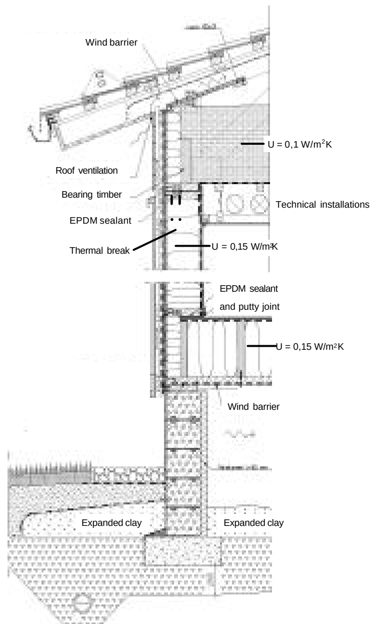


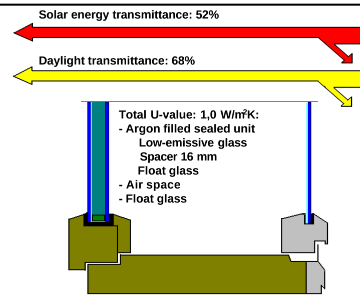


International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing





The project

Tuusniemi is a small municipality of 3000 inhabitants in East Finland. Tuusniemi is located in less than one hour travel time from two major regional growth centres and university towns Kuopio and Joensuu.

The housing area is located between two lakes, both with extremely pure water, and bounded by traditional rural cultivated area. Peaceful, pure, and safe environment together with eco-efficient housing were chosen as targets for the new housing area. The project demonstrates how eco-efficiency can be utilized as drivers in community economics, new business activities, and employment in municipalities outside growth centres.

The housing area consists of altogether 16 buildings, 13 single-family houses, two linked houses, and a building for common use**.** The master plan allows for construction of single-family houses up to 250 m^2. Two types of model houses have been developed. These houses can be extended from 75 - 125 m^2 up to 195 - 225 m^2 according to future needs of the users. The houses are built and sold ready-made or with existing building permission for extension. The linked houses are together 1500 m^2 with 14 apartments

The area has a distributed heating energy supply network based on ground heat and solar energy. The houses are built by a new company that will take over the maintenance and management of the area and its networks. The construction of the area starts on March 1, 2004.

Objectives - Goals

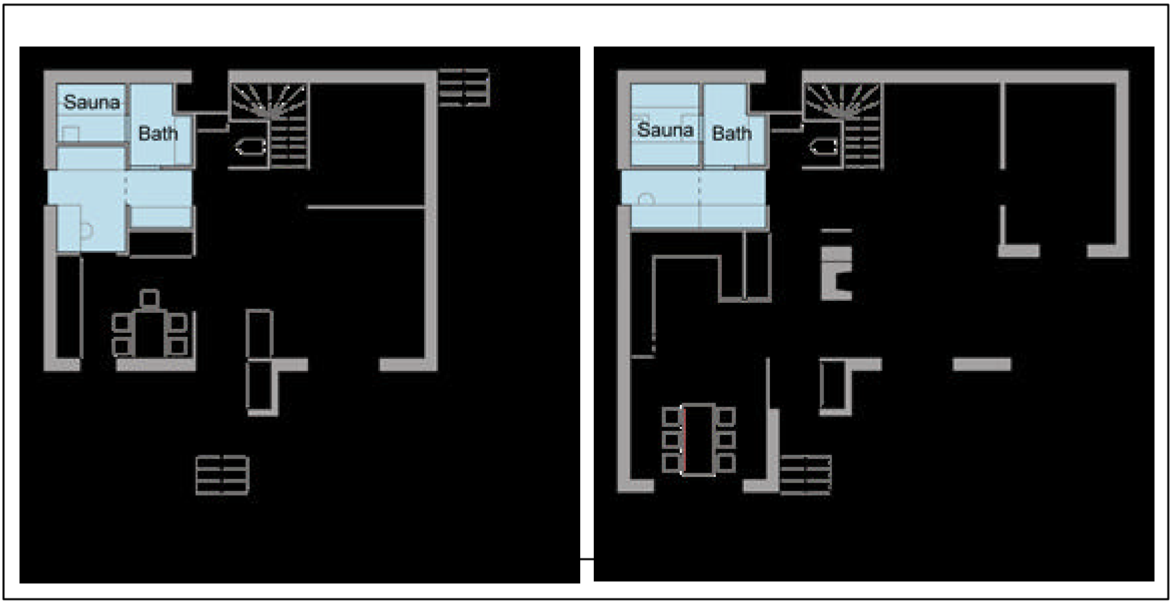
The Tuusniemi municipality suffers from depopulation and distortion of age structure. Due to poor working possibilities, young people move to other locations. This causes growing socio-economic problems.

The community decided to persuade new inhabitants to the community by offering high-class but acceptable cost housing possibilities especially for young families. The housing area is equipped with working facilities for common use to enable remote working. All the houses have high-standard internet connections. Public services, schools, nursery, health care center etc are available within walking distance. Public transport connections serve for working in the cities.

Building construction

Building envelope is based on a new open wood-framed building system Nordic Platform allowing for shorter delivery cycle than with typical construction. Special features of the system are 250 mm wood-frame with thermal break for exterior walls and trussed construction for internal floors. The walls have an air tight additional exterior insulation layer facing air cavity and wooden façade.

Insulation thicknesses and corresponding U-values including thermal bridging in construction are 275 mm (U=0,15 W/m^2K) for walls, 450 mm (U=0,15 W/m^2K)for floor with crawl space foundation, and 500 mm (U=0,10 W/m^2K) for roof. Windows are triple glazed with one argon gas filled sealed unit and one selective coating. Total U-value including frame is 1,1 W/m^2K.



Technical systems

All the houses have a mechanical ventilation system with heat recovery. Two heating systems are introduced: floor heating and ventilation heating system.

All the buildings are connected to local distributed heat supply network based on ground source heat pumps. The municipality built distributed heat pump system consists of four separate networks according to plot ration of building sites. Heat pumps are operated by the maintenance company, and they use wind energy. The yearly COP of the heat pumps is estimated 3,0.

All the houses and apartments have a fire place designed for a low-energy building. The design allows for a long heat supply with low supply power.

Energy performance

The houses are designed so that the larger is the house the less energy by m^2 it consumes. The heating energy demand can vary between 70 - 50 kWh/m^2, which includes energy produced for heating and hot water by heat pumps, and fire wood used in the fire places. Company built houses are required to have lower consumption than houses built by home builders. The peak auxiliary heating energy power is restricted to 35 W/m^2.

Consumption, kWh/m²	Existing buildings	Tuusniemi
Heating energy	140 - 170	25 - 30
HVAC electricity	20 - 30	10 - 20
Household	30 - 40	25 - 35
Total	190 - 240	60 - 85

Costs

The construction costs of the houses correspond to average costs of detached houses. The selling price of the houses start from 100 000 € including the site.

Planning tools

The project started with an intensive briefing using VTT's building properties classification tool EcoProP. The briefing tool produces automatically a document that is the basis for code of practice for construction. Energy analysis with regard to fire places in individual buildings were carried out using simulation tool VTTHouse. Life-cycle costs and life-cycle economy of the area are estimated using VTT's life cycle economy model based on ISO 15686. LCA tool BeCostwas used in environmental assessment of the buildings.

Marketing strategy

The marketing of the housing area is based on high environmental values introduced with safe and pure natural environment. The main target group for marketing is young families. A special direct marketing effort for young families in Kuopio and Joensuu is designed by the Design Institute of Savonia Polytechnics. A study on the housing preferences of target group in the regional town is being carried out to serve as marketing aid for the project. Information of the project can be found from the project web-site.

The project progress is followed and publicity gained by a project leaflet is published every two to four weeks. The project is presented in all the major fairs for home builders and annual housing fair in Finland. The houses are sold by a large housing agency in Finland operating country-wide.

Other information

Project management: Tuusniemi municipality, municipal director N.N., e-mail:
http://www.tuusniemi.fi/

Project co-ordinator: Architect Kimmo Lylykangas, e-mail: kimmo.lylykangas@arklylykangas.com
http://www.arklylykangas.com/

Project web-site: http://www.hietaranta.net/

Research: VTT, Jyri Nieminen, e-mail: jyri.nieminen@vtt.fi
http://www.vtt.fi/

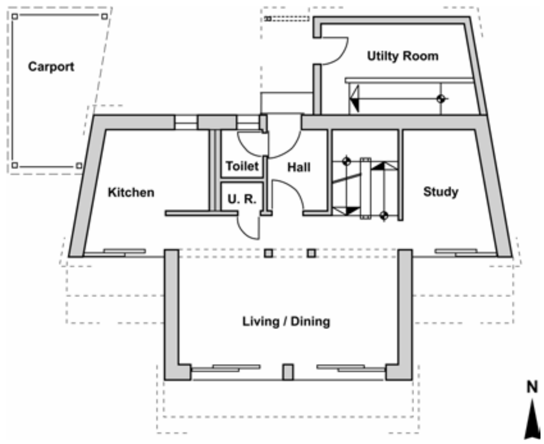
Nieminen, J. Eco-efficient housing as driver in community economics. Paper to ENHR European Network on Housing Research Biennial International Housing Conference. Cambridge, UK, 2-6 July 2004

Common text about Task 28

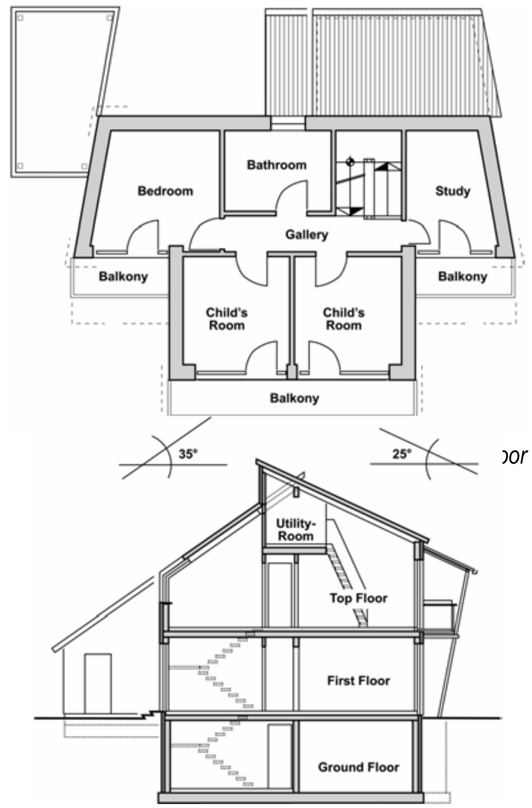
Ultra low Energy House
Durbach, Germany

INTERNATIONAL ENERGY AGENCY

IEA-SHC Task 28 / ECBCS Annex 38:
Sustainable Solar Housing



Ground Floor



Building characteristics	
Building volume V_e	576 m³
A/V	0.67 m^{-1}
Useable floor area A_N	184 m²

Project

In 1996, a timber-construction double house was built in Durbach near Freiburg within the framework of the "Weber 2001" project. One half of this building was conceived as a low-energy building, the other one as an ultra-low-energy building. This paper presents the ultra-low-energy building, which is also offered by the manufacturer as a single-family house (see photo). The two-storied building has a usable floor area A_N of 184 m²; the building has an air leakage characteristic A/V of 0.67 m^{-1}. The living room, the kitchen, a workroom, a toilet and a storeroom are on the ground floor. The bath-room, another workspace and three bedrooms are on the upper floor. From one of these rooms, a stairway leads to a gallery that provides access to the mechanical service room, which is located in the attic. The mechanical service room hosts the entire building services installations.

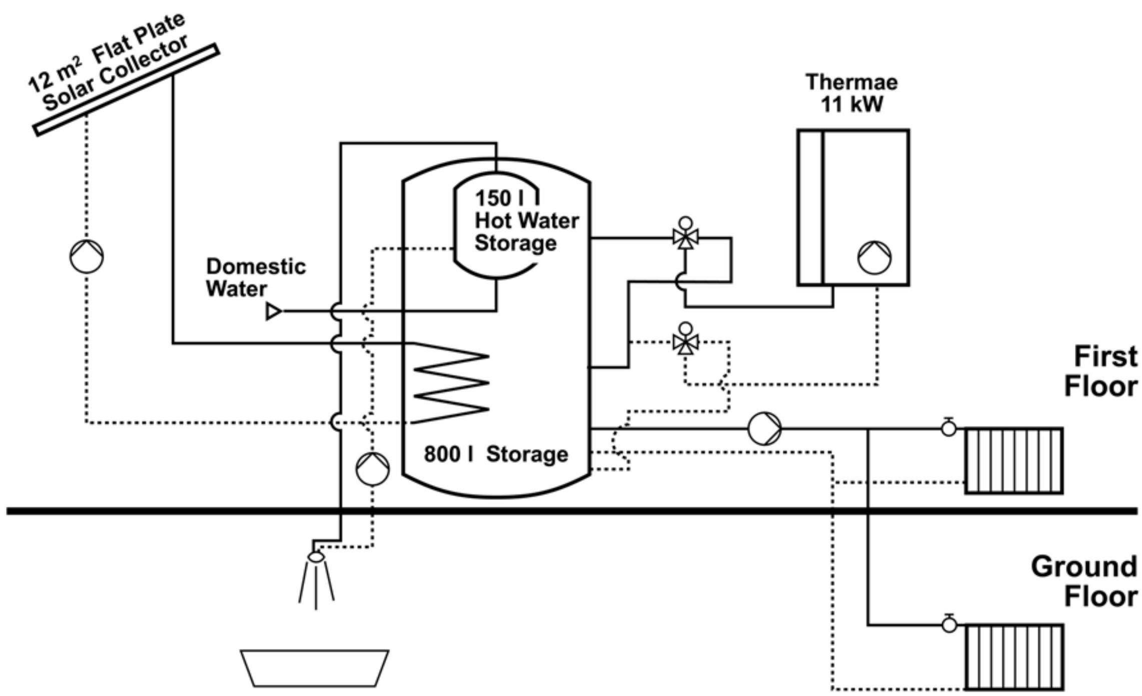
Objectives

With their project "Weber 2001", WeberHaus (a manufacturer of prefabricated buildings) followed the objective of developing building concepts with expected energy demands that were to remain clearly below the future requirements to a building's heating energy demand, and this even prior to the introduction of the EnEV regulations on energy conservation. Along with the WeberHaus Company, the project involved several enterprises specializing in services-engineering and construction-engineering. The ultra-low-energy building is an advanced type of the formerly produced low-energy building. In addition, this demonstration project was to prove that it is indeed possible to develop and build prefabricated dwelling houses, which combine very low heating-energy demands and a high level of amenity. As a high standard of thermal insulation and efficient building-services engineering are usually not that much appreciated (and paid for) by the purchaser, as are an exclusive architectural approach and extravagant interior furnishings, some cost-effective type of construction had to be favored. Besides, the objectives mentioned above, minimizing the primary energy input for production and construction was another focal point of this project.

Building construction

The building was raised as a prefabricated construction. The walls are insulated with a 160 mm layer of mineral wool between the wooden posts. At the outside of the wall, a 60 mm multilayer board was applied in order to avoid thermal bridging in the area of the timber posts, and to receive the exterior finish (U = 0.20 W/m²K). Parts of the external walls were not plastered, but sheathed with timber (U = 0.19 W/m²K). The mineral-fibre insulating board between the rafters is 200 mm thick. Below the rafters, there is another 40 mm insulation layer (U = 0.17 W/m²K). The basement ceiling is a wood construction. The insulating board between the timber beams is 200 mm thick. Above the timber beams, there is a particleboard with a 30 mm rigid foam board. The flooring was applied above a 60 mm screed layer (U = 0.14 W/m²K). Thermopane double-glazing was used for the windows (U = 1.4 W/m²K).

To ensure air tightness, the vapor barriers and the roofing membranes were continued across the respective prefabricated compounds and were fitted together on the construction site. The air tightness n_{50} was measured in a blower door test; the measured value amounts to 1.6 h^{-1}.



Technical systems

A gas condensing water heater with 11 kW power input, which can be reduced to 3.5 kW, runs the heating installation. The condensing boiler feeds an 800 liter combined storage, which contains a 150 l integrated service-water reservoir. As required by the situation, this storage can be loaded with energy at different levels. A 12 m² solar collector field on the 25° inclined southern roof supports heat supplies. The building is heated by means of tubular radiators. The system is controlled by way of central zone valves, allowing individual space heating control. The central zones valves are controlled via the internal building installation bus. They are protected against unintentional heating while windows are open (by means of window contacts). Besides, the building has PV modules with a total area of 8.7 m². The direct current thus produced is turned into alternating current; it is fed into the net of the local energy provider.
A mechanical ventilation system (including heat recovery) was installed in the ultra-low-energy building. The exhaust air that was extracted from bathroom, kitchen and WC transfers part of its energy (by means of a plate heat exchanger) to the intake air, which is then preheated to be supplied to the habited rooms. The system may be switched off by the users, and its capacity can be adjusted in three steps. If an occupant opens a window, the operation will be automatically interrupted.
The control functions (individual space heating control, locking the radiators and the ventilation system, controls of the lighting system including louvers and blinds) were implemented by means of a decentralised installation bus. To support the user, a central bus-operation and information tableau was installed.

Energy performance

Solar energy contributes to space heating and domestic hot water. In the 1998/99 heating period, the measured final energy consumption required for heating purposes was 70.6 kWh/m²a. This figure includes the power consumption of the heating circulation pump, namely 1.8 kWh/m²a. The balanced ventilation system required a power input of 0.7 kWh/m²a. In addition to the solar supports, heating of domestic hot water still required a final energy input of 10.4 kWh/m²a. If the final energy consumption rates are multiplied with the respective primary energy factors, a total primary energy supply of 84.1 kWh/m²a results.

Consumption	Final energy [kWh/m²a]	Primary energy [kWh/m²a]
Heating	61.2	18.3
Ventilation	0.7	2.1
Domestic hot water	10.4	11.4
Total	72.2	84.1

Planning tools

The building's annual heating energy demand was calculated on the basis of the calculation procedures prescribed in the 1995 regulations on thermal insulation standards (when the building was planned, the 1995 thermal insulation regulations were in force). Calculations of different variants were computed using the dynamic simulation programme Suncode.

Innovative products

Building: www.weberhaus.de
Building installation bus: www.siemens.de

Financing

The research project was funded by the Federal German Ministry for Economics and Technology (BMWi).

Project team

Manufacturer of the prefabricated building:
WeberHaus GmbH, Rheinau-Linx, Germany

Architect:
Architekturbuero Disch, Freiburg

Elaboration and evaluation of the energy concept and implementation of the monitoring programme: Fraunhofer Institute for Building Physics (IBP), Stuttgart.

Contact persons

Johann Reiß, Fraunhofer Institute for Building Physics (johann.reiss@ibp.fhg.de)
WeberHaus Company (www.weberhaus.de)

References

- Kluttig, H.; Erhorn, H. and Hellwig, R.: Weber 2001 - Energiekonzepte und Realisierungsphase. Report WB 92/1997 by Fraunhofer-Institut fuer Bauphysik, Stuttgart (1997).
- Hellwig, R. and Erhorn, H.: Primärenergieaufwand fuer die Herstellung und Nutzung der Gebäude. Report WB 93/1997 by Fraunhofer-Institut fuer Bauphysik, Stuttgart 1997.
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- DeBoer, J.; Erhorn, H. and Reith, A.: Weber 2001 - Hauskonzepte im Praxistest - Erste Messergebnisse. Report WB 94/1997 by Fraunhofer-Institut fuer Bauphysik, Stuttgart (1997).
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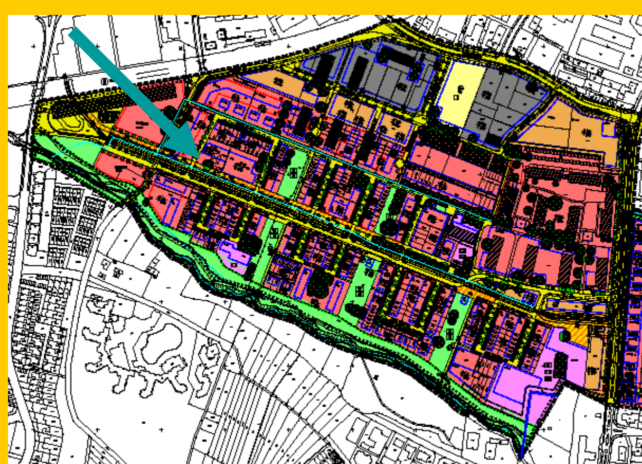
ISIS demonstration housing project in Freiburg, Germany



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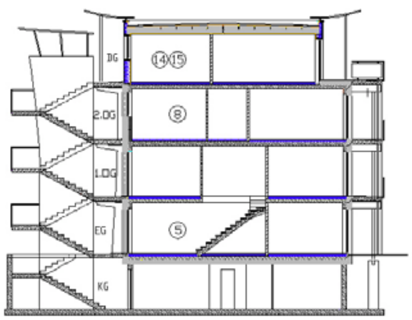
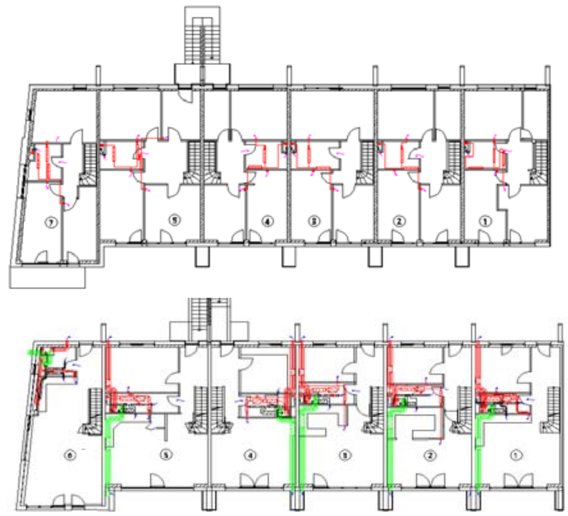


Passive solar apartment block ISIS

- cross section -



Ground floor plan (top) and first floor plan (bottom) with pipelines of the ventilation system

The project

The ISIS solar passive apartment block is situated in the recently developed residential area, Vauban, a former military barracks area in Freiburg. The four-storey apartment building, which was built within one year, has been occupied since its final completion in June 02. The passive solar apartment block has nine maisonettes and four one-storey dwellings with heated floor areas from 77 to 145 m².

The construction of the owner-occupied flats was commissioned by the building group ISIS.

49 % of the southern facade area consists of windows. Each dwelling has access to spacious balconies or terraces on the ground floor, which are situated on the south side.

The entrances to the dwellings, situated on the north side, are accessible from the open staircase via access balconies, which are thermally separated from the building.
The ground floor has thermal insulation towards the cellar.

Most of the dwellings are connected to the wood fired district heating system. Each of the dwellings is equipped with a ventilation system with heat recovery. Therefore the rooms are heated mainly with the supply ventilation air.
One dwelling has a combined heating and ventilation unit, which includes the air-to-air heat recovery and an exhaust-air heat pump providing the back-up heating of the supply air and the heating of the domestic hot water.

Design data:
net heated floor area: 1370 m²
heated volume: 3564 m³
ratio of exterior surface to volume: 0.39

Objectives

The construction of the ISIS passive apartment building adapts the energy-efficient residential building design with passive house standard from the single-family house to the multi-storey residential building. Super-insulation of the envelope and the windows, a ventilation system with heat recovery and an airtight envelope ensure a low heating demand. The use of district heating, provided by renewable energy, for domestic hot water heating and auxiliary space heating results in a minimal primary-energy demand and demonstrates a sustainable energy supply concept.

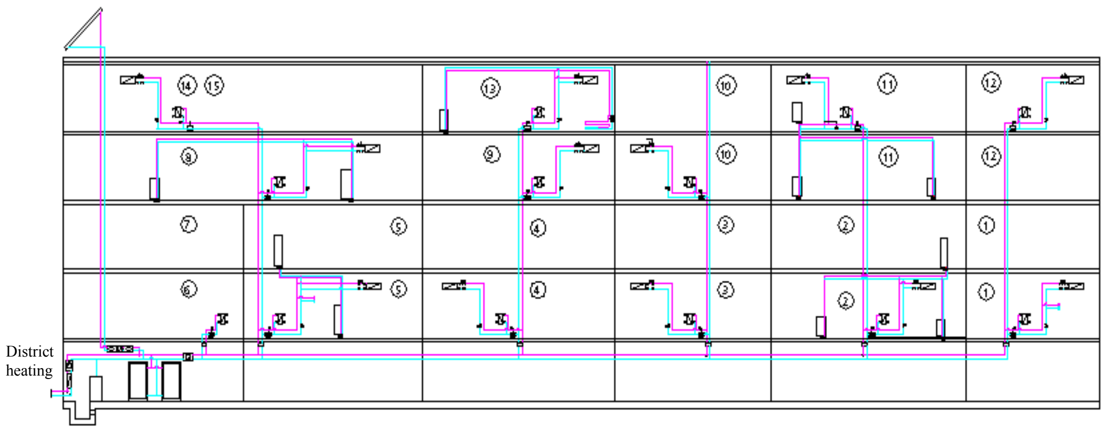
Building construction

Exterior walls: solid	
lime-sandstone brick	17.5 cm
thermal insulation	28.0 cm
Roof: lightweight construction	
thermal insulation	40.0 cm
Ceiling of cellar (cellar not heated)	
cement screed	6.0 cm
sound insulation	5.0 cm
concrete	22.0 cm
thermal insulation	20.0 cm

Windows: triple-glazed high-performance wooden frame, externally insulated

U value:

Exterior wall	0.13 W/(m²K)
Roof	0.11 W/(m²K)
Window	0.90 W/(m²K)
Ceiling of cellar	0.18 W/(m²K)



ISIS passive solar apartment block - heating supply system with district heating and solar collector array

Technical systems

- District heating provided by a wood heating plant ensuring domestic hot water supply and space heating;
- Two-pipe system with individual heating of domestic hot water via a heat exchanger in every dwelling;
- Ventilation system with heat recovery and back-up heating of the supply air via hot water heat exchanger;
- Radiators (hot water and electric) in bath room and living room in some dwellings;
- Combined heating and ventilation units supplying fresh air, air heating and providing domestic hot water via a storage tank. ;
- 23 m² thermal solar collector array supporting the central heating system - space heating and DHW;
- 5 kW_P PV system, installed by 9 of the families of the apartment block.

Energy performance

- **Heat demand**

  Space heating: 13.2 kWh/(m²a) (PHPP)

  Domestic hot water: 12.5 kWh/(m²a) (EnEV2002)
- **Yield of solar collector system**: 300 kWh/(m²a) (expected value)
- **Electricity**

  Ventilation / fans: 5 kWh/(m²a) (expected value)

  controls / pumps: 1.7 kWh/(m²a) (expected value)

  lighting and appliances: 27 kWh/(m²a) (after VDI 3087)

Planning tools

The heating demand was calculated according to a planing tool for passive houses (PassivHaus-ProjektierungsPaket PHPP) taking the ventilation heat recovery gains into account.
A major aspect of the building planning was to avoid thermal bridges in accordance to DIN 4108 - Annex 2.

Costs and benefits

The positive experience made with a free-standing passive houses has been adapted to the apartment building.
Compact design, efficient thermal insulation, minimising of heat bridges and airtight envelopes are integral components for cost-optimised building of passive apartment blocks.
Central or individual systems can be used for ventilation and heat supply for space heating and domestic hot water, to allow for individual user requirements.
While comfortable living conditions are ensured, the operating costs for heating in passive apartment blocks are low, since the heating consumption is reduced to 10% of that for conventionally constructed, modern buildings.

The construction costs for the passive solar apartment block amounted 1241 Euro/m² (for construction and HVAC)t and costs for land and planning). That is 9% more compared to building constructed according to the standards of the German energy-saving ordinance (Energieeinsparverordnung EnEV).

Heat exchanger LOGOTERM for domestic hot water

Installation of the combined heating and ventilation unit

Innovative products

Building envelope

Window and door:Fa. Klaus Müller, Lautenbach; www.muellerlautenbach.de

Ventilation and cooling

Heat recovery unit: www.maico.de

Space heating and DHW:

District heating based on CHP(60% wood ship) and solar collector

Combined heat and ventilation unit : www.maico.de

Thermal solar collector : Fa.Solvis, Braunschweig www.solvis.de

Financing

The members of the building group were already informed about energy-efficient passive building and they deliberately decided on a passive house. Building in a building co-operative makes cost optimisation possible. A building co-ordinator and the estate agent's commission are avoided and building materials are less expensive. Coping together with conflict situations serves the common interest of the building group.

The building costs were financed by the owners, supported by the German governmental subsidy „Eigenheimzulage“ and to deal in favourable credit terms by the KfW (Kreditbank für Wiederaufbau - KFW40/60 CO_2-Reducing program).

The monitoring was funded by the DBU - Deutsche Bundesstiftung Umwelt

Project team

Architect: Architekturbüro Meinhard Hansen (project manager H. Bollwerk), Freiburg www.meinhard-hansen.de

Building Services Technology: solares bauen Ingenieurgesellschaft für Energieplanung mbH, Freiburg www.solares-bauen.de

Electricity: Planungsgruppe Burgert, Ingenieurbüro für Elektrotechnik, Schallstadt

Monitoring: Fraunhofer Institute for Solar Energy Systems ISE, Freiburg www.ise.fraunhofer.de

Contact person

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Christel Russ, Fraunhofer ISE (christel.russ@ise.fraunhofer.de

Literature and links

www. ise.fraunhofer.de

www.phasea.de

Demonstration Houses in

Hannover-Kronsberg, Germany

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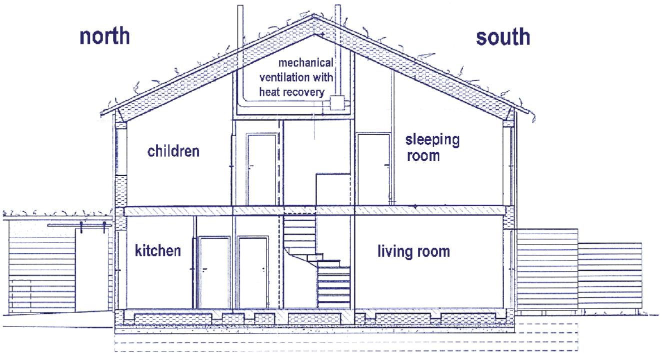
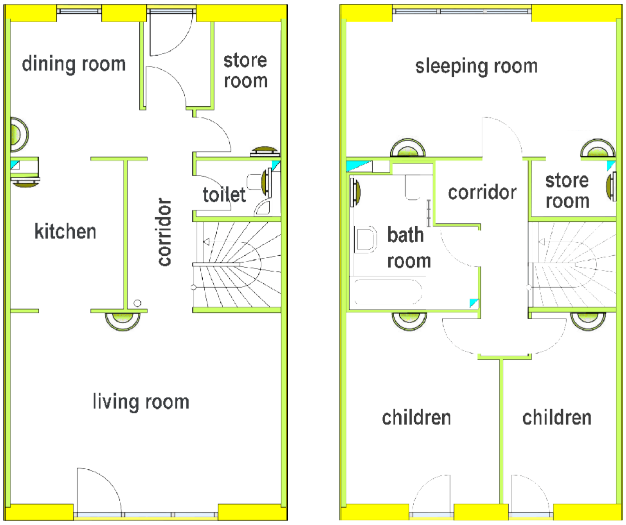
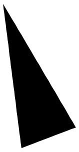


cross section, view from west



horizontal projection
supply-air and exhaust-air valves are indicated



Passive House standard

The conception of passive houses was developed in the late eighties. Meanwhile the super insulated houses with mechanical ventilation and heat recovery proofed to provide high thermal comfort with extreme low specific heat energy consumption of about 15 kWh/(m^2a). This is an energy conservation of about 75% compared to conventional buildings.

The project

The 32 terraced houses in Hannover Kronsberg are arranged in four rows with eight houses each row. This arrangement offers the advantage of reduced envelope surface area to volume ratio. The houses are type buildings which are available in three sizes with 79, 97, and 120 m^2 floor area respectively.

The main intention of this project was to show, that heat supply in passive houses can be realized by warming up the supply air of the balanced ventilation system. So these houses have no conventional heating system with radiators, except one in the bathroom.

The houses were built by a construction contractor to be resold for private use. The intention was to provide room for young families. The dwellings were partially funded by the Community of Hannover.

The Passive House Project in Hannover Kronsberg was a registered EXPO 2000 project (Cost efficient Climate Neutral Passive Houses, Reg. No. NI244).

Construction

Walls and roofs are made of light-weight wooden construction with U-values of U_{wall} = 0.13 W/(m^2K) and U_{roof} = 0.10 W/(m^2K). The core of the building, the cross-walls and end-walls are made of prefabricated concrete elements. This modular construction allowed cost reduction, so it was possible to achieve pure building costs that are as low as for conventional buildings.

Good airtightness of the building envelope is an essential precondition for passive houses. Many details of the construction had to be revised to fulfill the augmented specifications e.g. flash strips to join up window-frames to the wall are necessary. The airtightness was checked by means of a "blower door test", and reached a residual air change rate at 50 Pa of n_{50} = 0.3 ac/h in average.

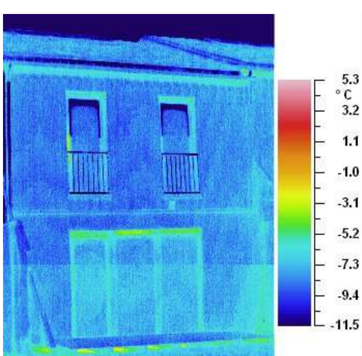
Installations in each row house:
Left: Solar hot water storage and supply-air heater (SAH).
Right: Mechanical ventilation system with heat recovery.

Controlled mechanical ventilation with heat recovery requires air- tightness

The passive house conception includes controlled air supply and exhaust-air extraction with heat recovery. The above mentioned excellent air-tightness of the building envelope is an essential pre-condition to the passive house standard, so that all the air change for ventilation takes place via the high-efficient counterflow air-to-air heat exchanger with a heat recovery rate of 80 %. Ventilation heat losses are thus reduced significantly.

The controlled ventilation system supplies the dwelling rooms all around the clock with fresh air warmed up in the heat exchanger. The inhabitants MAY open doors and windows, but they DO NOT NEED to accomplish ventilation through windows during the heating period. The length of the air ducts was designed to be as short as possible for architectual as well as for cost and efficiency reasons (pressure drop and heat losses).

The heating of the building during the heating period (November to March) is performed by a supplementary water/air heater placed after the heat recovery, which heats up the supply air. The only servicable part of the ventilation system are the air filters, which have to be changed regularly. Artificial humidification of air is not necessary. If humidity of air drops too low in winter, the inhabitants are advised to reduce the air exchange rate below the designed value of 120 m^3/h.



Infrared thermography test

Enery supply system

All houses are connected to a grid of district heat supply which is fed by a combined heat and power machine. In addition flat plate thermal solar collectors and a thermal storage tank in each house are used for domestic hot water production in summer.

The connection to the grid is implemented separately for two rows of eight houses each respectively. All houses are connected via a heat load line from the connector. This line supplies the hot water tank of the solar thermal system in each house, if not enough heat from the sun is available. Moreover it supplies the water-to-air heater to provide space heating.

Househould appliances

Almost all dwellings are equipped with dish-washer and the washing machine connected to the domestic hot water supply to avoid electrical heat production as much as possible. All inhabitants were advised to provide their households with energy saving electric appliances e.g. light, cooling and freezing, dish-washer, and washing machine. With the aid of a questionnaire the energy-saving potential was evaluated. The use of low energy appliances was funded by a repayment by the construction contractor.

Passive solar gains and shading in summer

Most passive houses have its main windows directed to south, so daylighting is provided by direct solar radiation most time of the day. In winter, solar gains through windows cover about one third of space heating energy demand.

In summer, a manual-driven shading system protects the rooms from too high temperatures. Besides this, the high-quality thermal insulation in combination with the large internal masses (concrete) help to keep the temperatures in summer on a moderate level, if cross ventilation during the night is applied.

Costs

Modular construction of terraced houses and multi-storey flats allow to achieve pure building costs that do not extend the costs of conventional buildings. This type of construction offsets the extra expenditure for insulation and ventilation system almost completely. Modular construction means a high degree of prefabrication of the various structural elements, a low number of different elements with improved quality, sophisticated logistics and a short construction time. This cost reduction provides for a broad introduction of passive houses into the market.

Planning tools

The planning process of passive houses is assisted by the PHPP (passive-house-planning package). This is a spreadsheet calculation tool, which is based on the EN 832. Some calculations and assumptions, such as air-tightness, heat-recovery, internal gains, solar gains and shading etc. are treated more sophistically. The reason for this is, that some assumptions in national standards are not valid with respect to passive houses. It is essential in this case to calculate with higher accuracy to get reasonable results. The PHPP is available at Passive House Institute (see below).

Scientific research studies

Within the CEPHEUS project (Cost Efficient Passive Houses as European Standards) funded by the European Commission, the temperatures and heat energy consumption was measured to show the reliability of the passive-house conception. See the following publications:

Feist, W., Peper, S., Oesen, M., CEPHEUS-Projektinformation Nr. 18, Klimaneutrale Passivhaussiedlung Hannover-Kronsberg, published by the Stadtwerke Hannover, 2001.

Peper, S., Feist, W., Kah, O., CEPHEUS-Projektinformation Nr. 19, Klimaneutrale Passivhaussiedlung Hannover-Kronsberg, Meßtechnische Untersuchung und Auswertung, published by the Stadtwerke Hannover, 2001.

Kaufmann, B., Feist, W., Vergleich von Messung und Simulation am Beispiel eines Passivhauses in Hannover-Kronsberg. CEPHEUS Projektinformation Nr. 21, published by the Stadtwerke Hannover, 2001.

Schnieders, J., CEPHEUS – Wissenschaftliche Begleitung und Auswertung, Endbericht, CEPHEUS Projektinformation Nr. 22, Passivhaus Institut, Darmstadt, 2001, see as well at www.cepheus.de

Peper, S., Feist, W., Klimaneutrale Passivhaussiedlung Hannover-Kronsberg. Analyse im dritten Betriebsjahr. Endbericht im Auftrag der Stadtwerke Hannover. Darmstadt, April 2002.

Danner, M., Institut für Umweltkommunikation, Universität Lüneburg, Nutzererfahrungen in der Passivhaussiedlung in Hannover-Kronsberg. Contribution to the 7. International Passive House Conference, Hamburg 2003, Conference Proceedings in German, Passivhaus Institut, Darmstadt, 2003

A further CEPEUS publication in english is available from Stadtwerke Hannover.

Illustrations: The cross section and horizontal projections originate from the architects Rasch & Partner, see below. All photographs PHI.

Architects: Rasch & Partner, Volkmar Rasch and Petra Grenz, Steubenplatz 12, 64293 Darmstadt

The energy supply and ventilation conception was developed by inPlan, Ingenieurbüro,
Norbert Stärz, Bahnhofstraße 49, 64319 Pfungstadt, Germany, email: inplan.pfungstadt@t-online.de

Scientific work, consulting and quality assurance management was done by
Passivhaus Institut (PHI), Dr. Wolfgang Feist, Rheinstr. 44-46, D-64283 Darmstadt, Germany
Phone: +0049 (0) 6151 / 826 99-0 Fax: +0049 (0)6151 / 826 99-11
internet: www.passivehouse.com email: mail@passiv.de

Funding

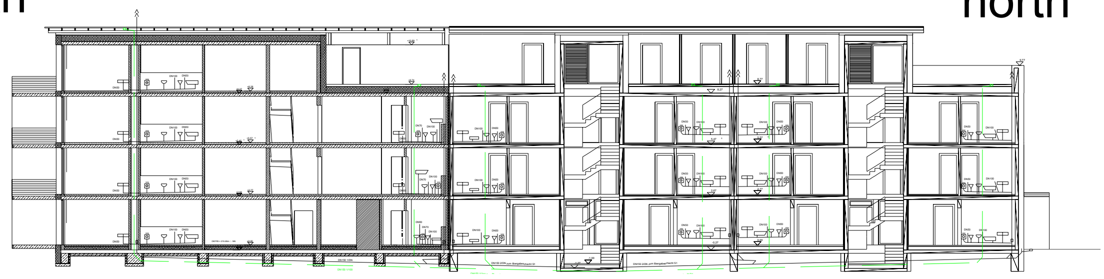
Scientific work about the Kronsberg passive houses was done within the CEPHEUS project, which was funded by the European Commission, Directorate-General XVII, Energy, Thermie, Project Number BU / 0127 / 97
Duration from 1/1998 to 5/2001.

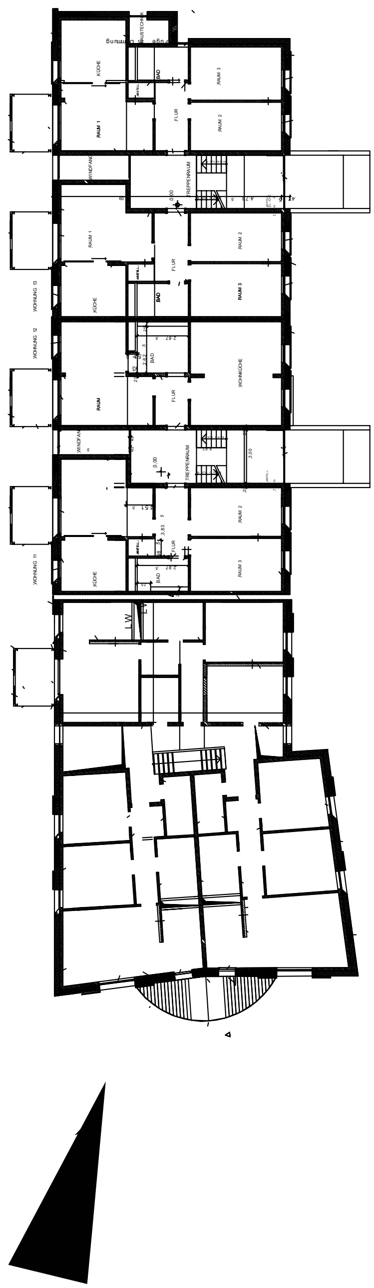
Kassel, Germany

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing

International Energy Agency





Passive House standard

The conception of passive houses was developed in the late eighties. Meanwhile the super insulated houses with mechanical ventilation and heat recovery proofed to provide high thermal comfort with extreme low specific energy consumption for space heating of about 15 kWh/(m^2a).

The main intention of this project was to show, that the conception of passive houses works with low-income housing in an urban environment even under unfavorable orientation and shading conditions, and can be realized at moderate costs.

The project

The apartment houses were built by the GWG, a local housing company for low-income people. The intention was to provide space for young families. The dwellings are rented to the inhabitants.

The two apartment buildings with 40 dwellings in total are situated in the redeveloped urban area of Marbachshöhe in Kassel. Up to the late nineties military barracks have been located there. In this brochure one of the two buildings (realized by HHS[1)] and ASP[2)]) with 23 dwelling units is described thoroughly. This appartment house has three main storeys with 7 dwelling units each. Two units are located towards south one floor higher. All 23 dwelling units have three rooms, bath and kitchen on an average area of 72 m^2. To save costs, no basement is available but each dwelling has it's storage room in the stair case.

As the development plan prescribed the main orientation of the buildings to be east / west, only two dwellings per storey are south oriented. So the living-rooms with balcony face towards west. To avoid overheating of the rooms in summertime temporary shading by shutters is provided. Low total solar gains during winter are compensated by the low A/V ratio and the high thermal insulation standard.

Construction

The construction of the exterior walls is massive by sand-lime bricks (thickness of 17.5 cm) with a thermal insulation layer made of expanded polystyrene (EPS, λ = 0,040 W/(mK)), thickness of 30 cm. The flat roof is made of concrete with a 35 cm thick EPS-layer on top. Above this a green flat 'flying roof' and some roof terraces are located. The lowest floor has a 33,5 cm EPS layer on top of the concrete plate. The outside walls of the ground floor have a thermal separating layer of tight PU-recycling-foam material (λ = 0,075 W/(mK)) to prevent from thermal-bridge effects.

Mechanical ventilation with heat recovery

The passive house conception includes controlled air supply and exhaust extraction with heat recovery. In this building a 'semi-central' ventilation system was realized: The heat recovery units (air-to-air heat exchanger) are located centrally on the flat roof. Inside the dwellings only few components of the ventilation system are located above the suspended ceiling and in the shaft. These are the silencers, the supplementary water-to-air heater, and the fans. So each inhabitant has the authority over the temperature and air exchange rate. The heat recovery is centralized to increase efficiency and to save costs. Every six to eight dwelling units are connected to one of the central heat recovery units.

Instruction for inhabitants

All inhabitants were instructed in the use of the controlled ventilation system. The inhabitants MAY open windows, but they DO NOT NEED to accomplish ventilation through windows any longer. Only air filters must be changed regularly by the inhabitants.

Controlled air supply requires air tightness

Controlled air supply and exhaust extraction with heat recovery requires good airtightness of the total envelope as an essential precondition to the passive house standard. The airtightness of the building envelope was checked by means of a "blower door test", and reached a residual air change rate at 50 Pa of n_{50} = 0.35 ac/h. This is not a misprint: the houses are intentionally extraordinary airtight.

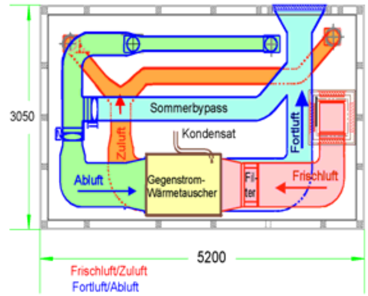
The supplementary room heating during the main winter(November to March) is performed by supplementary water-to-air heater of the supply air after the heat recovery which is connected directly to the heat supply line in the house. Artificial humidification of air is not necessary.

Energy performance

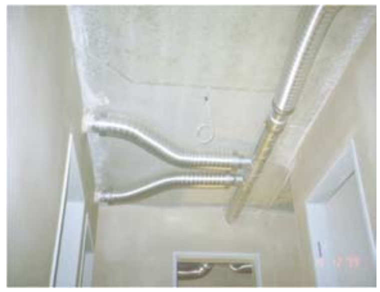
The house is connected to the grid of the local district heat supply. The connection (heat exchanger) to the grid has an additional heat storage tank (800 liters of hot water) to manage peak loads of hot water supply. The hot water installation is equipped with a circulation line.

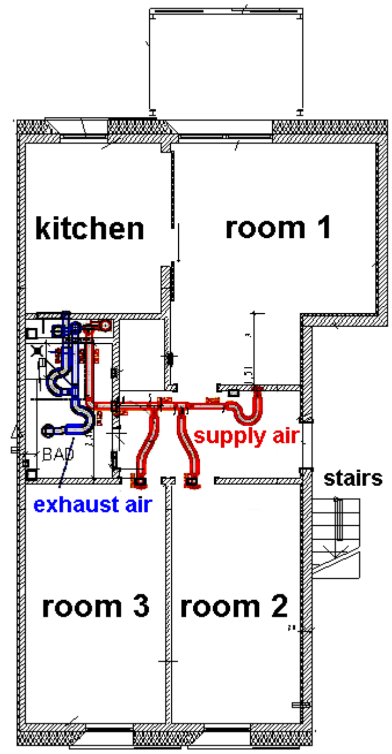
All dwellings have the possibility to connect the dish-washer and the washing machine with the domestic hot water (DHW) supply to save electricity as much as possible. Special water cocks were installed to achieve reduction of hot water consumption.

The common corridors are completely equipped with energy efficient lighting. All other appliances are in the ownership of the inhabitants. They were advised how to reduce the energy consumption of their household appliances.



central heat recovery unit

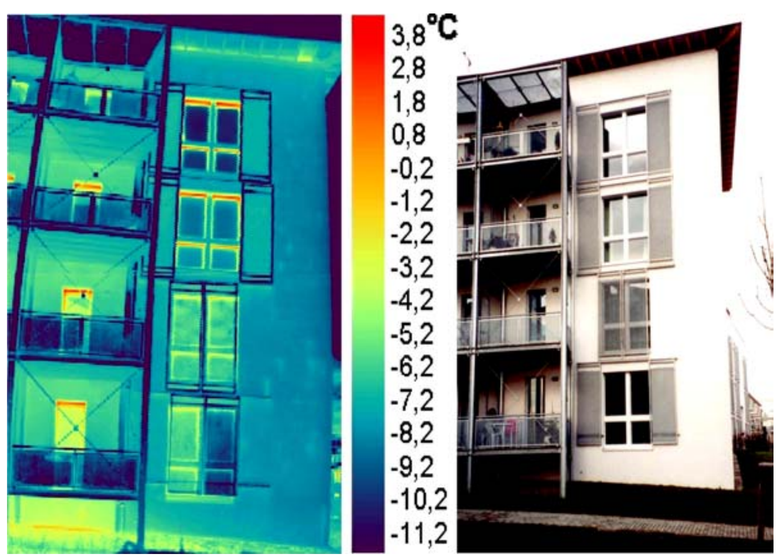

decentral installation in each dwelling



Costs

The building costs amount to about 90 000,- EURO per dwelling unit (72 m²). The extra costs to reach passive-house standard were about 8 000,- EURO per unit.

The houses were funded in the framework of low-income housing programs as all council houses in Germany For this reason the building cost were restricted to an upper limit. Nevertheless the passive house features could be realized within this restricted budget.



Infrared thermography test

Planning tools

The planning process of passive houses is assisted by the PHPP (passive-house-planning package). This is a spreadsheet calculation tool, which is based on the EN 832. Some calculations and assumptions such as air-tightness, heat-recovery, internal gains, solar gains and shading etc. are treated more sophistically. The reason is, that some assumptions in national standards (e.g. DIN 4108) are not valid with respect to buildings with a very low energy consuption especially passive houses. It is essential in this case to calculate with higher accuracy to get reasonable results.

Scientific research studies:

Within the CEPHEUS project (Cost Efficient Passive Houses as European Standards) the temperatures and heat energy consumption was measured to show the reliability of the passive-house conception in the framework of low income housing, see the following publications:

Fingerling, K.-H., Feist, W., Otte, J., Pfluger, R. 'Konstruktionshandbuch für Passivhäuser', Teil 1 des Forschungsberichts zum Projekt: 'Das kostengünstige mehrgeschossige Passivhaus in verdichteter Bauweise' gefördert mit Mitteln des Bundesamtes für Bauwesen und Raumordnung, Passivhaus Institut, Darmstadt, 2000.

Pfluger, R. , Feist, W., Kostengünstiger Passivhaus-Geschosswohnungsbau in Kassel Marbachshöhe, Endbericht, CEPHEUS-Projektinformation Nr. 16, Passivhaus Institut, Darmstadt, 2001

Schnieders, J., CEPHEUS – Wissenschaftliche Begleitung und Auswertung, Endbericht, CEPHEUS Projektinformation Nr. 22, Passivhaus Institut, Darmstadt, 2001, see as well at www.cepheus.de

Pfluger, R. , Feist, W., Sommerliches Innenklima im Passivhaus-Geschoßwohnungsbau, Meßtechnische Untersuchung und Auswertung des sommerlichen thermischen Verhaltens eines Passivhaus-Geschoßwohnungsbaus in Kassel-Marbachshöhe, CEPHEUS-Projektinformation Nr. 42, Passivhaus Institut, Darmstadt, October 2001.

Drawings on page 1 and 2 originate from the architects, HHS and ASP, see below.
Drawings on page 3 originate from innovatec. All photographs PHI.

Architects:

1) ASP, Planungs- und Bauleitungsgesellschaft mbH, Architektur und Stadtplanung, Emilienstraße 4, 34121 Kassel
2) Hegger, Hegger, Schleiff, HHS Planer + Architekten BDA, Habichtswalder Straße 19, 34119 Kassel

The energy and ventilation conception was developed by innovaTec Energiesystem GmbH,
Im Graben 5, 34292 Ahnatal-Weimar, email: info@innovatec-web.de

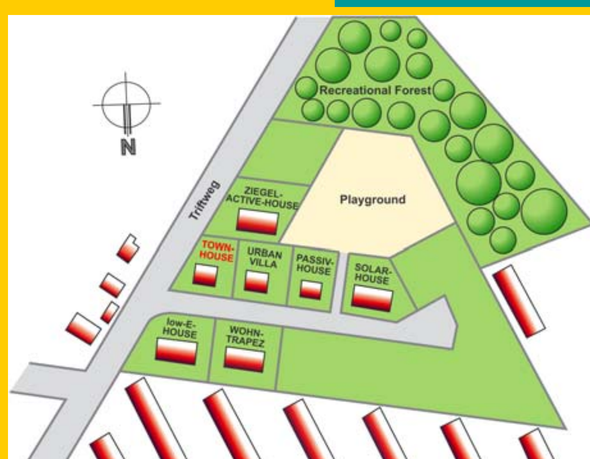
Scientific accompanying work and consulting was done by Passivhaus Institut (PHI),
Dr. Wolfgang Feist, Rheinstr. 44-46, D-64283 Darmstadt, Germany
Phone: +0049 (0) 6151 / 826 99-0 Fax: +0049 (0)6151 / 826 99-11
internet: www.passivehouse.com email: mail@passiv.de

Funding:

The conceptional project-phase was funded by the German 'Bundesamt für Bauwesen und Raumordnung' under contract No. B15-800198-15. See above: 'Konstruktionshandbuch für Passivhäuser'.

Additional scientific research about the Marbachshöhe passive houses was done within the CEPHEUS project, which was funded by the European Commission, Directorate-General XVII, Energy, Thermie, Project Number BU / 0127 / 97 Duration from 1/1998 to 5/2001 and the 'Hessische Ministerium für Umwelt, Landwirtschaft und Forsten'. Funding within the framework of IEA Task 28 (documentation) came from the german Bundesministerium für Wirtschaft und Technologie (BMWi).

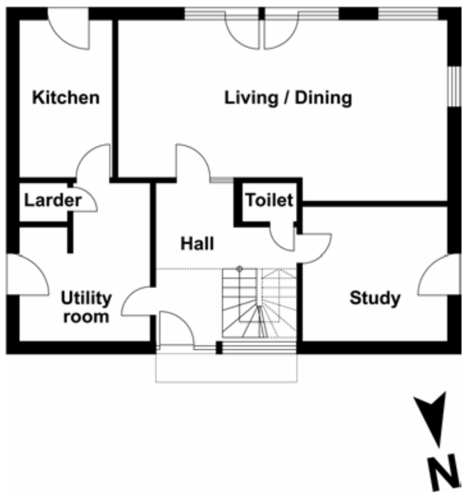
3-Litre Townhouse
Celle, Germany

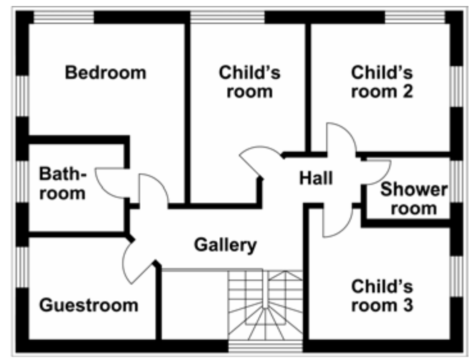


INTERNATIONAL ENERGY AGENCY

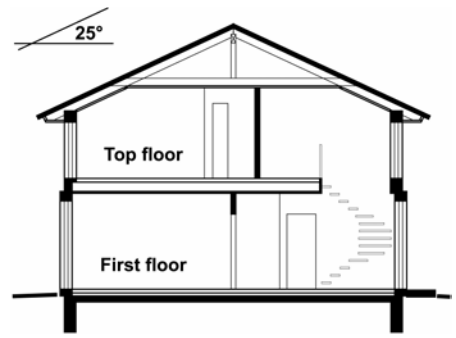
IEA-SHC Task 28 / ECBCS Annex 38:

Sustainable Solar Housing





Building characteristics	
Building volume V_e	654 m³
A/V	0.70 m^{-1}
Usable floor area A_N	209 m²



The Project

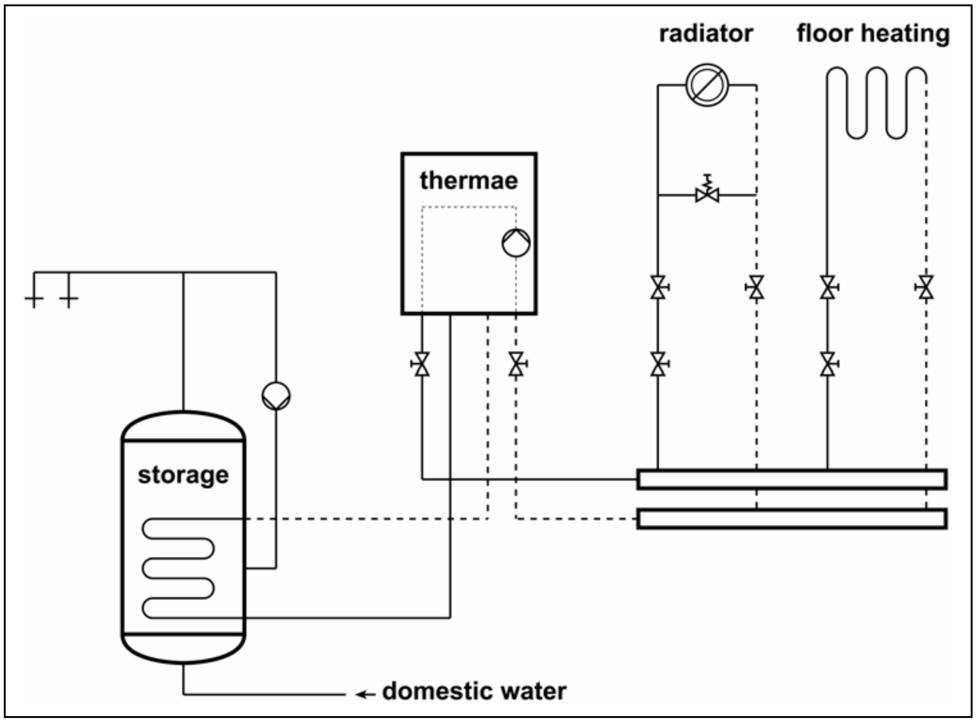
The detached single-family house was built in a newly developed area at the outskirts of Celle in 2001. The city of Celle is located about 30 km north of Hanover. To the south, this developing area abuts upon a recreation forest, and to the north upon an existing residential area. The 1 ½ storey building has a surface-to-volume ratio A/V of 0.70 m^{-1} and a usable floor area A_N of 209 m². The living room, the study, the kitchen, and the utility room are located on the ground floor. The top floor hosts five rooms and a bathroom. The building was raised by a major local manufacturer of prefabricated buildings as a lightweight timber construction.

Objectives

The manufacturer of this prefabricated house is expecting a growing demand for residential buildings with an extremely low energy demand in the near future. This is why the company developed this prototype building, designated 'Townhouse', as a 3-litre house. Low-energy buildings with an annual primary energy demand of less than 34 kWh/m²a for heating (inclusive of auxiliary energy for pumps and fans) are referred to as '3-litre houses'. This corresponds to the primary energy content of 3 litres of heating oil. To succeed in a competitive market, strict economic criteria had to be obeyed when developing the house. In future, the manufacturer will distribute this type of building all over Germany.

Building construction

The exterior walls are lightweight timber stud structures. The mineral-fibre insulation layer inserted between the vertical timber studs is 200 mm thick. An additional 85 mm polystyrene insulating layer was applied to the outside of the wall. This layer was plastered in the ground floor area, but sheathed with timber in the top floor area.



The wall has a U-value of 0.15 W/m²K. The roof was insulated with a 240 mm mineral-fibre layer between the rafters (U = 0.18 W/m²K). The building has no cellar. The concrete floor slab of the building was provided with a 120 mm rigid-foam insulation board below the screed (U = 0.31 W/m²K). The wooden windows have a double thermal insulation glazing (U_W = 1.6 W/m²K); the interspace is filled with argon gas. The total energy transmittance of the glazing is equal to 0.58.

To ensure air tightness, a polythene sheet was applied to the internal side of the walls. The outside of the walls was provided with a roofing membrane; all junctions were hermetically sealed. The air tightness n_{50}, which was determined in a blower-door test, amounts to 0.65 h^{-1}.

Technical systems

The heat required for townhouse space heating and domestic hot water is generated by a gas-condensing water heater, which can be operated between 3.5 and 11 kW. The heat is distributed to the spaces of the house by means of a single-room controlled, water-bearing floor heating system on the ground floor, and through radiators located on the top floor. There is an individual space heating control in each room with underfloor heating. The spaces are equipped with indoor-air temperature sensors that control the servomotors of the heating circuits, thus influencing the throughput of water. In the other radiator-heated spaces, the indoor-air temperature is controlled by means of thermostatic valves.

The necessary air change is ensured by means of a balanced ventilation system (with heat recovery). This system is provided with a high-efficiency counterflow heat exchanger. Re-heating of the supply air was therefore considered unnecessary. As a rule, the ventilation system is run at stage 2. Depending on demand, the system can be manually switched to setback operation (stage 1) or to intensive ventilation (stage 3). There is also a time-programme that allows the fan stages to be timed in advance.

The domestic hot water is heated in a 300-litre storage tank by the gas condensing water heater. The entire technical systems were installed in the utility room on the ground floor.

Energy performance

The calculated primary energy demand for heating amounts to 26.9 kWh/m²a. This value includes the auxiliary energy required for heat generation and heat distribution. The ventilation system has a primary energy demand of 6.6 kWh/m². The total primary energy supply for domestic water heating is equal to 32.8 kWh/m²a. The calculated primary energy demand for heating and venting is

33.5 kWh/m²a. This corresponds to the primary energy content of 3 litres of heating oil per m² and year. The total primary energy supply for the building amounts to 66.3 kWh/m²a; this value is about 40 % less than the permissible value of 110 kWh/m²a that is specified in the current German regulations on energy conservation (EnEV)

Consumption	Final energy [kWh/m²a]	Primary energy [kWh/m²a]
Heating	21.6	26.9
Ventilation	2.2	6.6
DHW	28.3	32.8
Total	52.1	66.3

Planning tools

The energy demand for heating, ventilation and domestic hot water was computed by way of the calculation routine that is applied in order to verify the energetic requirements specified in the German regulations on energy conservation (EnEV).

Costs

The sales price for the ready-for-occupancy prefabricated house amounts to € 268,600. This price does not include the costs for the foundations.

Innovative products

Ventilation:
Heat recovery unit: www.jestorkair.nl

Space heating and DHW:
Condensing boiler: www.junkers.com

Financing

The elaboration of the concept was funded by the German Federal Ministry of Economics and Labour (BMWA).

Project team

Manufacturer of the prefabricated building:
Haacke + Haacke GmbH + CO. KG,
Am Ohlhorstberge 3, D-29202 Celle

Architect:
Dr. Stauth, Braunschweig

Evaluation of the concepts and performance of the monitoring programme:
Fraunhofer Institute for Building Physics, Stuttgart.

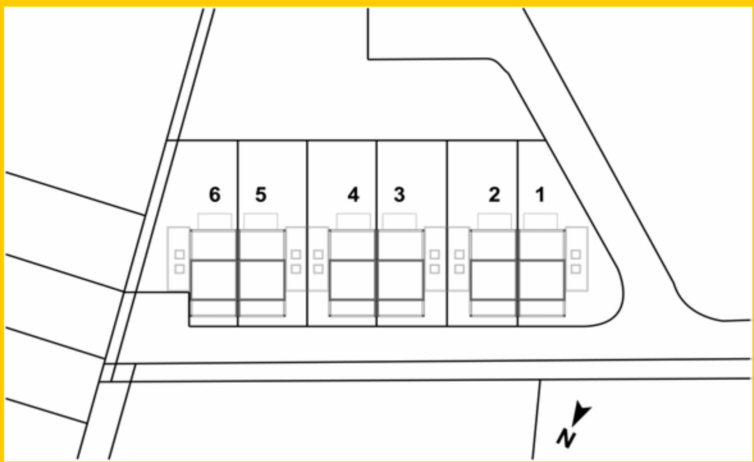
Contact persons

- Johann Reiß, Fraunhofer Institute for Building Physics (johann.reiss@ibp.fhg.de)
- Manufacturing Company:
  Haacke + Haacke GmbH + CO. KG
  (info@haacke-haus.de)

Literature

Reiss, Johann; Erhorn, Hans: The Celle 3-litre-house - validation by measurements IBP Report WB 123 (forthcoming).

3-Litre Twin Houses
Ulm, Germany



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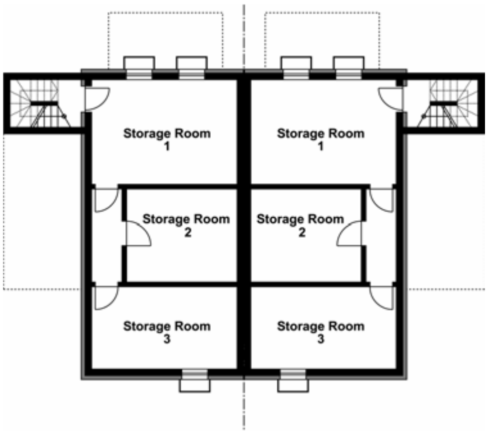
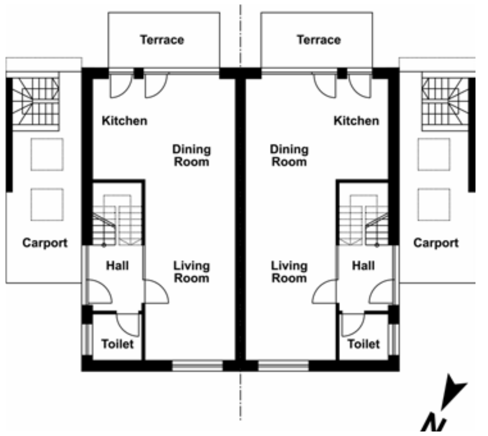
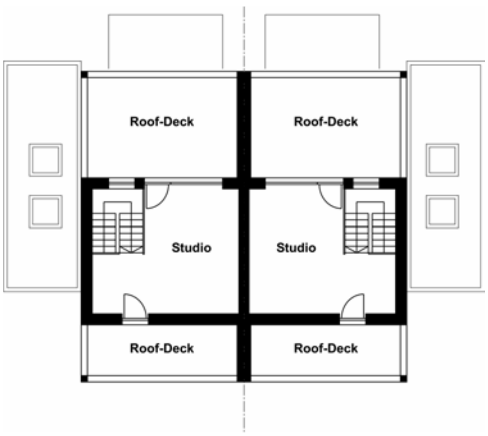
Sustainable Solar Housing



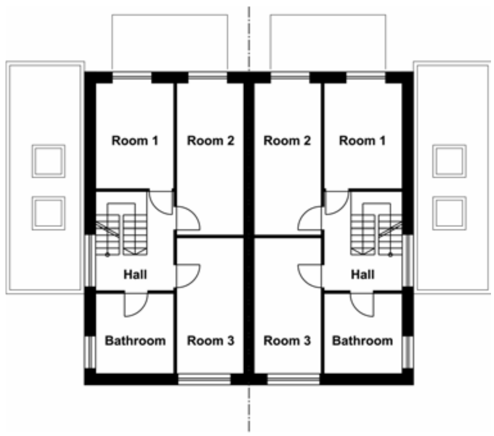
Basement



First floor



Top floor



Second floor

Building characteristics	
Building volume V_e	556 m³
A/V	$0.62 m^{-1}$
Usable floor area A_N	178 m²

Cross section

The project

In collaboration with major manfacturers of building materials, the municipal housing society (NUWOG) of the city of Neu-Ulm, Germany, raised 3 semi-detached buildings that were designed as 3-litre houses within the framework of a model project located in Ulm. The term '3-litre house' applies to low-energy buildings, whose annual primary energy demand for heating figures below 34 kWh/m²a (including the auxiliary energy required for pumps and fans). This corresponds to a primary energy content of 3 litres of fuel oil. The buildings were optimized with regard to their energetic performance and to construction costs, offering maximum amenity in conjunction with a maximum of liberty regarding the floor plan and possible uses. On the first floor, there is a small draught-lobby, the stairway, the kitchen and a south-facing living room, a toilet with a shower and an additional room for uses as required. The bedrooms and a large bathroom are situated on the second floor. The top floor hosts a studio giving access to the south terrace and an exit to the north terrace. In all the buildings there is a basement. Covered courtyards are located between the buildings. During two heating periods, the Fraunhofer Institute of Building Physics will validate the energy concept of these buildings that were completed and occupied at the end of 2003.

For the construction of these 3 semi-detached houses, the municipal housing society was awarded the builders' prize 2004 for "High quality – Affordable costs"by the Association of German Architects.

Objectives

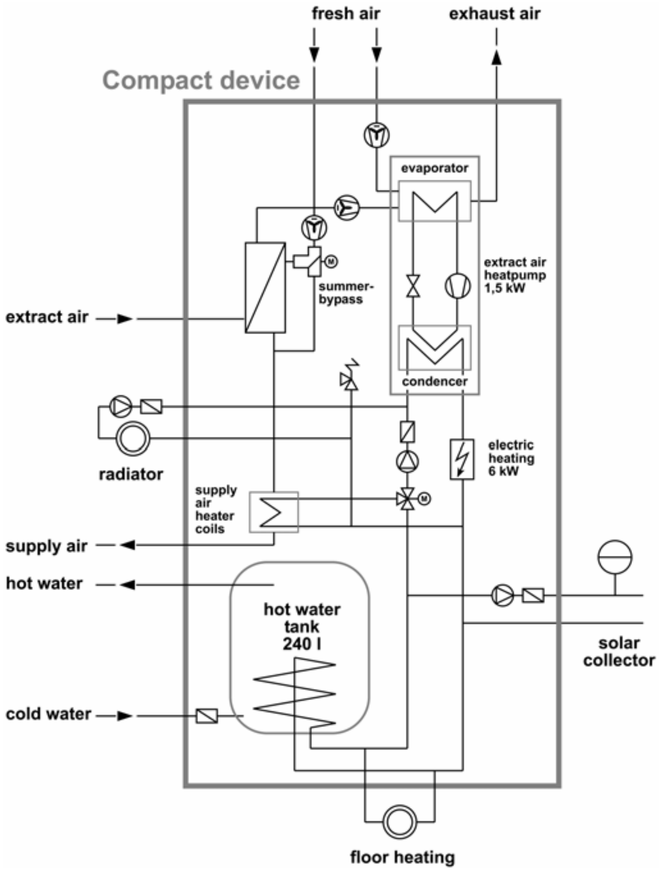
The model project was to demonstrate how innovative technologies and innovative external wall blocks, in conjunction with an optimally selected building orientation, make it possible to construct monolithic buildings that achieve the standard of a 3-litre house without any thermal insulation being applied to the external walls. The buildings are referred to as "Houses for all periods of life" because they can be adapted to meet the occupants' changing needs and wants concerning space and habitation during their different periods of life. Initially designed as a spacious, open home, the house can be broken up into zones as time goes by. It is possible to separate the first floor to obtain a supplementary, self-contained flat.

Building construction

The buildings have a south-east orientation of approximately 25°. The surface-to-volume ratio is 0.62 m^{-1}, with a gross volume of 556 m³. The building's usable floor area is 178 m², the floor space is 142 m². The external walls are monolithic, 42.5 cm brickwork constructions (U=0.20 W/m²K). The windows are made of triple glazing and wooden frames (U_w=0.80 W/m²K) with high-performance thermal insulation. The horizontal roof is a lightweight construction with high web girders between which a mineral wool insulation was inserted (U=0.08 W/m²K). A 20 cm layer of rigid foam insulation (U=0.11 W/m²K) was applied to the lower surface of the concrete basement ceiling. Special importance was placed upon the building's airtightness. Appropriate sealing strips were used to seal the connections between the window frame and the wall. The n_{50} – values that were measured in the blower-door test range below 0.6 h^{-1}.

Technical systems

The buildings are heated by means of a warm air heating system. The entire building services equipment comprising fans, filters, an extract-air heat pump, a cross-flow plate heat exchanger and a hot water tank with an electric heating rod, is integrated in one compact device which was installed in the bathroom. The outdoor air is drawn in from above the roof. While the air is passing into the habitable rooms, the cross-flow plate heat exchanger will transfer part of the heat contained in the extract air to the fresh air.



Scheme of installation

The air is further heated up by the heat pump. The exhaust air will be extracted from the wet rooms (kitchen, bathroom and toilet) to be then passed on through the cross-flow plate heat exchanger. This is where it cools down by transferring part of its heat to the supply air. The heat pump's evaporator unit will cool the air still further. The exhaust air will be discharged via the roof. In some residential units though, radiators that also receive energy from the compact device were installed in the bathroom. The heat pump also heats up the service water. In case of insufficient power output, the electric heating rod can be used for reheating the water. To support domestic water heating (and space heating, as well) a supplementary solar heating system with a collector area of 5 m² was installed.

Energy performance

According to the EnEV (German regulations on energy conservation) method of computation, the application of which is required by law, the calculated primary energy demand for heating and ventilating including the auxiliary energies amounts to 23 kWh/m²a. This figure implies solar supported heating, and the cross-flow plate heat exchanger is assumed to have a heat recovery rate of 80 %. Further, all thermal bridges were minimized in such a way that no allowances were required when calculating the transmission heat losses. The calculated value of 23 kWh/m²a corresponds to a heating oil equivalent of 2.1 litres of heating oil per square meter per year. Domestic water heating (DHW) requires a primary energy input of 16 kWh/m²a including the solar supports. Accordingly, a primary energy total of 39 kWh/m²a will cover heating, ventilating and domestic hot water including the required auxiliary energies.

Planning tools

During the planning stage, the different options for the building's optimization were evaluated by means of the monthly balance method laid down in the regulations on energy conservation (EnEV). The calculations required for minimizing heat losses due to thermal bridging were performed by means of TRISO, the three-dimensional thermal bridges programme developed at the Fraunhofer Institute of Building Physics (IBP).

Costs

The building's costs per unit floor area (without carport, floor coverings, interior painting work, costs for development and land) amount to 1050 €/m². This value corresponds to the cost limit for local authority housing in Bavaria.

Marketing strategy

The twin houses were built by the Neu-Ulm Wohnungsgesellschaft GmbH (NUWOG), a communal housing construction firm owned by the city of Neu-Ulm, possessing a stock of almost 2,500 flats (either owned or administrated). Sales strategies for the six halves of the three twin houses included both traditional methods (e.g. press advertisements, on-site inspections, sales literature etc.) and unconventional procedures, namely members of the "construction team“ who had accompanied the building project engaging in sales promotion activities. For instance, the building society Allianz-Dresdner Bauspar-AG introduced this project on a national scale to interested visitors from the trade on the occasion of the "Bad Vilbel Talks" staged by this company. Further, the manufacturer of building bricks Ziegelwerk Bellenberg has used several occasions during the building brick industry's trade conferences to draw the attention to the exceptional qualities of this pilot project. Last but not least, the City of Ulm (represented by the mayor in charge of urban construction projects) has not ceased to propagate the project as an excellent example of residential building in these times of severer requirements with regard to ecological concepts, being fully aware of hosting a very special residential building in its city limits.

Innovative products

Building envelope

Wall: Bricks (Planziegel SX plus): www.bellenberger.de
Window: Passive house windows: www.freisinger.at
Roof: Insulating rafters (PN-Daemmsparren): www.1a-kmh.de

Heating and ventilating

Space heating and heat recovery unit:
VITOTRES 343: www.viessmann.de

Financing

The validation measurements scheduled to be performed after the occupancy of the dwellings will be funded by the housing society of the city of Neu-Ulm (NUWOG), by the Supreme Building Authority in the Bavarian State Ministry of the Interior of the free state of Bavaria (Germany), and by the Ministry of the Environment and Transport of the federal state of Baden-Wuerttemberg, Germany.

Project team

Builder:
NUWOG Neu-Ulmer Wohnungsbaugesellschaft mbH,
Johannisstrasse 12, D-89231 Neu Ulm

Architect:
G.A.S.-Architektur und Stadtplanung
Sahner + Sahner, Ludwigsstrasse 57,
D-70176 Stuttgart

Construction supervision:
Planungsgruppe Sterr – Ludwig,
Arnegger Strasse 1, D-89134 Blaustein

Building services planning :
Planungsbuero Bohnacker,
St.-Antonius-Str. 2, D-88601 Schmiechen

Scientific monitoring of the execution of the works and performance of the validation measurements:

Fraunhofer-Institut fuer Bauphysik,
Nobelstrasse 12, D-70569 Stuttgart

Construction team:

- Allianz Dresdner Bauspar AG,
  Am Sonnenplatz 1, D-61116 Bad Vilbel;
  Dresdner Bank AG in Ulm.

- BAYOSAN Wachter GmbH & Co. KG,
  PO Box 1251, D-87539 Hindelang/ Allgaeu

- Freisinger Bau- & Moebeltischlerei GmbH & Co. KG, Wildbichlerstrasse 1, A-6341 Ebbs

- Viessmann Werke GmbH & Co.,
  D-35107 Allendorf/ Eder

- Ziegelwerk Bellenberg Wiest GmbH & Co. KG,
  Tiefenbacher Str. 1, D-89287 Bellenberg

The construction team cooperated from the very beginning, performed joined marketing measures and accompanied the building process by giving professional support.

Contact persons

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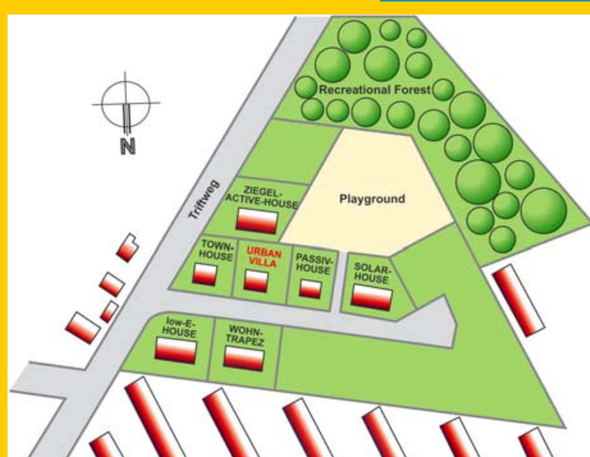
(Johann.reiss@ibp.fhg.de)

NUWOG Neu-Ulmer Wohnungsbaugesellschaft mbH
(info@nuwog.de)

Technical literature

Reiss, Johann; Erhorn, Hans: 3-Liter-Haus Modellprojekt OE.KOM.MOD in Ulm/ Soeflingen. Concept development and validation by measurements. IBP Report WB (to be published on completion of the validation measurements)

3-Litre Urban Villa
Celle, Germany



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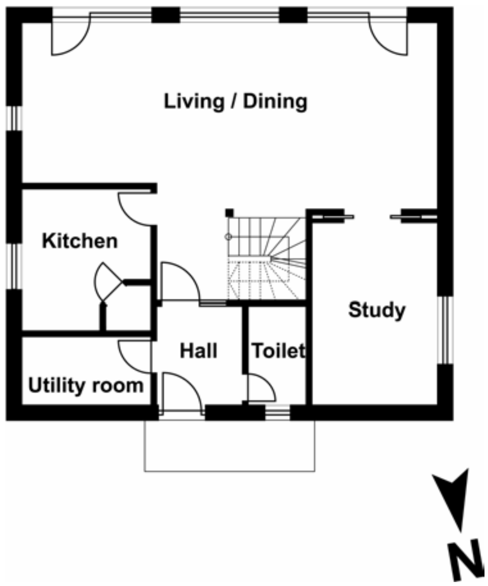
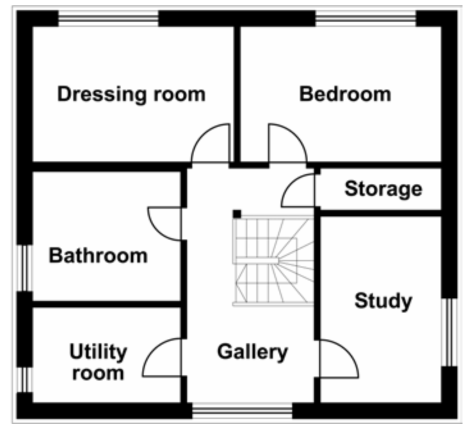
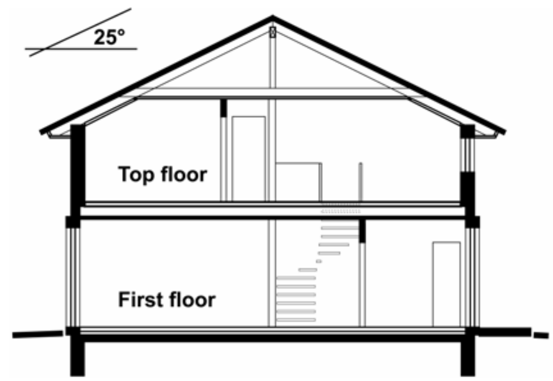






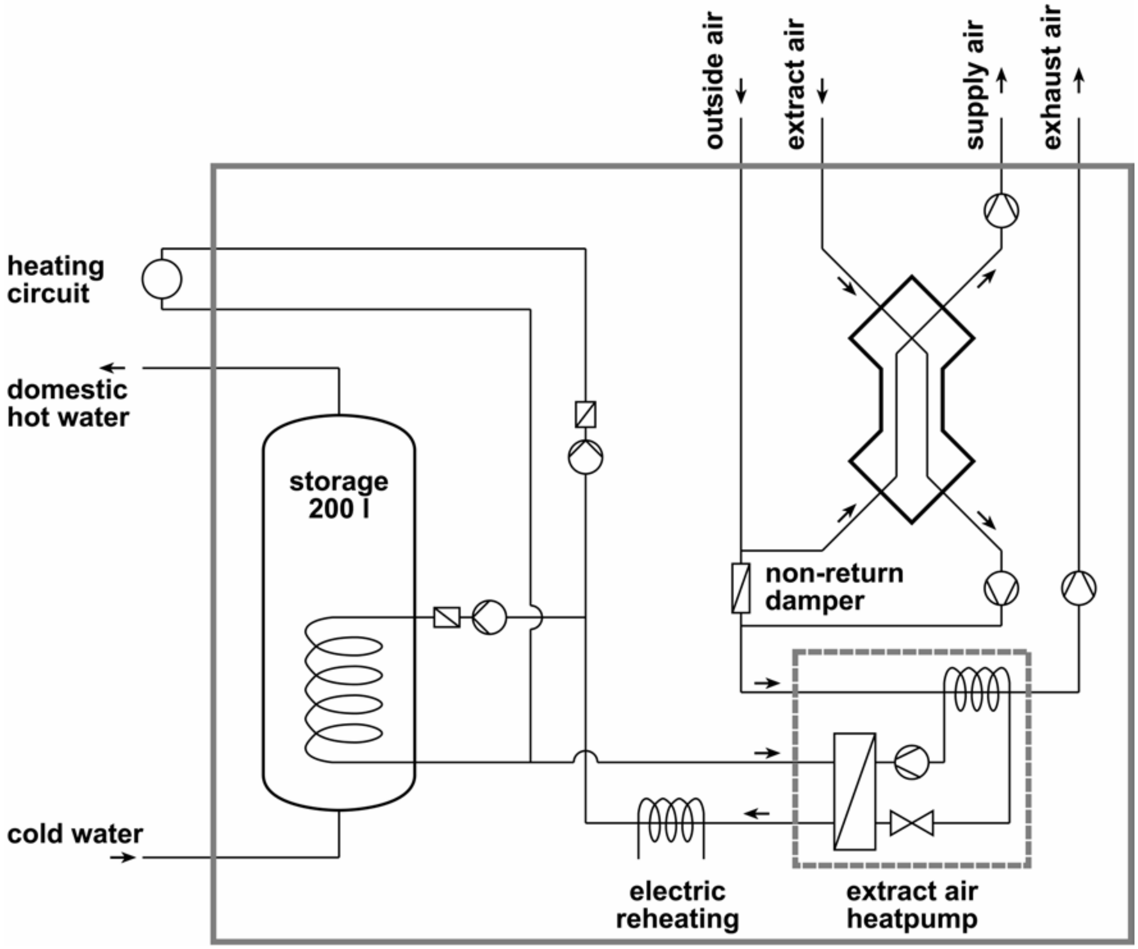
Building characteristics	
Building volume V_e	599 m^3
A/V	0.69 m^{-1}
Usable floor area A_N	191.8 m^2

The project

The detached, single-family house was raised in 2003. It is situated in a newly developed area at the outskirts of Celle. The city of Celle is located about 30 km north of Hanover. To the south, the developing area abuts upon a recreation forest and to the north upon an existing residential area. The one-and-a-half-storey building has a surface-to-volume ratio A/V of 0.69 m^{-1}. The usable floor area AN amounts to 191.8 m^2. The ground floor hosts the living room, the kitchen, a study and a housekeeping room; on the top floor, there are a bathroom, another housekeeping room and three more bedrooms. The building was raised by a local manufacturer of prefabricated buildings as a lightweight timber construction.

Objectives

The manufacturer of this prefabricated house is expecting a growing demand for residential buildings with an extremely low energy demand in the near future. This is why the company developed this prototype building, designated 'Urban villa', as a 3-litre house. Low-energy buildings with an annual primary energy demand of less than 34 kWh/m^2a for heating (inclusive of auxiliary energy for pumps and fans) are referred to as '3-litre houses'. This corresponds to the primary energy content of 3 litres of heating oil. To succeed in a competitive market, strict economic criteria had to be obeyed when developing the house. In future, the manufacturer will distribute this type of building all over Germany.



Building construction

The exterior walls are lightweight timber stud structures. The mineral-fibre insulation layer inserted between the vertical timber studs is 200 mm thick. An additional 60 mm insulating level with a mineral wool infill was applied on the inside. In the ground floor area, the external face of the wall was covered with cleaving tiles; in the top floor area, it was covered with profiled timber. The roof was insulated with a 240 mm mineral-fibre layer between the rafters (U = 0.14 W/m²K); below the rafters, there is a 60 mm layer of mineral wool. The building has no cellar. The floor of the building was provided with a 120 mm rigid-foam insulation board both above and below the concrete slab (U = 0.15 W/m²K). The windows were provided with passive house frames and have triple thermal insulation glazing (U_W = 0.8 W/m²K); the space between the panes was filled with argon gas. The total energy transmittance of the glazing is equal to 0.55.

To ensure air tightness, a polythene sheet was applied to the internal side of the walls; externally, a roofing membrane was fixed to the walls, which was hermetically bonded at the junctions. The air tightness n_{50}, which was determined in a blower-door test, amounts to 0.85 h^{-1}.

Technical systems

In the 'Urban villa', a compact device with a heat pump is charged with all the tasks of energy supply, i. e. centralised balanced ventilation, DHW and space heating. The essential components of the device include: extract air heat pump, crossflow/ counterflow heat exchanger and DHW storage tank. The exhaust air is extracted from the wet rooms to be conveyed through a crossflow/ counterflow heat exchanger, which transfers the heat gained in this way to the intake air. A heat pump that was installed in the extract airflow draws more heat from the exhaust air and supplies it to the 200-litre DHW tank and the heating system. As a heat pump is more efficient at lower temperatures, the spaces of the 'Urban villa' were provided with a floor heating system. The supply air will not be heated after having passed the cross/ counterflow heat exchanger. Before entering the evaporator, the extract airflow can be mixed with outside air. In case of very high heat demands for space heating or domestic hot water, direct electrical supplementary heating is possible.

Energy performance

The final energy demand for heating and ventilation amounts to 6.1 kWh/m²a; the demand for domestic hot water is 6.6 kWh/m²a. These figures refer to electrical energy. Accordingly, the primary energy demand results to 18.3 kWh/m²a and to 19.9 kWh/m²a, respectively. With a value of 38.2 kWh/m²a, the total primary energy demand of the building is about 65 % below the permissible value of 110 kWh/m²a that is specified in the current German regulations on energy conservation (EnEV).

Consumption	Final energy [kWh/m²a]	Primary energy [kWh/m²a]
Heating	6.1	18.3
Domestic hot water	6.6	19.9
Total	12.7	38.2

Planning tools

The energy demand for heating and preparation of domestic hot water was computed in accordance with the German calculation standards DIN 4108 part 6 and DIN 4701 part 10, as specified in the German regulations on energy conservation (EnEV).

Innovative products

Compact device for heating, ventilation, and domestic water heating:

www.tecalor.com

Financing

The evaluation of the energy concept was funded by the German Federal Ministry of Economics and Labour (BMWA), Berlin.

Project team

Manufacturer of the prefabricated building:
Haacke + Haacke GmbH + CO. KG,
Am Ohlhorstberge 3, D-29202 Celle

Architect:
Dr. Stauth, Braunschweig

Design evaluation and performance of the monitoring programme:
Fraunhofer Institute for Building Physics (IBP), Stuttgart.

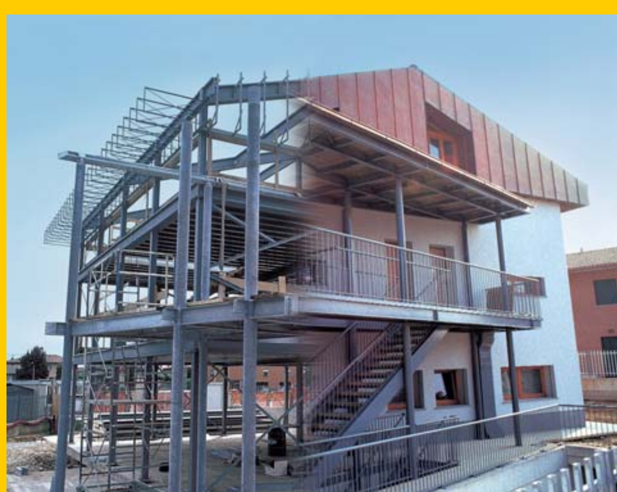
Contact persons

- Johann Reiß, Fraunhofer Institute for Building Physics (johann.reiss@ibp.fhg.de)
- Manufacturing Company
  Haacke + Haacke GmbH + CO. KG
  (info@haacke-haus.de)

Literature

Reiss, Johann; Erhorn, Hans: Messtechnische Validierung der 3-Liter-Haus-Stadtvilla in Celle [The Celle 3-litre urban villa - Validation by measurement]. IBP report (forthcoming).

Chignolo, Italy



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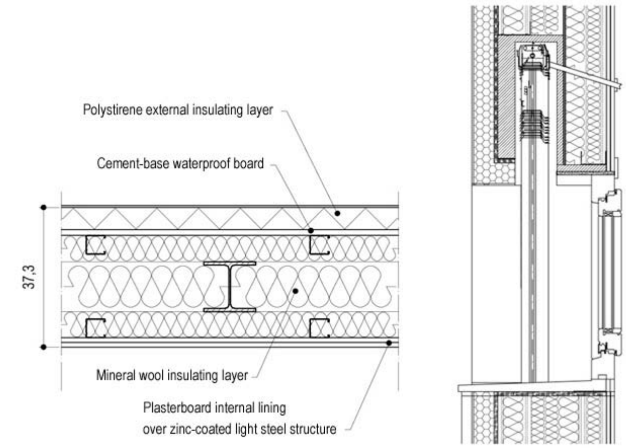


The project

4-flat detached house with two 60 m^2 units (one bedroom) and two 120 m^2 units (two bedrooms). Building has two floors above ground, plus basement with storage and parking and attic floor.

The house was built by a construction company wishing to realize a demonstration building for low-energy strategies and light Str/En construction with a relatively traditional appearance.

Flats are wheelchair accessible thanks to a lift linking basement and first floor levels.

Construction period was from February 2002 to January 2003.

Objectives

The house was built with the aim of demonstrating the feasibility of an extremely low energy consumption level for winter and summer comfort in the climate of Pianura Padana.

The house complies with the German "Passivhaus" standard (15 kWh/m2 per year) for winter heating and guarantees artificial summer cooling mostly through renewable energy.

Moreover, light Structure / Envelope (Str/En) technologies were used, in order to provide high thermal and acoustical comfort, minimum energy for transport and assembly (the whole building weighs some 100 t) and possibility of final dismantling and recycling of components. This is possible by layering light and functionally specialized materials on independent sub-structures.

Marketing strategy

The house was followed, during the construction stage, by a research group of the Politecnico di Milano – Dipartimento BEST, in particular on the occasion of a PhD work. This is being followed by a monitoring campaign that will control the most critical parameters during one or more years.

The experience was made public by articles on specialized and generic reviews, books and conferences (some of them international).

Building construction

The design strategy relies on heat conservation in winter and protection from direct solar radiation in summer. The envelope is hyper-insulated and made air-tight by a continuous windproof layer in the walls, while thermal bridges were minimized by the use of a continuous, 6 cm thick thermal insulation layer outside the perimeter walls.

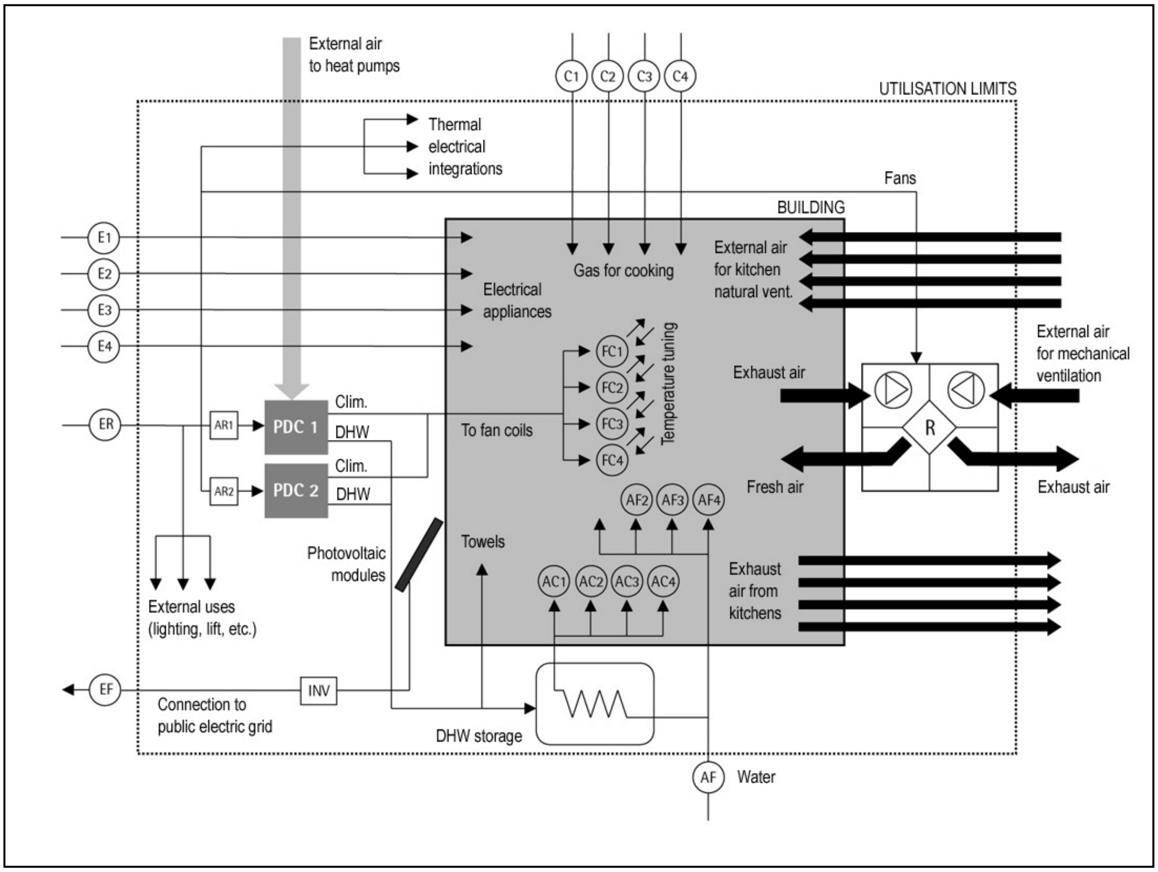
As concerns summer, the windows are smaller than is the norm in Central European countries and they are all equipped with solar control devices (aluminum Venetian blinds). South-facing windows are protected from the sun by PV panels that in winter do not prevent the sun from entering the house.

U of opaque components (walls, roof) is lower than 0.10 W/m^2K;

U of windows is 1.5 W/m^2K;

U of roof skylights is 0.8 W/m^2K.

Double shell construction was used throughout to ensure optimal thermal and acoustic separation between exterior and interior.



Technical systems

All flats have mechanical ventilation for indoor air quality reasons with heat recovery of 75% efficiency. This ventilation air is post-heated, or post-cooled, when the building is no more able to guarantee spontaneously the indoor comfort conditions (envelope as efficient climate filter). Post-treatment of air is performed by a simple fan-coil unit per apartment and floor, which is fed by hot or cold water from an air-to-water heat pump.

The same heat pump produces domestic heat water, thus eliminating completely fossil fuel burning from the house – except for cooking.

Temperature and ventilation can be controlled directly by the users, also remotely thanks to a state-of-the-art domotic system.

In mild seasons, users can switch off the ventilation and simply open windows (free-running mode).

A photovoltaic field installed on the south façade (36 m^2) supplies electrical energy, covering some 40% of the overall need over the year. Its production is higher in summer, satisfying energy-demanding cooling loads.

Energy performance

The heating consumption for the cold season is lower than 15 kWh/m^2 per year, that is some 80% lower than current Italian regulations require.

Heating of space and ventilation air: 15 kWh/m²

(Air-to-water heat pump)

Domestic hot water: kWh/m²

(Air-to-water heat pump)

Fans and pumps: kWh/m²

Lighting and appliances: kWh/m²

Total calculated/monitored auxiliary energy demand: kWh/m²

Total calculated/monitored energy demand: kWh/m²

(Please state if the figures are calculated or monitored, or both)

Planning tools

Energy performance was checked against the Passivhaus Institut tool Passivhaus Projektierungspaket 2002 in order to classify the house as such.

Costs and benefits

Capital costs for hyper-insulation and other energy-saving strategies were in line with the mean costs of Central European experience, but of course higher in absolute value as the energy consumption reduction is larger than in Germany (Italian current consumption standard is far higher).

Innovative products

Str/En technologies

www.vanoncini.it

Building envelope

Window: www.faliselli.it; www.velux.it

Walls: www.knauf.it; www.sto.de; www.rockwool.it

Ventilation and cooling

Heat/cooling recovery unit: www.daikin.it

Controls

Solar and shade control:

Space heating and DHW

Heat pump: www.climaveneta.it

Electricity

Solar PV: www.siemens.it

Financing

None.

Project team

Design:
Brandolini Valdameri studio di architettura associato
Structures:
G. P. Imperadori
Technical installations:
Silvestri & Associati
Construction and detail design:
Vanoncini S.p.A.

Contact person

Pietro Antonio Vanoncini (pa.vanoncini@vanoncini.it)
Gabriele Masera (gabriele.masera@polimi.it)

Literature and links

- G. Masera, *Residenze e risparmio energetico*, Il Sole 24 Ore, Milan 2004 (italian).
- G. Masera, *Passivhaus all'italiana*, in "Costruire" no. 241, june 2003, pages 34-39 (italian).
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- E. Zambelli, M. Imperadori, G. Masera, M.Lemma, *High energy-efficiency buildings*, in Proceedings of the 4th International Symposium on heating, ventilation and air conditioning ISHVAC 2003, Tsinghua University Press, Beijing 2003 (english).
- G. Masera, M. Imperadori, M. Silvestri, La Passivhaus di Chignolo d'Isola: alto comfort, bassi consumi, in Atti del 44° Convegno internazionale AICARR 2004 "Impianti, edifici, città", Milano 2004 (italian).

Chiryu, Japan

International Energy Agency

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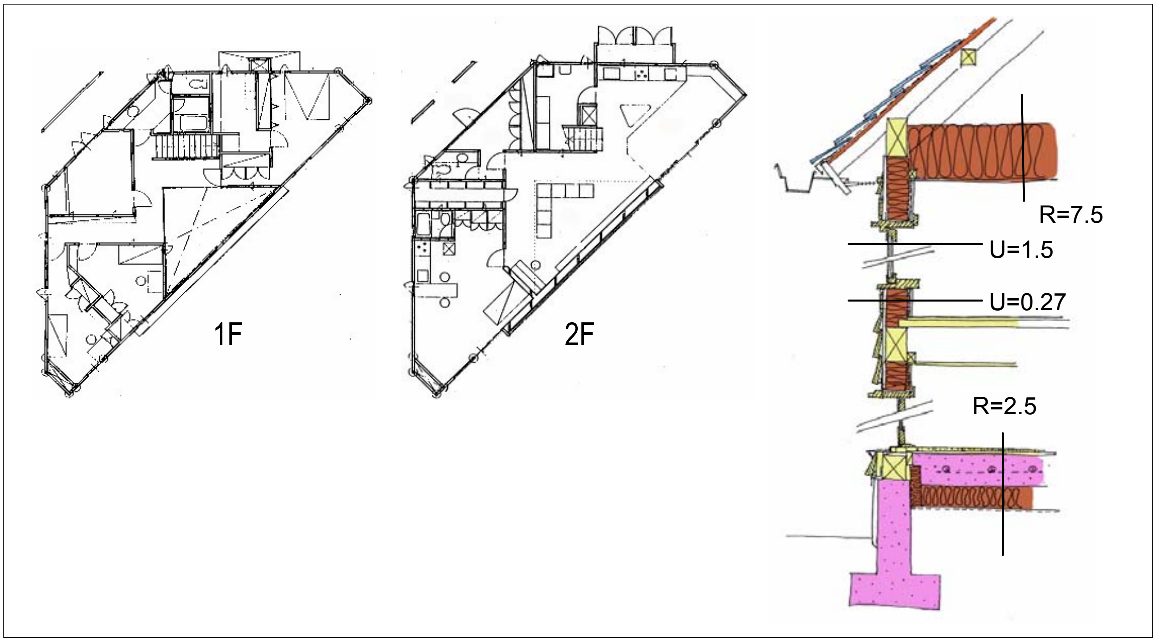

The project

The Okamoto Solar House is in a semi-urban town of Chiryu, Japan. The town is close to Nagoya in the central part of the Japanese main island (on the pacific coast). This solar house is a single-family house in a residential district. The project was finished in February 2003.

The house has 3 bedrooms and an elder's room with kitchen and bathroom to make it possible to accept homecare. The kitchen and dining room is often used for cooking lessons and as a studio. The garden is a spiritual, secluded shelter in this crowded area.

Objectives

From the far past to the present, most Japanese houses have not been heated whether whole house or just during the winter - despite Japan having a cold winter carried down from Siberia. This custom has been the cause of various health and safety problems, for example dewing, ticks, allergy, asthma, heart attack, drowning in bathtub, etc.

Natural cooling, passive solar designs and active solar techniques are applied to this house to provide high quality of indoor climate through the year through whole house, whole season heating with same energy consumption compared to typical present day Japanese homes, in which, only a few rooms are heated or cooled as needed. Energy demand for domestic hot water occupies more than 1/3 of Japanese home energy, so DHW should be supplied by sun.

Marketing strategy

Seminars to educate the advantage of the solar house for people interested in the new home have been held more than 40 times a year throughout Japan, featuring the hybrid solar house "AMATELAS". Some 200 home builders are participating.

Building construction

Structure is by Japanese traditional "post and beam" method with 105mm thick wall cavity. To increase insulation thickness and minimize wooden cold bridges, vertical and horizontal bars are attached to make wall cavity thickness 140mm.

Exterior walls are insulated with cellulose insulation, U-value 0.27 W/m^{2}K.

Ceiling is 300mm cellulose insulated, R 7.5 m^{2}KW (0.13 W/m^{2}K).

Floor is slab-on grade, R 3.5 m^{2}KW (0.29 W/m^{2}K), solar heated heat-storage-floor is insulated with 100mm foamed polystyrene, R 2.5 m^{2}KW (0.4 W/m^{2}K).

Windows are double glazed, low-emission coated, argon filled, wood frame, total U-value of 1.5 w/ m^{2}K. Ventilation with heat recovery is not applied because of this rather mild climate but fresh air is drawn via cool tube to reduce ventilation loss.

Solar Collecters

Shutter/reflector for
the Trombe wall

Technical systems

The house has a triangular plan with the widest wall facing true south to maximize solar gain in winter. The south roof has 45deg. tilt to provide maximum winter insolation to the solar collectors. Airlock entry and storages are arranged along north wall to be buffers for the living space.

Passive and active hybrid solar system for floor heating and DHW, named AMATELAS, is developed for this house. A micro-processor is central to AMATELAS and this system stores winter solar heat in the floor for radiant floor heating, makes hot water by excess solar heat, and activates auxiliary boiler when necessary. This makes AMATELAS the principal heating management system to integrate auxiliary boiler with the solar systems.

A 25m^2 trombe wall, widest in Japan, occupies the middle of the south wall, with a bi-fold R 2.5 (0.4W/m2K) insulated shutter and refractor, which is automatically operated responding to the intensity of the sun. The stainless steel surface of the shutter, when it is folded, reflects the sunlight to increase heat gain of the wall when it is needed, and when it is not needed it is closed to reflect summer heat.

Disconnected from city water, well water is used for domestic water demand, as well as space cooling for some parts of the house, especially for the bedrooms on tropical nights. Air conditioning is the primary cooling system with the major demand in the Japanese climate for dehumidification.

To provide good wind passages for either heated nor cooled season, casement windows are used for windows on east, north and west to provide both small window area and free flowing air passages.

Energy performance

The heating energy demand is reduced to 26% compared to a house with same floor plan and insulated according to 1999 building code of Japan (12% compared to 1992 building code). The houses under '92 building code are not heated whole house or whole winter, so this comparison makes no sense.

Total energy demand is reduced to 59% (40% compared to '92 building code)

Heating of space and ventilation air: 12.1 kWh/m²
Domestic hot water: 8.9 kWh/m²
(Energy source: Kerosene,
monitored total 22.2 kWh/m²)
Cooling of space and ventilation air: 10.8 kWh/m²
(Energy source: Electricity, COP 3.0,
monitored 4.5 kWh/m²)
Fans and pumps: 2.2 kWh/m²
Lights and appliances: 36.9 kWh/m²
(Energy source: Electricity,
monitored total 40.9 kWh/m²)
Total calculated energy demand: 70.9 kWh/m²
(Total monitored 69.6 kWh/m²)

•Degree Day (20-12) for heating : 1940
•Degree Day (18-18) for heating: 1840
•Degree Day (24-24) for cooling: -199

Planning tools

Energy demand simulation by SMASH and EESLISM.

Costs and benefits

The cost of the house is approximately 340,000 Euro, including costs for solar systems and other energy saving techniques. This is estimated 8-10% more expensive than a same house assumed to be built according to 1999 Japanese building code.

Innovative products

Space heating and DHW

Hybrid solar house system “AMATELAS”:

http://www.chiryuheater.jp

Envelope

Cellulose insulation: http://www.chiryuheater.jp

Windows: http://www.andersenwindows.com

Project team

Architect: Okamoto Yasuo (Chiryu Heater)

Contractor solar: Chiryu Heater

Builder: Kyowa Kensetsu

Contact person

Okamoto Yasuo(ChiryuHeater)
okamoto@chiryuheater.jp
Anyone in Chiryu Heater
office@chiryuheater.jp

A ZERO ENERGY HOUSE
（a low energy house with PV system） in

Kanagawa, Japan

International Energy Agency

IEA – SHC Task 28 / ECBCS Annex 38:

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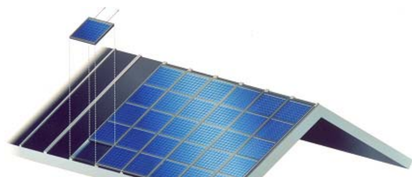


Roof integrated PV system

Section	*Insulation Spec.*
WALL	PALC80mm + GW125mm
FLOOR	GW100mm
ROOF	GW150mm
WINDOW	AL+Plastic sash Triple glazed

Building Spec.

Total Floor area : 228.56 m^2

U values : Wall 0.38 W/Km^2

Roof 0.48 W/Km^2

Floor1.00W/Km^2

Window 2.55 W/Km^2

Total equivalent leakage area : 891 cm^2

Heat loss coefficient : 441.1W/K

The project

This house was built at Kanagawa pref. (near Tokyo) as a zero energy house. The building is a single-family house private development. The Zero Energy House (named Hybrid-Z), was developed through technology and the experience accumulated by Misawa Home, who are a housing developer that specializes in this kind of development.

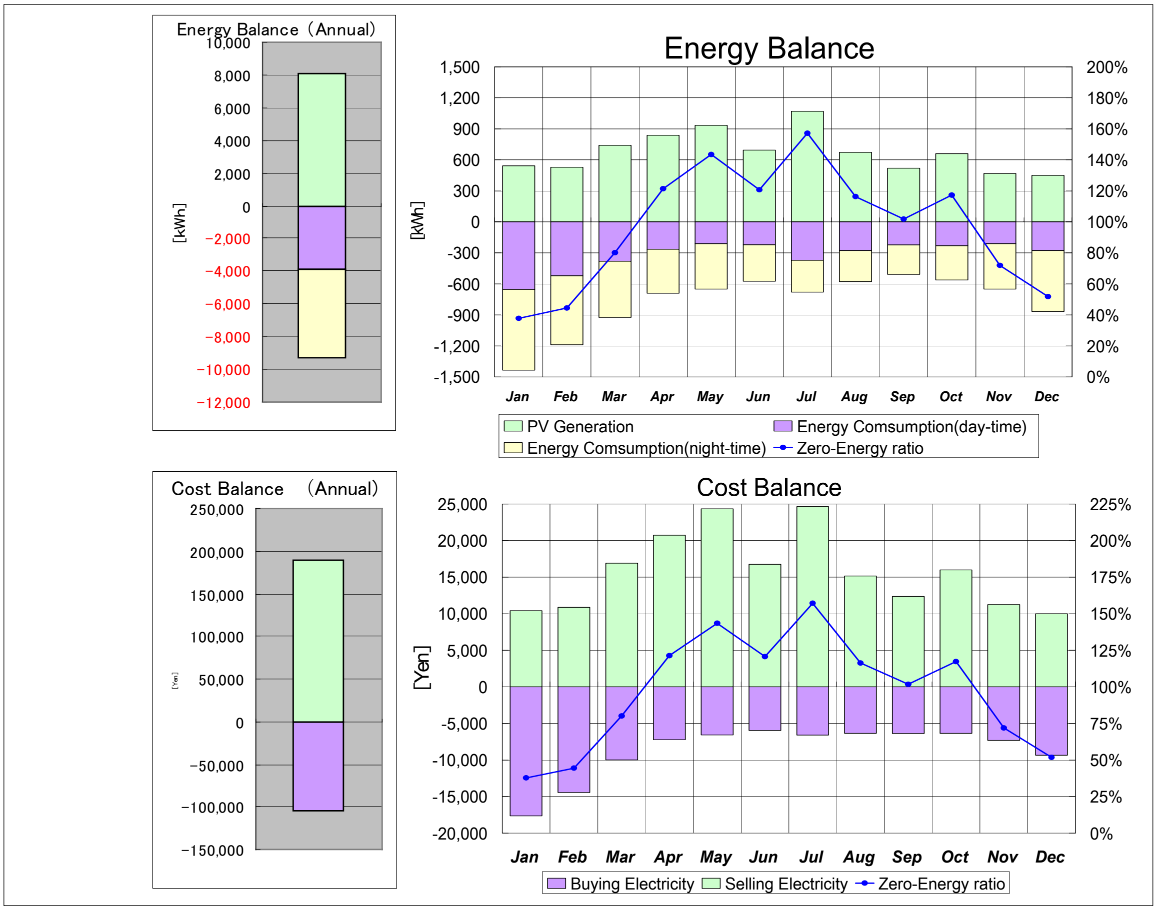
Objectives - Goals

The main goal for the home was to create a comfortable living space with a low energy demand. It is impossible to enjoy comfortable indoor life through all seasons due to Japanese climate condition without some technological intervention. Misawa Homes to ensure that a development has a energy demand close to zero by the adoption of energy saving technology and reduction of energy consumption. We define this house as "Zero Energy House". The home aims to not be reliant on external sources of energy from, for example, gas and oil. This means supplying energy required for living by renewable sources of energy such as photovoltaic power generating system.

The photovoltaic power generating system can produce the energy equivalent to consumption energy. The photovoltaic power generating system should not be the only solution, we should also seek to reduce our consumption. Improvement of thermal insulation performance and the design of a home that reduces energy consumption of the air conditioning is important. Using high efficiency products for air conditioning, water supply and kitchen reduces consumption of energy in this home also. It is necessary, however, that this technology is at a reasonable price for wide spread use. Therefore an affordable price is a main goal for the project. After considering all the factors, "Zero Energy House" is designed and built by Misawa Home.

Building construction

The outer wall covering of this house, Hybrid Z, which is a laminated wall of 234mm thick based on new ceramics (PALC) of 80mm thick, wraps around the whole house. Windows, which have great thermal loss, employ triple glass sash, which improves thermal insulation and air-tightness of housing itself. Realizing a house that is naturally kept cool in summer and warm in winter positively serves to suppress excessive energy consumption in air conditioning.



Technical systems

The PV system on the roof of this house has a 11.3kW value over all (east side:5.2kW, west side :6.1kW). This is made of reinforced glass surface and crystallized silicon has a high durability, and never causes harmful substance or noise in generating power. When the electricity generated by photovoltaic power generation system is in excess of energy consumed in the house, surplus electricity is automatically sold to power companies. It is the very ideal system in terms of environmental preservation as well as for enriched living. Energy-saving technology such as this is the base for realizing zero-energy homes,. Further energy-saving technology, for example in the air conditioning, is provided by a heat pump system and the COP is over 3.0, in hot water supply, the hot-water is heated during the night to benefit from lower electricity costsand reduces power consumption at the day-time at peak-cost. In kitchens, IH portable cooking heater is adopted with thermal efficiency as high as 90% and less waste heat, contributing to improvement of efficiency of equipment.

Energy performance

Actual data that makes reference to the energy performance of this house are shown in the above figures. The energy consumption of this house is 8,500kWh/year whereas the PV generation is 8,000kWh/year. The PV generation, therefore, covers 94% of the consumption.

(Electricity)

Heating	1,600kWh
Cooling	1,200kWh
Domestic hot water	2,100kWh
Lighting and appliances	4,000kWh
Total	8,900kWh

Costs

This house was subsidized from New Energy Foundation in accordance with the subsidy program for residential PV system. The subsidy ratio of this program is 1/3 in the total installation cost. In result, the total additional cost compared to a reference standard house is 7 million yen, and the saving running cost is about 300,000yen per year.

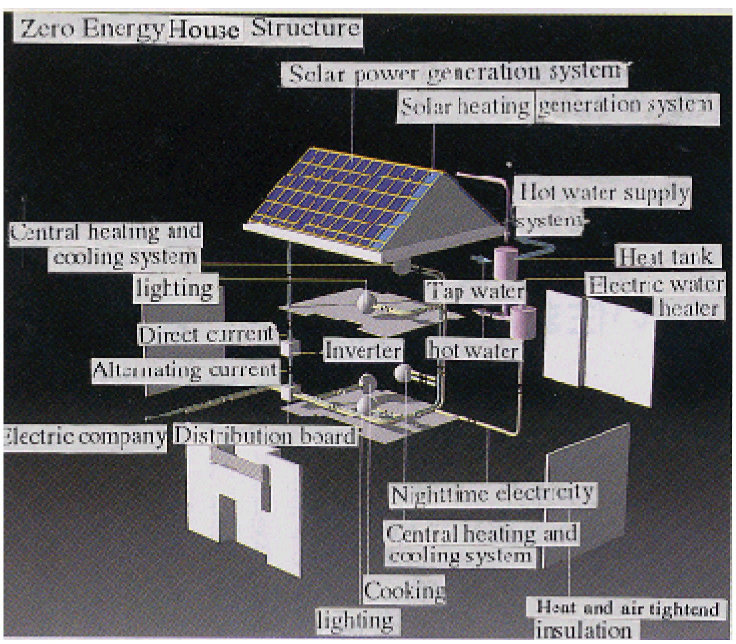
Planning tools for LCA, energy performance, solar energy design and more

Air conditioning load calculation software "SMASH"

Parametric analysis method (PV generation)

Marketing strategy

Hybrid-Z, which satisfies basic condition of "Photovoltaic power generation system all over the roof" "High thermal insulation" and "Equipment with high efficiency", was authorized as the first zero-energy house by the Institute for Building Environment and Energy Conservation (IBEC).



Direct current electricity generated by the solar power generation sysytem is converted to alternating current by the inverter.

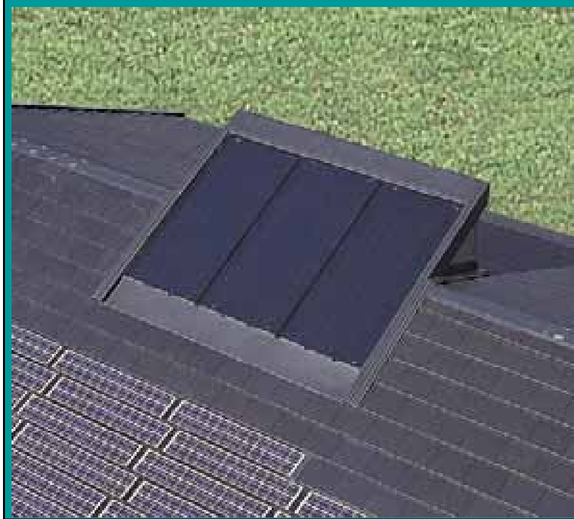
Equipments in the house are all high-performance ones and can utilize the solar power.

Other information

H Ida,I Ohta(Misawa Homes Institute of R&D co.,Ltd); "Zero Energy Home" ,ECO DESIGN 2001 in Tokyo

KankyoKobo,

Sunny Eco-House



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IEA – SCH Task 28 / ECBCS Annex 38:

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Floor plans (Total floor area:150.35m^2)

The project “Kankyo Kobo”
-Single family house with two stories
-Date of completion: April 1st 2000
-Total floor area: 117.90–167.47m^2
-Private built house and Ready-built house
-Number of houses sold:
 (Apr 2000 through Sep 2002)

Objectives

“Protect the environment” is now vital to every human being on Earth. Daiwa House, as a housing company, proposes a solution to the matter.

Improving energy efficiency, utilizing natural energy, and making the most use of natural resources was our policy when we developed our Eco-house, Kankyo Kobo.

1. Improving energy efficiency

Kankyo Kobo, with highly efficient performance for insulation and air tightness, satisfies the Japanese Housing Energy Efficiency Standards established by the Ministry of Land, Infrastructure and Transport, so-called “Next Generation Standards” in force since April 2002.

It has potential to reduce the CO_2 emission by 58.6% compared to the houses built in accordance with the Housing Loan Corporation standards, one of the requirements for the loan.

2. Utilizing the natural energy.

To utilize natural energy effectively, Kankyo Kobo is equipped with solar cell and solar collector.

3. Making the most use of natural resources

The water reclaim system is adopted to reduce the use of clean water. The reclaimed graywater is used for toilet flushing and garden sprinklers.

The kitchen unit is designed to facilitate the classification and storage of the recyclable items.

Although ecology conscious housing is usually expensive, we developed this prefabricated house, Kankyo Kobo, and realized and affordably priced Eco-house.

In addition, a drastic reduction of volatile organic compounds (VOCs) has been achieved. With its barrier free design, Kankyo Kobo supports the health and a comfortable life.

Building construction

Industrialized house

Kankyo Kobo is a prefabricated house, a structure with a high and stable quality formed with steel frames and proof stress panels. All the panel frames, exterior wall materials, heat insulating materials, and window sash frames are preset in the factory.

Painting exterior walls is also carried out in the factory in order to avoid the possible air pollution to the surroundings.

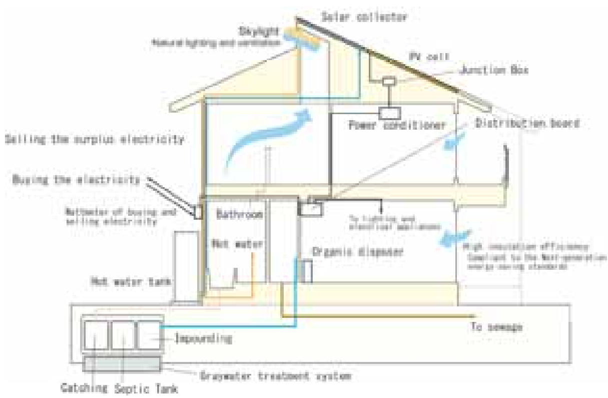
The air tightness is improved by binding panels with highly efficient bolts and by patching sheets and taping scrupulously.

Light gauge steel is used for the frames, ceramics for the exterior walls, highly efficient glass wool for heat insulating materials.

In cold districts, a greater amount of insulating materials are utilized to improve the efficacy.

Longer eaves prevent the fierce sunlight of summer and reduce the energy for air-conditioning. The rays of sunlight in winter can shine into the rooms and heighten the effectiveness of heating.

Kankyo Kobo satisfies “the Next Generation Standards” in every district of Japan.



System and material spec

		Districts IV & V		District III		District II	
		Material/System	K-Value	Material/System	K-Value	Material/System	K-Value
Roof/Ceiling		Blow-forming cellulosic fiber(25kg type), t=160	0.24	Blow-forming cellulosic fiber(25kg type, t=160)	0.24	Blow-forming cellulosic fiber(25kg type, t=200)	0.19
Exterior walls	General	High efficiency glass wall (16kg type), t=72	0.59	High efficiency glass wall (16kg type), t=100	0.45	High efficiency glass wall (16kg type), t=100	0.45
	Between floors	Hard polyurethane foam t=20	1.00	Hard polyurethane foam t=20	0.88	Hard polyurethane foam t=20	0.88
Flooring	General	Polystyrene foam sheet (B3),t=62	0.51	Polystyrene foam sheet (B3),t=62	0.51	Polystyrene foam sheet (B3),t=62	0.51
						Hard polyurethane foam t=80	0.34
	Tatami	Polystyrene foam sheet (B3),t=45	0.52	Polystyrene foam sheet (B3),t=45	0.52	Polystyrene foam sheet (B3),t=45	0.52
						Hard polyurethane foam t=80	0.30
	Unit bath	Hard polyurethane foam t=10	1.46	Hard polyurethane foam t=10	1.46	Hard polyurethane foam t=10	1.46
Aperture	Window	High adiathermic air-tight sash	2.91	High adiathermic air-tight sash	2.91	Resin sash	2.33
		High adiathermic double-glazing glass (A12)		High adiathermic double-glazing glass (A12)		High adiathermic double-glazing glass (A12)	
	Front hall door	adiabatic door	2.33	adiabatic door	2.33	adiabatic door	2.33
	Back door	adiabatic door	2.91	adiabatic door	2.91	adiabatic door	2.33
Ventilating system		New-VAC system		New-VAC system		PAC system	
Heating system		Connecting sleeves & outlet for air conditioner in each room		Connecting sleeves & outlet for air conditioner in each room		Central hot water heating	
Air tight works		Patching sheets, taping & etc.		Patching sheets, taping & etc.		Patching sheets, taping, airtight outlet & etc.	
Insulation efficiency (Q-value) heat loss coefficient: W/m2K		2.37		2.21		Polystyrene foam sheet: 1.74 Hard polyurethane foam: 1.68	
(Next Generation Standards)		(2.70)		(2.40)		(1.90)	
Insolation shielding efficiency (μ)		0.07 and below		0.07 and below		0.08 and below	
(Next Generation Standards)		(0.07 and below)		(0.07 and below)		(0.08 and below)	
Air tightness efficiency: C-value cm2/m2		5.00		5.00		2.00	
(Next Generation Standards)		(5.00 and below)		(5.00 and below)		(2.00 and below)	

Disctrict II: Cold districts, District III: Coldish districts, Districts IV & V: Temperate districts

Technical systems

-Ventilation
Variable Air Control (VAC) System:
Standard model (III IV V on the list above)

Ecology conscious ventilation system with the convergence control. Inspiration grill which opens and shuts censoring the atmospheric temperature change adjusts the air intake.

Photocatalytic Air Cleaning (PAC) System:
Cold district model (II)

In cold districts, PAC is introduced. It heats the outside air up to the indoor temperature before intaking. The system holds down the heat loss.

Common device

Motor operated air-cleaning louver is installed in the monitor roof.

-Energy saving devices

Window glass

There are the three types of glass, heat-sealed high adiathermic double glazing glass, high adiathermic double glazing glass and double glazing glass. The one best suited to the climate of the location and the direction of the windows will be chosen.

Window sash

Resin framed sashes for the cold district (II), and High adiathermic sashes for the other districts (III, IV, V)

Doors Adiabatic doors

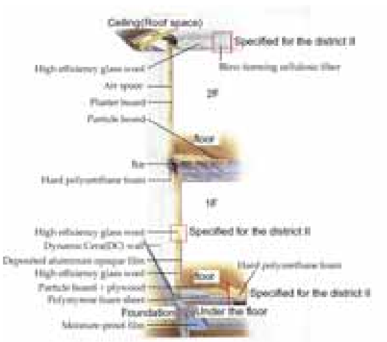
High adiathermic doors (k=2.33)

Lighting apparatus

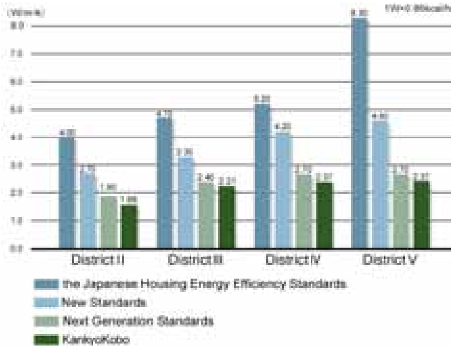
Inverter lighting is used in corridors to reduce the electricity.

Automatic lighting system is introduced on the porch. The light is switched on by a censor that perceives a human approaching.

Energy saving performance



Insulating material



Comparison of heat loss coefficient

Energy performances

- Solar energy generation

PV cells are a hybrid type of monocrystal and amorphous. Conversion efficiency is favorable of 17.3%, and decrease of power generation by heat is suppressed. Loading capacity is 3.00kw. Exterior appearance is designed to go well with the plain roof tiles.

At night, when the solar power cannot be obtained, electricity is bought from the power company. Surplus energy can be sold to the company.

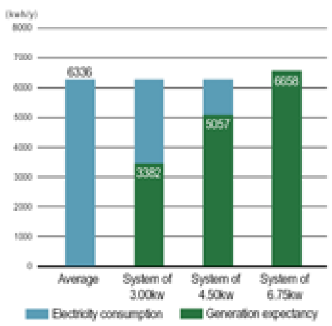
With the system of 3.00kw, annual production of electricity is estimated at 3,382kw. At the same time, the average electricity consumption of a general household is 6,336kw a year. 53% of consumption will be generated domestically. (Simulation model: Average family of 4, Total floor space of 150 m^2, in Osaka)

An indoor monitor shows the power generation to raise the residents' awareness.

-Solar collector

Hot water from the solar collector with controlled circulation system is potable and can be supplied to 3 to 4 feeders, contrary to the natural circulation system.

Solar utilization reduces the annual consumption of gas by 54%.



Annual average electric power consumption and generation expectancy

Solar collector and hot water supply

Recycling of graywater

Recycling facilities

-Recycling of graywater

Rainfall and discharged water from the bath tub are decontaminated and utilized for toilet flushing and water spray for plants in the garden or for car washing. This recycling of water can reduce the use of clean water by 200 liters per day.

Costs

¥ 25,220,000 (150.35 m^2)
¥ 167,700 /m^2

Without solar system
¥ 21,268,000 (150.35 m^2)
¥ 141,400 /m^2

Marketing strategy

Kankyo Kobo is not an idealized prototype of a solar house, but an industrialized house with an affordable price. It supports the residents' healthy and comfortable eco-life with solar energy utilization, graywater recycling, and garbage recycling and with the devices to make life easier.

Housing with energy saving efficiency or a solar system can be the object of an extra-loan from the Housing Loan Corporation. In addition, the New Energy Foundation supplies the subsidy to the energy generated by solar power, ¥100,000 per kw with the limit of 10kw (April 2002 through March 2003).

These advantages are a part of our marketing strategy.

Other information

Daiwa House Industry Co., Ltd., Japan
3-5, 3-chome,Umeda,Kita-ku,Osaka 530-8241 JAPAN
Phone:(06)6342-1402 Fax:(06)6342-1591
http://www.daiwahouse.co.jp/

A low energy house with
(1)all heat exchange type central air conditioning ventilation systems,
(2)passive solar,
(3)the photovoltaic system.

Kyoto, Japan

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

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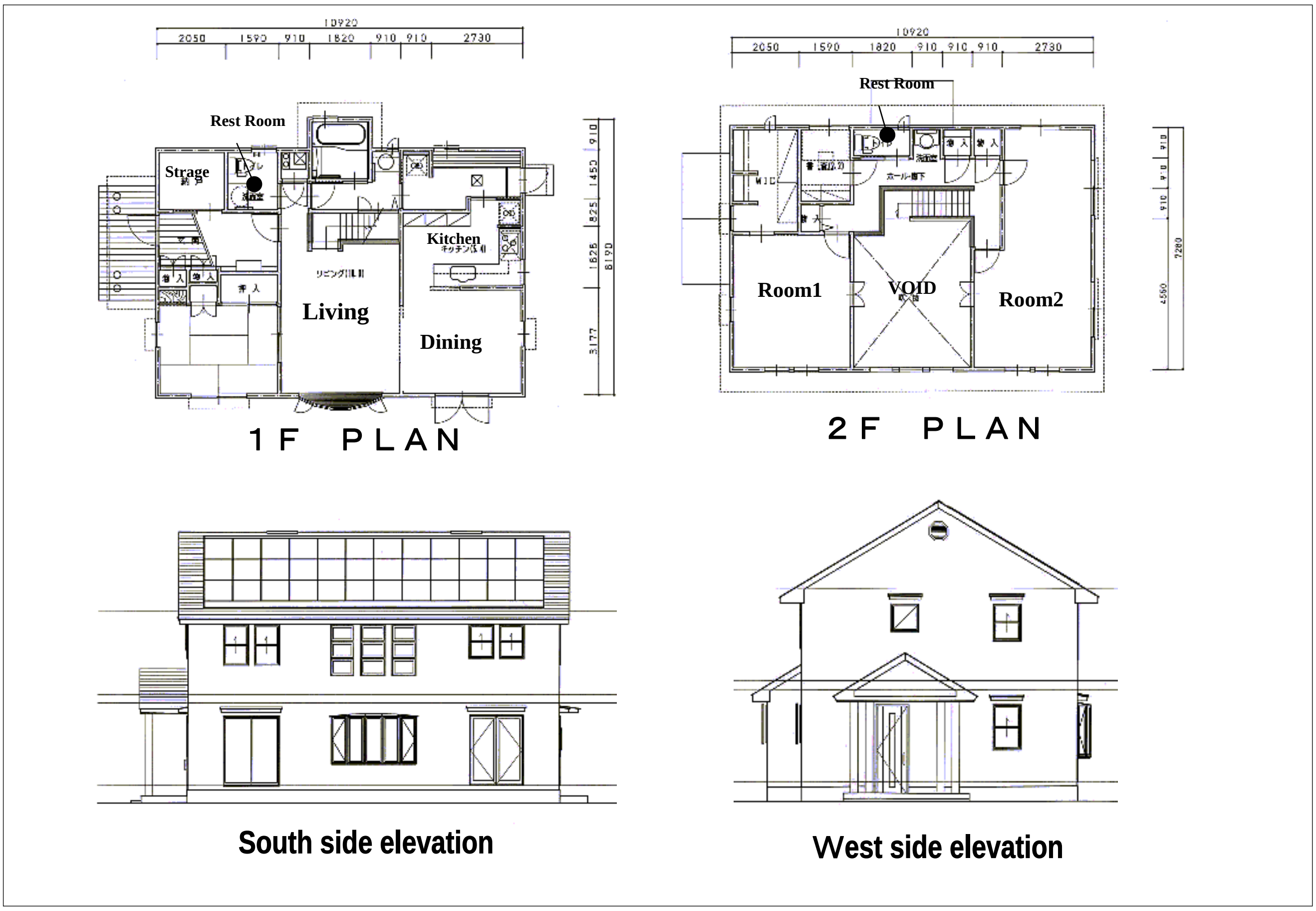


The project

This residence is built in Kyoto. Kyoto is an area where it becomes 35 degrees C of maximum temperature in a summer, and thelowest temperature becomes 0 degree C in winter. It is a residential section and is the site where there is no high building in the circumference, and on the south and the west sides serve as a road. In order to employ the condition efficiently effectively, "the passive solar system of a direct gain system" is adopted.

The number of these residences is two and the floor of living and a dining room is a thermal storage floor. the upper part of living serves as a big well Since the large opening is taken in the well upper part, solar heat can fully be taken in to the back of living in winter. Moreover, as for the second floor portion, the device to which the first floor portion does not put in direct solar heat indoors in a summer by planting of the yard is given by eaves. And reflection of the solar heat to the first floor is suppressed by planting many plants in the yard on the south. About the western opening, the influence of the solar heat from the west side of a summer is suppressed by making a opening small as much as possible.

Objectives - Goals

By consuming much energy, our old life has acquired convenience. However, the increasing energy consumption has given the serious damage to earth environment. We are asked selecting the compact life style, which does not apply load to environment. It is using energy for it without futility and maintaining convenience with the least possible energy. The residence introduced here is the example which adopted all heat exchange type central air conditioning ventilation systems, passive solar, and the photovoltaic system, and just mitigated the damage to earth environment.

Building construction

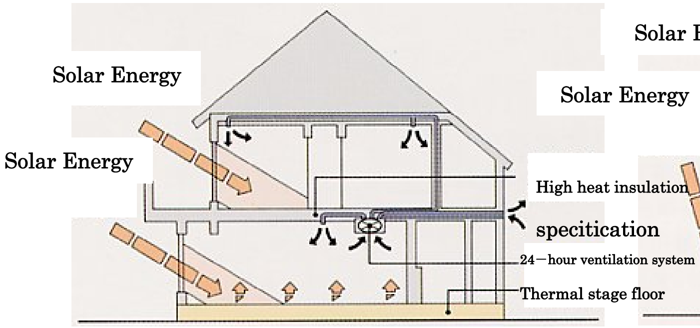
This residence is two-by-four structure. Two-by-four structure is the method of construction which was excellent in heat insulation nature and air-tightness from the first.

However,the heat insulation performance is raised as follows.

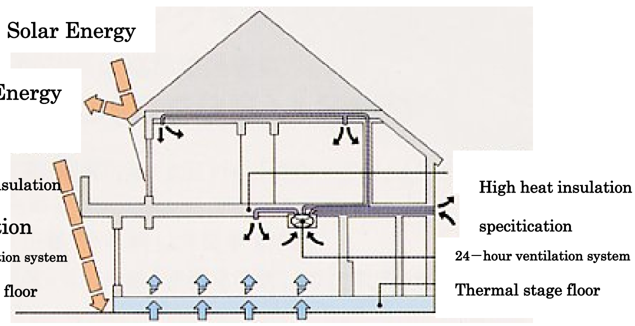
In order to acquire the thermal storage effect of solar heat effectively, heat insulation and the airtight performance of a residence are becoming important. In the heat loss coefficient [Q value] of this residence, 1.6W/ m^2K and the equivalent leakage area [C value] serve as 3cm^2/m^2.

Heat insulation Performance

Heat insulation part	Thermal insulation	Thickness	[Kvalue]
Ceilling	Rock wool	180mm	0.23[W/m²·K]
Out wall	Rock wool	90mm	0.50[W/m²·K]
Floor	Polystyrene form (the bead mothod)	90mm	0.44[W/m²·K]
Thermal strage floor	Polystyrene form (the pushing-out mothod)	50mm	0.45[W/m²·K]
Opening	Aluminum sash (double-glazed glass)	—	3.49[W/m²·K]



Winter



Summer

Technical systems

In winter, a passive solar system accumulates the solar heat which goes indoors at daytime in the thermal storage floor of concrete. A thermal storage floor heats a floor with the heat slowly at night. Work like a natural floor heater is carried out. Conversely, in a summer, direct solar heat is made for eaves not to enter indoors.

An indoor temperature rise is suppressed by doing so. There are few energy losses and they fill the inside of a residence with adopting all heat exchange type central air conditioning ventilation systems with clean air. In this residence, since it is considering as the system of air conditioning one apparatus, comfortable nature with few differences of temperature in a residence has been realized. Moreover, photovoltaic system 4.53kW is installed in this residence. That is, the solar blessing will have been acquired from passivity and active both sides. This residence is an all electrification residence which adopted the electric induction heater and the electric warm water machine, and provides all energies electrically.

Energy performance

(1)Winter temperature measurement result

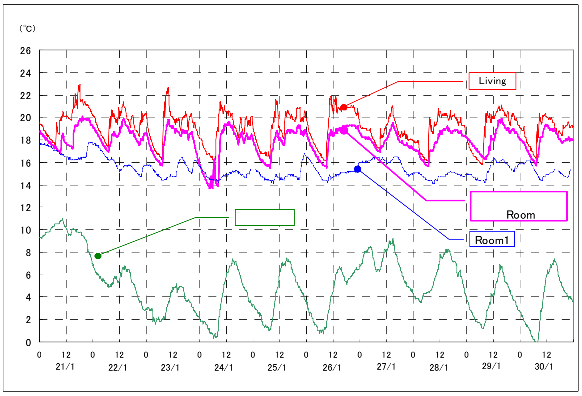
The living into which, as for winter, solar heat goes is over 20 degrees C daytime. There is no necessity of heating most night. The Japanese-style room is 18 degrees C - 20 degrees C under the influence of living daytime. It is not heated like [a Japanese-style room] living most night. The main bedroom is made into the setting temperature of 15 degrees C. Although heating is hardly used through one day, the extreme temperature fall is not produced.

(2)Summer temperature measurement result

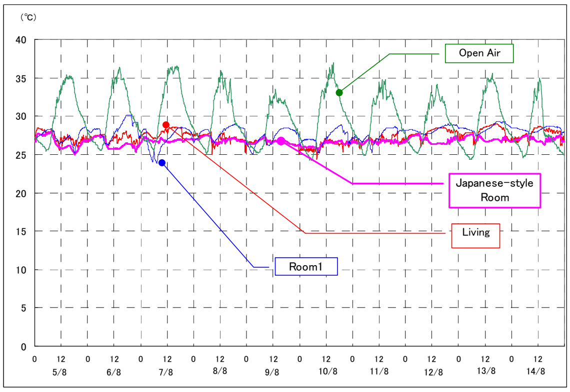
Since solar heat is covered well, there is no necessity of making air conditioning temperature low extremely. The temperature of each room is 25 degrees C - about 28 degrees C.

(3)The amount of photovoltaic system power generation

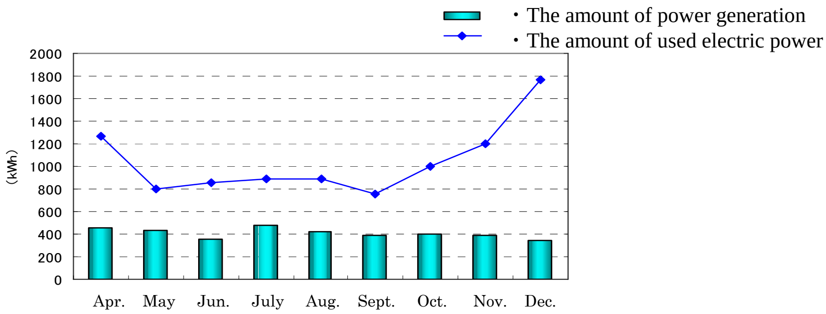
Since on the south is opened wide and sunlight can fully be obtained, about 400kW has been generated constantly every month. 3690kW of about about 90000 yen is generated in the sum total in April - December. The abbreviation half is provided in May - September with little electric use by power generation of a photovoltaic system.



Temperature of a winter



Temperature of a summer



The amount of photovoltaic system power generation

Costs

The expense, which starts when these systems are carried, is as follows. It costs 1,800,000 yen to carry a whole building air-conditioning ventilation system. It costs 3,300,000 yen to carry photovoltaic. It costs 450,000 yen to carry a passive solar system. It costs 250,000 yen with the difference that changes a gas hot-water supply machine and a gas range into electrical machinery. Sum total expense changes to 5,800,000 yen.

Planning tools for LCA, energy performance, solar energy design and more

Special tools and analyses done for the building.

Marketing strategy

By the ability of a resident to use the subsidy obtained by carrying these system , we are raising the rate of system loading.

The subsidy of the "residence and building efficient energy system introduction promotion base enterprise" of NEDO (New Energy and Industrial Technology Development Organization) is received for a passive solar system, a central air conditioning ventilation system, an IH cooking heater, and housing heat insulation strengthening. A subsidy frame is 1/3 of the expense concerning the object system, and changes to about 1,200,000 yen in this residence.

Other information

These systems are studied at the MITSUBISHI Estate home – Comfortable air research institute.

Common text about Task 28

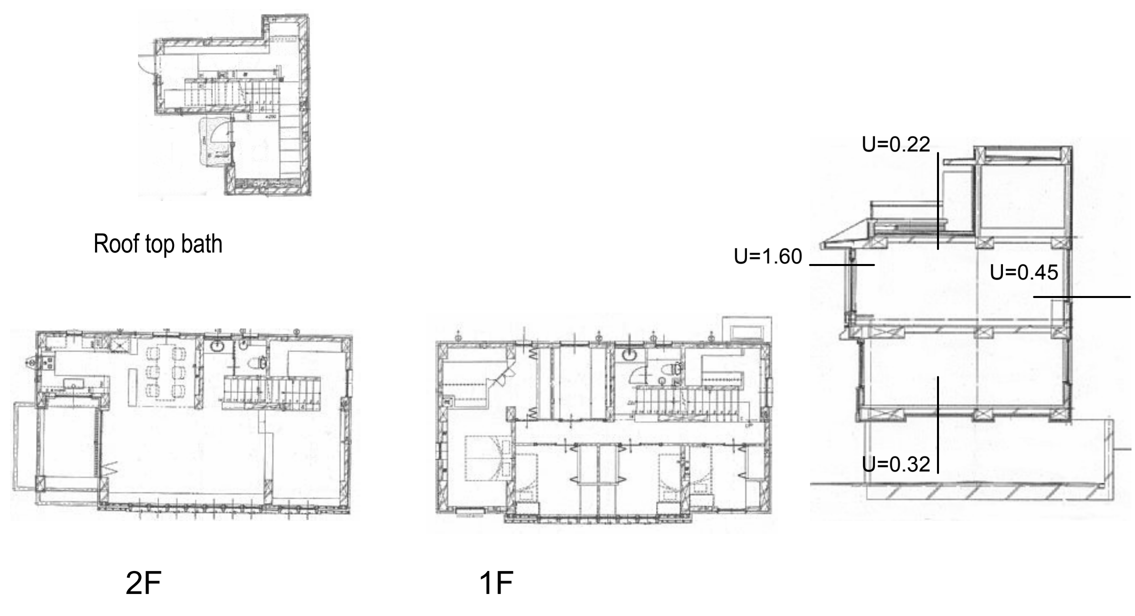
www.iea-shc.org **www.ecbcs.org**

Okayama, Japan

International Energy Agency

IEA – SHC Task 28 / ECBCS Annex 38:

Sustainable Solar Housing



The project

This single-family house is in the suburb of Okayama, on the beautiful bank of Asahi River, overlooking clear water flow and reedy marsh. The project finished in February 2003.

Total floor area is 233m2.

Objectives

Low energy demand, with good and stabilized indoor climate, is the main target of this project.

A solar water heater is used for DHW demand including hot water for a roof-top bath to enjoy a Japanese dream to take bath under the starlight, looking over the river and city lights far beyond.

Marketing strategy

The owners often open their house for people interested in the new home, to educate and to highlight the importance of heating the whole house through the winter, of which most Japanese homes have not benefited from in the past.

Building construction

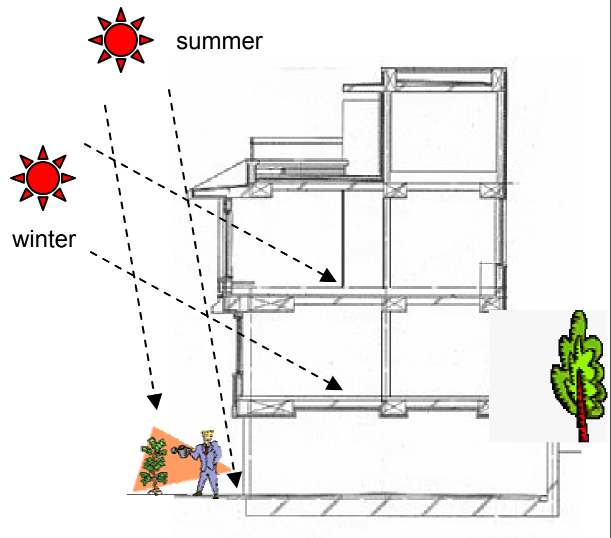
The building is constructed by reinforced concrete so as to benefit from thermal mass inside the insulation envelope.

Windows : Dual pane, low emission coated, argon gas filled, wood framed. Overall U-value is 1.64 w/m2K

Wall: Foamed polystyrene (50mm, R 1.79 m2K/w) over 150mm concrete. U-value 0.45.

Floor: Foamed polystyrene (75mm, R 2.68 m2K/w) over 200mm concrete. U-value 0.32.

Roof: Foamed polystyrene (115mm, R 4.11 m2K/w) over 200mm concrete. U-value 0.22.



Technical systems

South facing window area is optimized by calculation, to maximize winter solar gain and minimize heat loss.

Eaves are carefully designed considering solar position for each season, as illustrated above.

Concrete structure inside the insulation envelope is, coated with plaster, naked and exposed to the room temperature to maximize the heat absorption in the daytime.

8 m2 of solar collectors are installed on the roof for solar water heating with 370 liter storage tank.

Auxiliary heating is by radiant floor heating installed in the 2nd and 3rd floor and in the roof top bathroom as well.

Energy performance

The auxiliary heat demand is calculated for 3 cases.

A: This demonstration building.

B: Building with same plan but has insulation according to 1999 Japanese building code.

C: Building with same plan but has insulation according to 1992 Japanese building code.

The heating energy demand:
A: 27.4 kW/m2, while B 63.4 kW/m2

The DHW energy demand:
A: 6.4 kW/m2, while B 22.4 kW/m2

The cooling energy demand:
A: 17.5 kW/m2, while B 17.1 kW/m2

Pumps and fans
A: 2.2 kW/m2, while B 5.3 kW/m2

Lights and appliances
A: 36.8 kW/m2, while B 36.8 kW/m2

Total energy demand:
A: 90.3 kW/m2, while B 145.0 kW/m2

The heating energy demand and the total energy demand for C is calculated to be 134.6 kW/m2 and 203.2 kW/m2, but buildings according to 1992 building code is not heated whole house, so the comparison has no reality at all.

Degree Day(20-12) for heating : 1866
Degree Day(18-18) for heating: 1822
Degree Day(24-24) for cooling: -240

Planning tools
Energy performance calculation tool
SMASH

Costs and benefits
The extra costs for energy concept, taking into account reduced costs for heating and solar hot water system, is 13,000 EURO, compared to the same building with 1999 building code and without solar water heater.

Innovative products
Solar water heater: http://www.chiryuheater.jp/

Financing
The subsidy of the New Energy and Industrial Technology Development Organization(NEDO) partly assisted.

Project team
Architect: Uno Tdahide
Solar water heater: Chiryu Heater
Builder: Okayama Komuten co.,ltd.

Contact person
Info@kinarinoie.com

A Sustainable Solar House with OM Solar System in Hamamatsu, Japan

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing

www.iea.shc.org

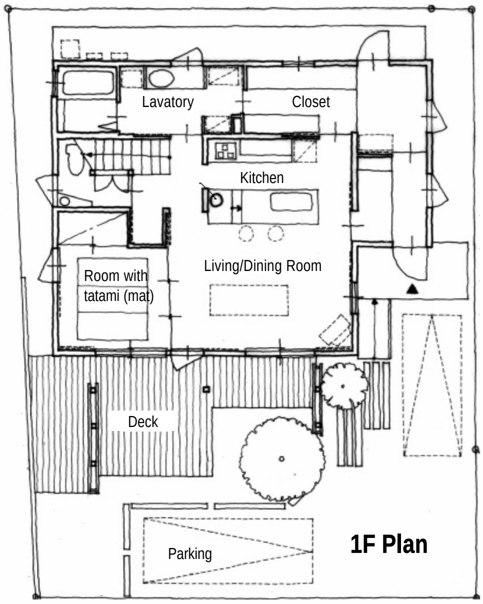
www.ecbcs.org

The project

This house was built at Hamamatsu of Shizuoka Pref. in the fall of 2002. It is a prefabricated house (named Volks Haus -ProjectA) equipped with the OM Solar system. Volks Haus are a concept and an aim that is completely different from those of prefabricated houses offered by Japan's home manufacturers. The fundamental idea of Volks Haus is to use a wide space as effectively as possible before dividing it into rooms, hall, etc. This is different from building houses from a finished floor plan. The plywood used for structure is left in its original state to form the inner walls. The ceilings and the floor of the second floor are also left in the original state of laminated wood and plywood. This method can be called an exposed wood method, from its resemblance to the exposed concrete method.

The body of Volks Haus is built of prefabricated posts and beams that are joined by metal joints. Insulated panels are fitted in between posts. These panel serve as braces. Because it uses metal joints instead of traditional joints, the house can be put together without conventional skill. The project has been applied to more than 3,000 homes and the OM Solar system has been used in more than 20,000 homes.

Southern view of the house

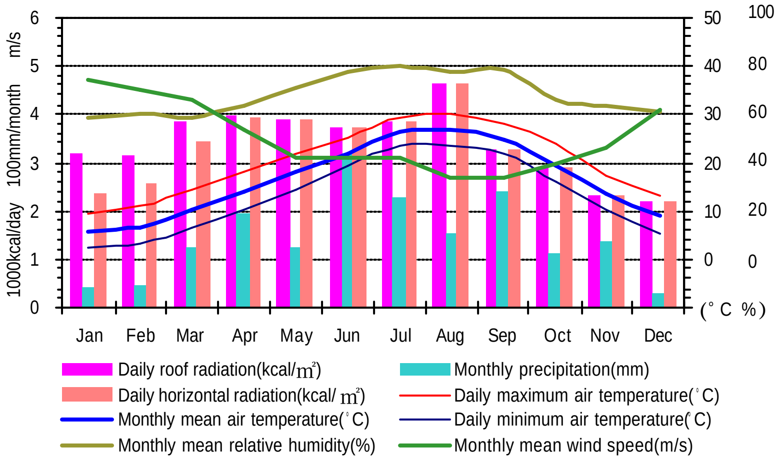


Design concept of the house

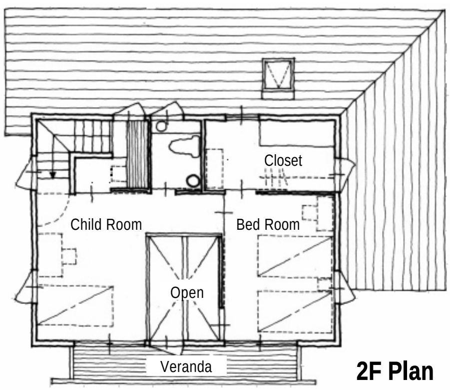
The house was ordered by a three-person family. The husband was a salary man in age of 35 and his child was a three-month-old boy. Since married, the couple was living in an apartment. After their son was born, they hoped to build a theirs own home with their savings.

The house was aimed to be designed based on the following points.

- Employ the OM Solar system to create a comfortable living space by using the solar heat.
- Externals of the building are well-matched with the wooden deck and planting.
- Built of wood and internal walls are finished with plaster.
- The kitchen is the center of the home and Island-shaped.
- The living room is integrated with the deck.



Annual meteorological data for Hamamatsu



Climatic conditions of the location (Hamamatsu)

Hamamatsu is located in the central middle part of Japan (N34°42', L137°43 '), where heating is required for five months from November to April. Because the daily sum of horizontal solar radiation exceeds 2000kcal/m^{2}day in these months, the effect of the OM Solar heating can be expected in the heating-required months.

Solar system Specification

Glass-covered heat-collector: $16m^2$
Metals heat collector: $11m^2$
Under-floor storage: $64m^2$
Volume of fresh air supply:
$600m^3/h$ (during heating / cooling)
Hot water tank: 300liter

Building Specification

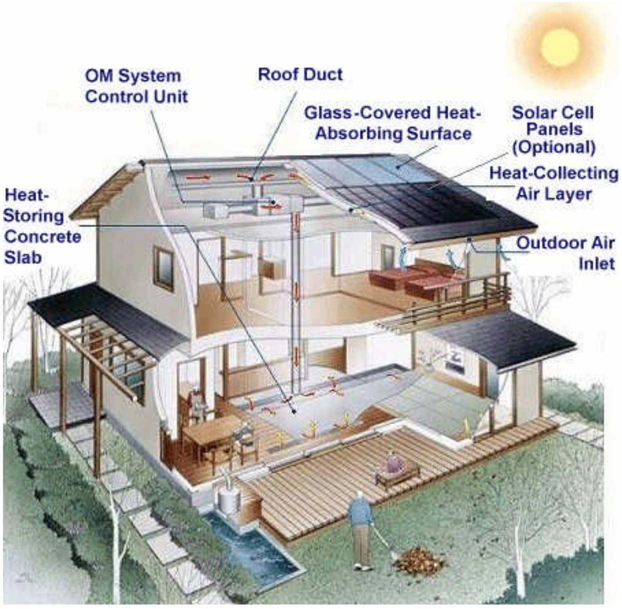
Total floor area: $116m^2$
K values: Roof 0.31W/Km^2
Wall 0.59W/Km^2
Floor 1.85W/Km^2
Window 3.49W/Km^2
Total equivalent leakage area: $2.4cm^2/m^2$
Heat loss coefficient: 2.71W/Km^2

Section	***Insulation Specification***
Roof	Polystyrene foam 98mm
Wall	Polystyrene foam 50mm
Floor	Polystyrene foam 25mm
Window	Wooden sash, Double glazed

Technical systems

The OM Solar system operates on the principle of taking solar-heated air collected under the surface of a building's roof and channeling this hot air, via an interior vertical duct, down beneath the ground floor to a heat-storing concrete slab. This concrete slab warms the ground floor and releases hot air through floor vents for distribution throughout the building's interior spaces. Auxiliary devices come into operation for hot water supply and for backup heating on overcast or very cold days.

When external air exceeds a certain temperature, hot air collected under the roof's surface is expelled through an exhaust duct located directly under the roof without being circulated through the interior spaces.



The OM Solar system on a sunny winter day

The underfloor concrete slab, which as pure thermal mass saves heat in winter for release at night and on cloudy days, also serves to cool the house in summer by releasing, during the high-temperature daytime hours, the coolness it accumulates during the low-temperature nighttime hours.

Heat balance in an OM Solar house comprises three factors: heat collection, heat storage and insulation/air-tightness. Insulation and air-tightness are especially critical factors in providing energy-efficient and comfortable living conditions during winter, yet completely sealed structures are to be avoided because of the need for regular ventilation. A key feature of the OM Solar system is that it provides home occupants with continuous fresh air circulation.

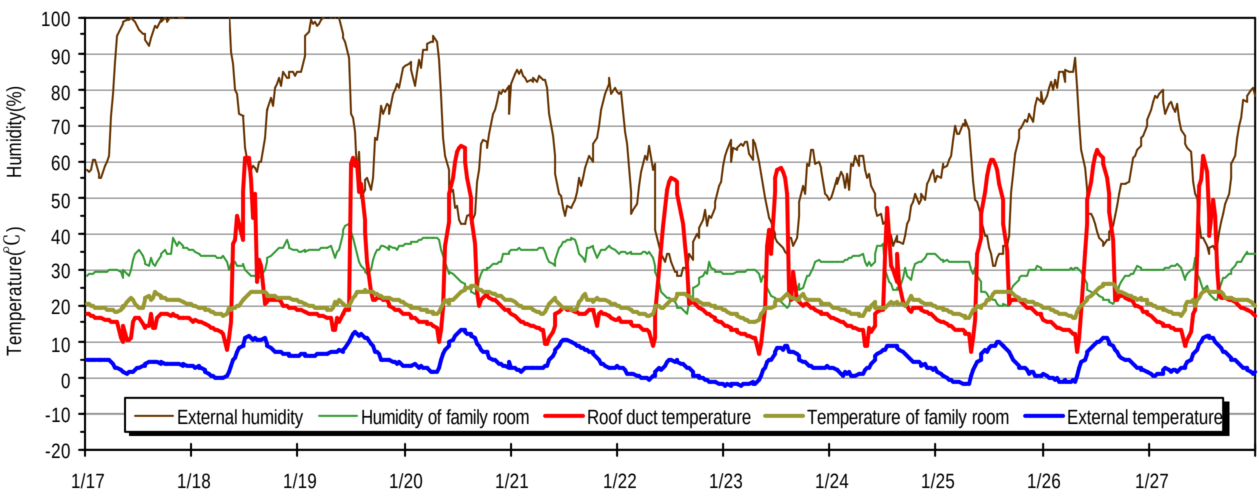
Planning tools for solar energy design, energy and thermal performance

OM computer simulation software "SunsonsV5" is used to design an OM Solar house before construction and the software was authorized as an heating/cooling load calculation software by the Institute for Building Environment and Energy Conservation (IBEC), Japan.

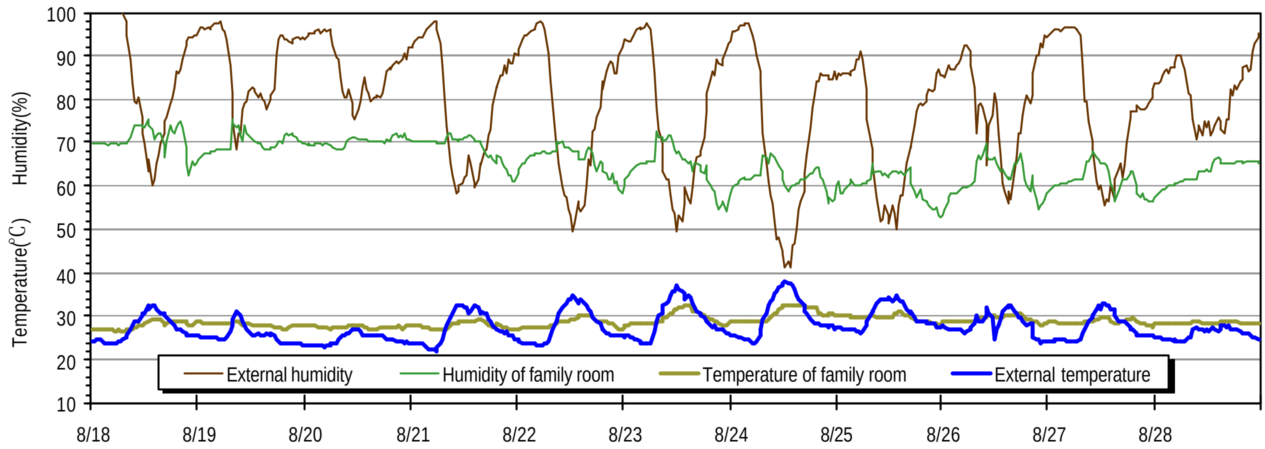
Thermal performance of the house

As shown in the top of the next page, on a clod day (Jan. 23) an outdoor morning temperature of -2℃ gradually rose to a high of 8.5℃. The daytime temperature of the OM Solar heating air reached 60℃ or so. As a result, indoor temperature was maintained at 15℃ in the morning and rose to a high temperature of 23℃. On a cloudy day as Jan. 21, although the solar heat was not obtained, the room temperature was kept above 17℃. Note that this data was recorded in the coldest month for the year 2004.

On the other hand, the data collected in summer is also indicated in the middle of the next page. The difference between daytime and nighttime outdoor temperatures was more than 12℃. Under these conditions, the most effective way to maintain a comfortable interior temperature is to shut out external heat during the day by keeping the windows closed, and then to open the windows at night and/or bring external cool air into the interior through OM Solar system operation. On a hot day as Aug. 24, daytime outdoor temperature exceeded 35℃, while nighttime temperature dropped to 24℃. The room temperature was maintained at between 29℃ to 32℃ during the day long without resorting to an air conditioner.



Monitored data for a 11-day period in winter 2004



Monitored data for a 11-day period in summer 2003

Energy performance

The calculated heating load of the house for a year is given in the following table. It shows that 59% of the annual heating energy can be supplied by the solar heat (OM Solar system). An actual data of energy performance for a year is also listed in the following table. As an auxiliary heating system, a kerosene stove was used in this house. The gas was not used. The kerosene consumption for heating energy during a winter-period(Nov. 2002 to Mar. 2003) is about 548L that is equivalent to 3651Mcal(31.5Mcal/m^2).

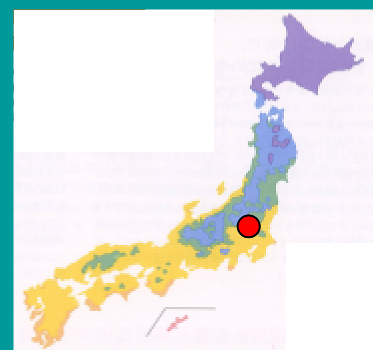
Heating load calculated OM computer simulation software "SunsonsV5"

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Year	Ratio
OM Heating(Mcal)	419	543	513	474	739	505	3193	59%
Auxilairy Heating(Mcal)	0	387	930	731	153	19	2220	41%

Energy consumption recorded for a year from Nov. 2002 to Oct. 2003

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Year
Kerosene(L)	40	133	140	156	79	0	0	0	0	0	0	0	548
Electricity(kWh)	477	457	612	611	604	577	475	539	552	659	675	526	6764
Water(m^3)	24	23	23	20	22	23	24	25	25	27	29	29	294

OM Solar Association
4601 Murakushi-cho, Hamamatsu, Shizuoka Prefecture , 431-1207 JAPAN
Phone:(053)-488-1700 FAX:(053)-488-1701 http://www.omsolar.net/



Example of a Prefabricated House with Solar Power Generation System

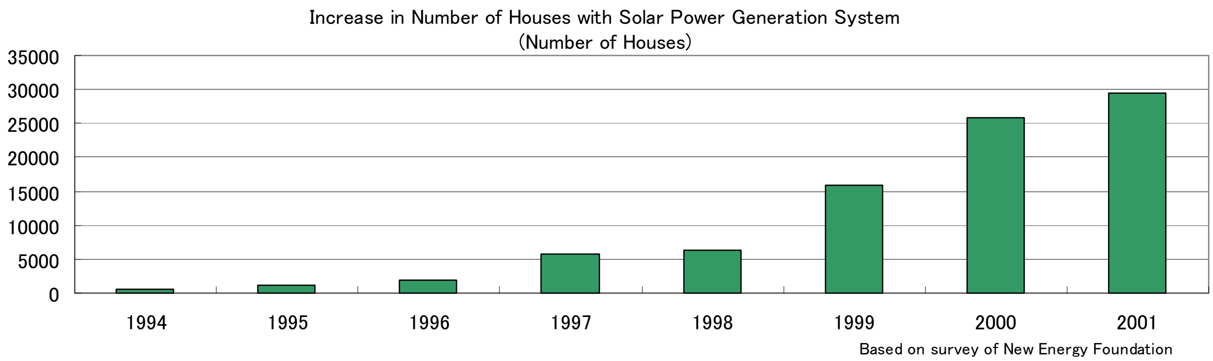
International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

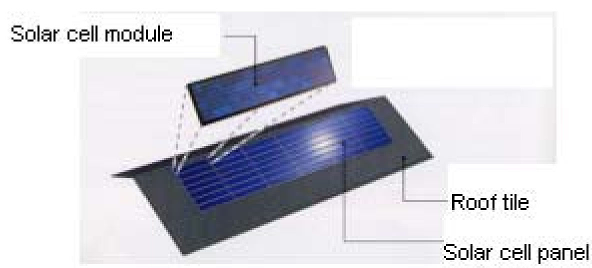
Sustainable Solar Housing

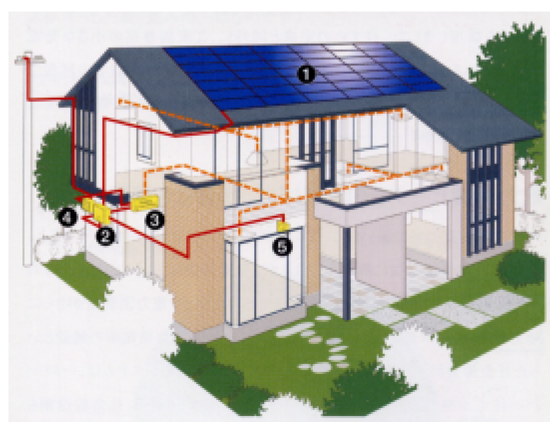
The project and the Objectives - Goals

The number of households using a solar power generation system in Japan has rapidly increased in the last three to four years. This trend is due to the expanded coverage of the solar power subsidy, more widespread buying by electric power companies of electricity generated by each household which is surplus to needs (hereafter referred to as “electricity sales”), and mainly due to increased consumer awareness about the importance of generating clean energy in their homes.



The solar power system consists mainly of a solar cell module and a power conditioner.Since the solar cell module used here doubles as the roofing material, it blends well with the entire building design as well as the street appearance. Furthermore, as no additional roofing material is required, the cost is lower in comparison with conventional solar cells. The direct current generated by the solar cell module built into the roof flows through the power conditioner, and after being converted to alternating current as used in general households, is distributed from the panel board to each electric appliance in the house. Since the system operates automatically (it starts operating when it receives sunlight and stops when there is no sunlight), no human intervention is required. The amount of electricity being generated and the total amount of electricity generated each month can be checked on the indoor remote control monitor. The system also comes with an environmental monitor function that indicates the amount of CO_2 emissions reduced by solar power generation, thus giving the user a sense of satisfaction about using solar power.





①Solar cell module
②Power conditioner
③Panel board
④Integrating wattmeter
⑤Indoor remote control monitor

First floor

Second floor

1.Entrance hall
2.Japanese-style room
3.Living and Dining room
4.Kitchen
5.Utility room
6.Laundry room
7.Bathroom
8.Toilet room
9.Nursery
10.Bedroom
11. Balcony
12.Stockroom
13. Toilet room

Building construction

◆Building overview:
Address: Maebashi, Gunma Prefecture
Total floor area: 165.9 m^2
◆System overview:
Solar power generation system 3.46 KW type
Cooling system: Air-conditioner
Heating system: Air-conditioner and kerosene fan heater
Exhaust ventilation system: Third method of ventilation
◆Heat insulator specifications:
Q value: 2.2 W/m^2K
C value: 5 cm/ m^2
Ceiling: Glass wool insulating material 10K 200 mm
External wall: Glass wool insulating material 16K 100 mm
Floor: Polystyrene beaded foam No. Ⅰ 94 mm
Window: Heat-insulating aluminum sash and low-E glass(heat-ulating)

South Elevation

West Elevation

Technical systems

This home, completed in 2000 and located in a residential district in Maebashi, Gunma Prefecture, is fitted with a power generation system using sunlight. Solar power is a clean source of energy, and unlike oil and coal, is inexhaustible and does not produce CO2 emissions. The home was built with many factory-prefabricated members which were then assembled at site. In recent years, house manufacturers such as ourselves who sell and build prefabricated houses have been playing a leading role in encouraging the replacement of the solar power system that must be installed on top of the roof, with roofing material that has built-in solar cells, both for improving roof designs and reducing the cost.

Marketing strategy

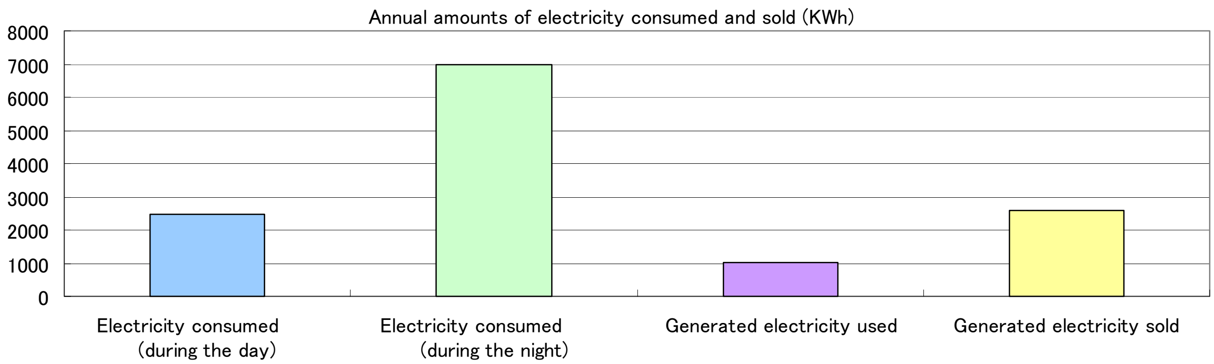
This two-story home, with a total floor area of 165.9m2, is built with light-gage steel. Out of the total construction cost of approximately 30,000,000 yen the solar power system cost approximately 2,460,000 yen of which a loan of 500,000 yen was provided by NEF (New Energy Foundation). The heat insulator specifications meet the next-generation's energy saving criteria (Region III) and an entire building ventilation system was adopted.

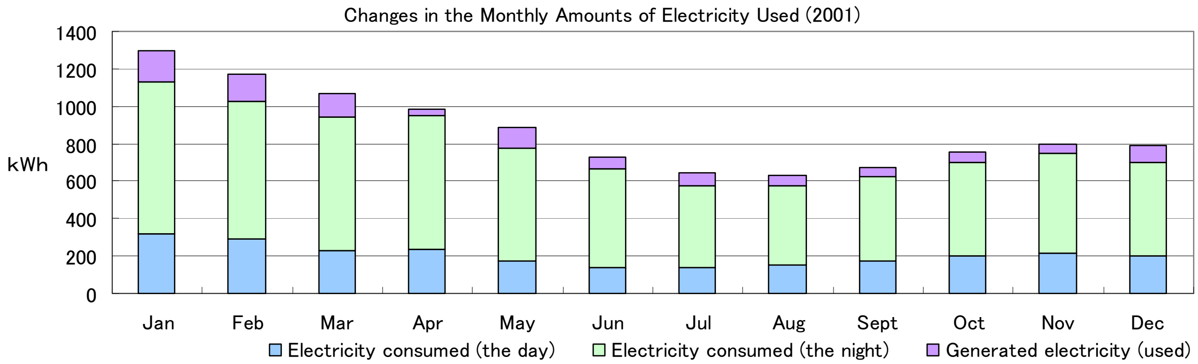
The amount of electricity generated by the solar power system during the day usually exceeds the amount of electricity used (see the figure below). For promoting wider application of solar power generation, a system is now in place to sell surplus electricity to electric power companies (electricity sales). (During nighttime hours, however, electricity is bought from electric power companies as usual.)

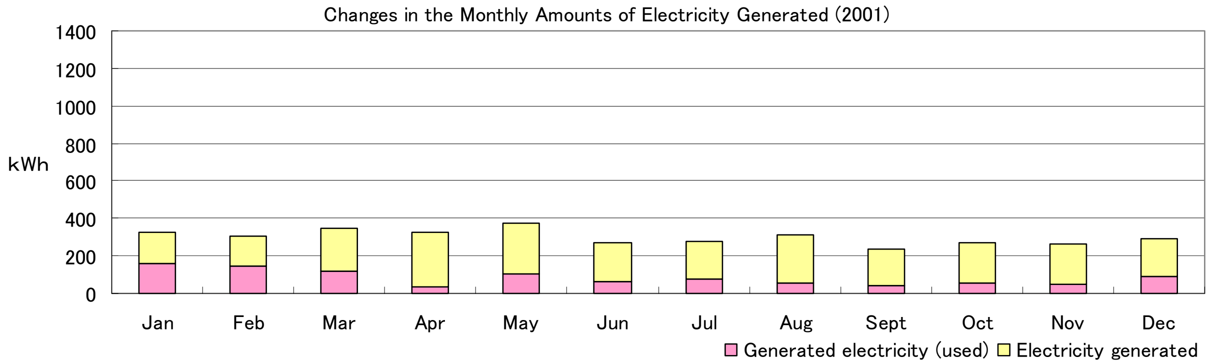
Energy performance

Since such selling and buying of electric power automatically take place at almost uniform selling and buying rates, the electricity generated by the house is directly reflected on the electricity bill. Since higher rates are applied when calculating electricity charges as the amount of electricity consumed increases, introducing the solar power system helps reduce not only the amount of electricity that must be bought from the utility company, but also the buying rate, thus producing synergistic effects in reducing the cost.

During a one-year period, this home, for example, used approximately 10,500 KW of power, of which 1,000 KW was generated by the house, and 2,500 KW of power was sold to the power company. This means that this household was approximately 33% self-sufficient in electricity. Degree Day(20-12) for heating : 2231,Degree Day(18-18) for heating: 2134,Degree Day(24-24) for cooling: -165







SEKISUIHOUSE,LTD. TOKYO TECHNOLOGY DEPATMENT
SHINJUKU MAYNDS TOWER. 1-1. YOYOGI 2-CHOME SHIBUYA-KU. TOKYO. 151-8070 JAPAN
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Waaldijk, Dalem
The Netherlands

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing

The project

Because of the river water coming down from the Rhine, the river dikes almost collapsed in 1995. So a special law was accepted to strengthen and raise the Dutch river dikes. Because of this, the inhabitants of an old house in Dalem, on the inside hang of the dike, lost their nice view over the Waal river, an old castle and the little old town on the other side. In the end they decided to build a new more comfortable private house on the same location, to give them back their magnificent view.

Besides this, due to a visit to a few passive solar houses in Germany, the new house had to be based on passive house technology. Because of the limited building volume (544 m³), the new house was build (2000) on piles in the dike.

Objectives

This had to be a house for the future, with easy access for elderly people, a so called lifecycle resistant dwelling, where they could live as long as possible in a comfortable and healthy way in combination with low costs for energy consumption and maintenance based on the energy efficient PassiveHouse technology.

Building construction

The light weight concrete main structure of the extended walls is covered with 300 mm EPS insulation and finished with a mineral plaster (u=0,115 W/m²K); insulated window frames, windows and doors (u=0,68 W/m²K), together with integrated sun shading systems in the large south and west facing windows; 300 mm EPS roof insulation (u=0,116 W/m²K) on the roof and 300 mm EPS insulation on the floor (u=0,113 W/m²K) make a perfect insulated envelope around the living areas of this passive house of which the exterior building connections are designed to avoid thermal bridges.

The living room, kitchen, bathroom and main bedroom are connected with the main entrance, which can be reached by a long walkway from the road on top of the dike. The living room and the kitchen have access to a transparent balcony and a steel and wood terrace structure; underneath the overhang of the main floor is space for car parking.

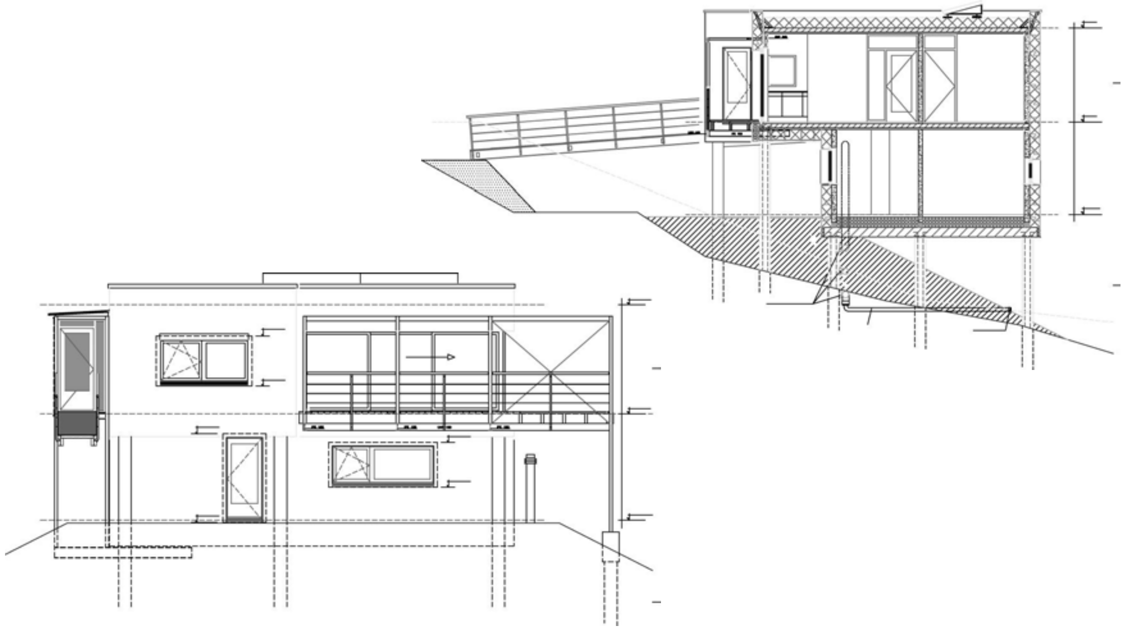
Technical systems

Through a horizontal earth heat exchanger of about 30 meters in the dike, fresh air flows into the ventilation and heating system which easily covers the total energy needed for space heating.

A system with heat recovery and auxiliary space heating using a water to air heat exchanger applied to the fresh air intake. And also the use 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.

This house was built as a pilot project by the Dutch Foundation of Passive House Holland. This foundation was formed to encourage the development and realization in Holland of the so-called ‘Zonhuizen’, special solar houses based on the passive house technology (already in use mainly in Germany and Austria) as one of the most promising energy concepts for the future.



The foundation was formed in 1998 by 8 companies in the building sector: 5 manufacturers, 1 installation company, 1 consultant in installations and building physics and 1 architect. After having completed two pilot-projects – 'Heilig Huisje' in Sliedrecht and this dike house in Dalem – the first major passive house project in the Netherlands is at this moment being built in Sliedrecht, for sale in the open market.

Energy performance
Because of the little compact shape of the house and the relative large exterior surface, due to being built on piles, this project didn't quite reach the passive house targets; and energy performances (current Dutch standards).

Reference calculations based on the EPC calculations, including assumption appliances:
EPC 1,0 (NL)

- Heating of space and ventilation air	89 kWh/m²a
- Domestic hot water	30
- Fans and pumps	15
- Lighting and appliances	79,7
Total primary energy demand	213,7kWh/m²a

EPC 0,47 (NL)
The annual primary energy demand based on EPC calculating:

- Heating of space and ventilation air	12,9 kWh/m²a
- Domestic hot water	13,4
- Fans and pumps	15
- Lighting and appliances (assumption)	79,7
Total primary energy demand	121,-kWh/m²a

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	25kWh/m²a
- Domestic hot water (solar energy covers 55% of the demand)	15,1
- Fans and pumps	18,9
- Lighting	11,7
- Appliances	48,0
Total primary energy demand	118,7kWh/m²a

First monitoring results 2001 – 2002, Passief Huis Dalem (BEC 13-01-03):

- Heating and space / vent.air	31 kWh/m²

- High appreciation, especially of the indoor climate conditions, by the occupants

Costs and benefits

Net building costs, including taxes: € 190.000,-, this makes the house, as compared to the reference standard of conventional houses, competitively priced. This first home in Holland based on the PasiveHouse technology was built without any financial support. The monitoring was financed by NOVEM (the Dutch national institute for energy and environment).

Project data

- net floor area 127m2
- heating volume 323m3
- building volume 544m3
- u-values
  - exterior walls 0,115 (W/m²K) 300 EPS 20
  - ground floor 0,113 " 300 EPS 20
  - roof construction 0,116 " 300 EPS 20
  - windows wood 0,68 " (insulated)
  - glazing triple Argon 0,60 "
- design 1998 – 1999
- realization 2000
- monitoring 2002 – 2004

Information and contactperson

Private principal - Mrs. v.Duyvenbode and Mrs. M. Ploegmakes

Architect (contactperson) - Franke Architekten BV (proj.arch. ir. Erik Franke)

Nijverheidsstraat 52

3371 XE Hardinxveld-Giessendam

tel.: 0031-184420170 fax.: 0031-184411908

email: franke.arch@hccnet.nl

Building, serv.,techn. - Aannemings bedrijf J.A.de Jager

Groot-Ammers

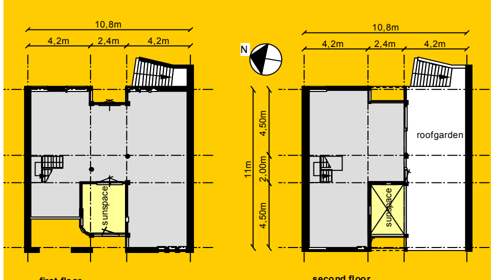
List of publications

- De Dordtenaar febr. 2001
- Bouwwereld nr. 4 / 01
- Tijdschrift leefomgeving nr. 1 / 01
- Home juni 2001

This house was one of the five, and the only privately owned, projects nominated for the prestigious national award for inspiring principals 2003 for the stimulation of architecture in the Netherlands.

Casco-zonnewoningen

Groenlo, the Netherlands



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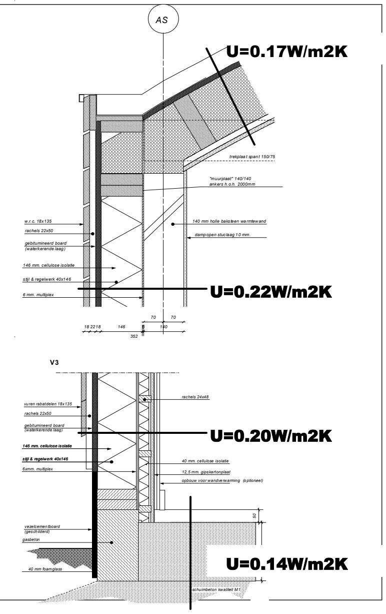

The project

The four buildings are designed as houses to live in and to work in. All four houses are different and could be partitioned to the inhabitants demands. The houses were designed to fit in perfectly in the landscape situated just ouside the centre of the small Dutch town of Groenlo, near the German border. A great deal of attention was put into sustainable aspects. Mostly recyclable and natural materials were used. Untreated wood was used on the outside and untreated tree trunks are used as support structures. Vegetation grows in the garden on the ground floor, but also on first floor level. Sustainable energy is provided by 70 m^2 of solar cells, which forms the roof of the communal parking space. A sun space is located in each house. This area shelters the entrance from weather conditions and pre-heats ventilation air. DHW is generated through an exhaust-air heat pump. A communal condencing boiler supplies the hot water for the low-temperature wall heating system.

Site description

The houses are situated in a semi-suburban setting. The location is just outside the centre of a small Dutch town, near the German border. The houses stand on a former agricultural plot and were designed to blend into its surroundings.

Building structure

The houses have a ground floor and a first floor. The entrance of the house is through a sun space covering the complete height of the building. The sun space serves as a wardrobe and provides in some houses access to the lavoratories. Except in one house the kitchen and main living quarters are situated on the first floor. The bedrooms, bathroom and office are located on the ground floor.

Building construction

The foundations are made of foamed concrete. The façades are constructed with a wooden skeleton with 140 mm cellulose insulation and extra insulation of 40 mm cellulose on the inside. The outside finishing is done in deal and red cedar. The inner walls are made of hollow bricks, for their low mass and for the in-wall heating. The first-level floor is made of wood with a floating cover floor. The roof is constructed of wood. The flat roof has 195 mm cellulose insulation and the arched roof 220 mm cellulose insulation. Roof covering is EPDM. The flat roof has vegetation.Only European wood was used. Depending on the load, deal, pine or Oregon pine was used.Swedish natural paint was used for the pine on the façade.

Technical systems

Ventilation:

The houses have a natural inlet of air. The inlet to the living quarters is mainly through the sun space, whereas the inlet in the sleeping quarters can additionally be done through direct openings to the outside. There is an automatic exhaust. Exhaust air is utilised by a heat pump for DHW.

This system was chosen as in such "natural houses" a mechanical system is completely out of place. The sun space yields direct energetic gain because of the natural ventilation.

energy supply system

Heating through a low-temperature wall system fed by a common high-efficient boiler. The boiler runs on natural gas.

The heat distribution between the houses is via a small common medium-temperature grid.

DHW through an electric heat-pump on the exhaust air.

solar energy utilization

70 m^2 solar panels (4200Wp)

Sun space over two floors for pre-heating of ventilation air. Inlets very low and complete in the top of the sun-space to prevent over heating. Restriction of amount of sun by horizontal shutters.

The sun space can very efficiently be thermally isolated from the house.

Ample daylight in all living quarters.

Energy performance

Total energy demand per house:	73,2kWh/m2y
Heating of space:	51.9kWh/m2/y
Pumps	4kWh/m2/y
Domestic hot water	
Ventilation	
Cooking	
Lighting and appliances:	17,3kWh/m2/y

Costs

Aprox.€ 300,- ex VAT/m3

Planning tools for LCA, energy performance, solar energy design and more

Dutch "EPN"-calculation: about 50% better than legal requirement

"New method 5000"

"Dywag" used only for the Novem report, see list of publications

Marketing strategy

The houses were developed in cooperation with the furure inhabitants

Further information

The project, that is finished in 2001, is an example of an integral design of ecological living and working with emphasis on sustainability and energy efficiency. To preserve the special features of the environment, the houses were designed using a landscaping scheme.

The four coupled houses were completed with very few internal walls. The internal divisions are done by the inhabitants and can be changed easily in the future, because they are not load-bearing.

The houses have possibilities for extensions (on the flat roof).

The space surrounding the houses is divided in three levels with decreasing level of privacy. They are the roof-top garden, the private garden on the front of the house and a communal garden surrounding the buildings.

Because the houses have a living room on the top floor, the roof-top garden is very well accessible.

Innovative products

Ventilation and cooling
Heat recovery unit:
Stiebel Eltron www.**stiebel**-eltron.nl

Electricity
Solar PV:
stroomwerk www.**stroomwerk**.nl

Space heating and DHW
Heat pump:
Stiebel Eltrum www.**stiebel**-eltron.nl

Design:
Architecture, landscape and installations:
Eva van Panhuys & Rob Bais architecten
Koninginneweg 10
2243HB Wassenaar NL
www.vanpanhuysbais.com

Construction:
Omnis Bouwadvies
Den Haag NL

Advice and coordination of the inhabitants:
Jaap van der Laan/ Stichting Ecologisch Bouwen
Bergambacht NL

Solar pv-system:
Stroomwerk
Deventer NL

Publications:

Novem report, januari 2004
Monitoring Casco serrewoningen in Groenlo by moBius consult, Driebergen

Novem report, november 2003
Casco zonnewoningen een evaluatie by van Panhuys & Bais architecten

Bouwwereld, nr.16 2002

Bouwwereld, nr.22 2002

Het houtblad, nr. 6 2002

Duurzaam Bouwen, nr. 8 2002

"Wohnbauten mit geringem Energieverbrauch", C. F. Müller Verlag , Caroline Hoffmann e.a. 2004

Rivierdijk, Sliedrecht
The Netherlands

International Energy Agency

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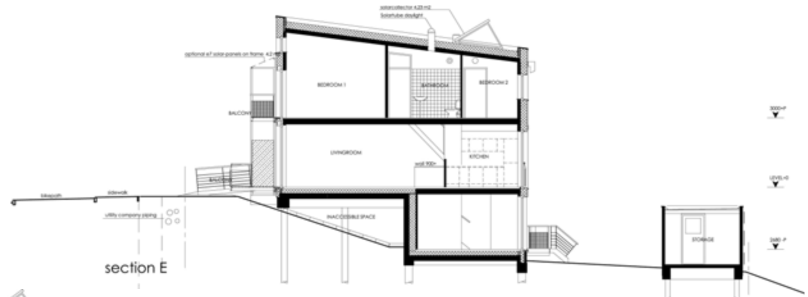
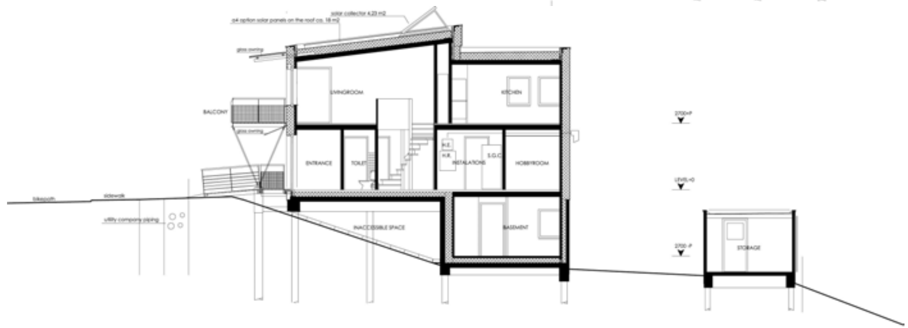
Sustainable Solar Housing



section E



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

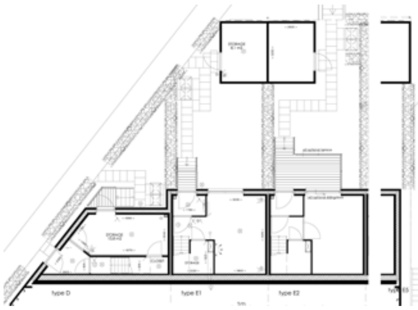
Technical systems
Controlled air supply and extraction with heat recovery: the heat recovery unit (WHR 950 J.E.STORKAIR with 100% bypass, 88% efficiency, PHI-Zertifikat), together with the F7 air filter box, the water-to-air supply air-heater unit and the gas-burning DHW system (high performance Solar 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.

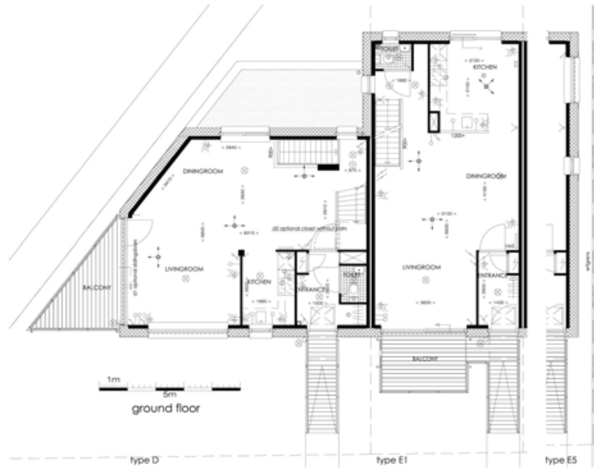
Energy performance
Primary energy consumption for heating and lighting. According to the Dutch standard NEN 5128 the primary energy consumption is : the total energy consumption of fossil fuels per year in MJ.

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 m² of the surface area is 6 kWh/m² 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 ηel = 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/m²a
- Domestic hot water	42,1
- HFns and pumps	14,9
- Lighting and appliances	50,9
Ttotal primary energy demand	195,5kWh/m²a

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/m²a
- Domestic hot water	20,1
- Fans and pumps	14,9
- Lighting and appliances (assumption)	50,9
Total primary energy demand	96,8kWh/m²a

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/m²a
-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/m²a

Costs and benefits
The calculated building costs turned out to be € 1.285,- / m² for the 12 solar houses. After the restricted tender, the real building contract was closed at € 1.153,- / m²; this means: the real costs € 132,- /m² for the 12 solar houses were more than 10% less than calculated. The calculating costs for the traditional Dutch reference houses were € 1.089,- / m² ; after the tender, the contract costs were € 1.101,-; so the 11 conventional houses + € 12,- / m² , 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

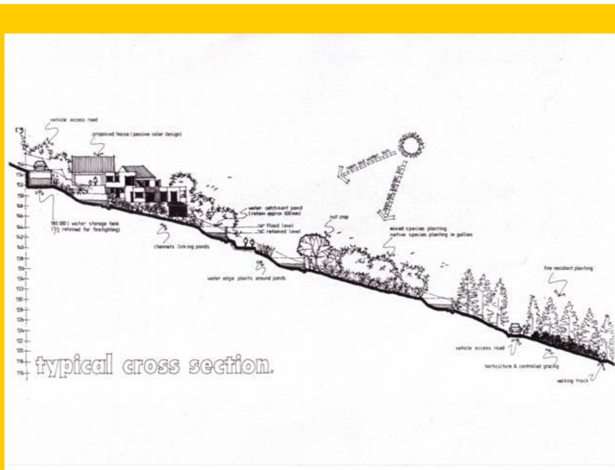
Developer	- Archidome Holland BV (proj.manager M.Bezem) Hardinxveld-Giessendam
Architect	- Franke Architekten BV (proj.arch. ir. E.Franke) Hardinxveld-Giessendam
Building, serv.,techn.	- Consultant installations and building physics J.P.v.der Weele BV, Groningen - Brouwer Energy Consultant BV, Apeldoorn - 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

Kakariki Lane
Christchurch

New Zealand



International Energy Agency

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The photo shows in red the development boundaries, in blue the storm water containment and distribution system and in yellow the existing and planned properties on the Kakariki site.

The project

• The Kakariki* Lane project consists of a small group of houses built on a 2.8ha steeply sloping (80m -170m elevation msl), north-west facing, originally bare erosion-prone urban site.

• The land is zoned by the City Plan for up to 26 houses. Instead, an eventual maximum of eight is intended – a decision based on minimising commuter travel, and providing a significant amount of open space around the houses for revegetation and recreational purposes

• Five houses have 1800m2 sites; three average around 650m2. All are detached dwellings, located on the upper part of the land. The entire site is being progressively planted, predominantly with native species. Stormwater is collected from houses and other impervious surfaces within and above the site, and redistributed within the boundaries of the site.

• The average house size is around 220m2, and they are all privately/self built, for individual family ownership. Three have a substantial passive solar content, two less so but still quite good. The remaining three planned houses will be to high standards. The variability between the houses relates mainly to the amount of thermal storage and insulation (including double glazing), which reflect individual owner preferences.

* 'Kakariki' is Maori for 'green'

• The site was purchased in 1984, and all design and development has been carried out cooperatively by the five owners/occupiers. It has a fairly large self-build content. Work on site commenced about that time; three houses have yet to be built.

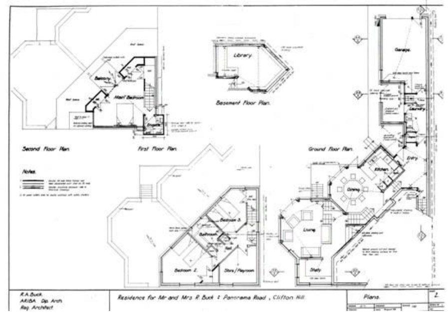
• Stormwater containment is achieved by a gravity drainage system that feeds at various levels into a 180,000 litre below ground tank (at the top of the site), four concrete dams of approximately 10,000litre capacity, and miscellaneous other storage providing a total capacity of around 250,000 litres. All these discharge by gravity into a piped system supplying some thirty overhead sprinklers which give a relatively uniform distribution of water over the lower half of the land. There is a choice of both source and discharge zones. The system is remotely operated from a single point, and allows for sources and discharge sectors to be selected as required.

Objectives

To:

• demonstrate the benefits of thoughtful environmental and building design, and to provide a comparison between this and the generally poor quality of both to be found elsewhere;

• minimise erosion, by planting extensively and by managing stormwater runoff;



• share all this with others – for example, the hillside is highly visible from other parts of the city, and the planting is intended to provide a relief from the bleak wall-to-wall housing so loved by the city planners

• introduce a generally beneficial microclimate, and a supportive habitat for plants and wildlife, and the results of this are now evident;

• provide a high quality of life for the residents, affordably, through cooperative effort;

• encourage other self-build groups to do the same;

• recognise elements of sustainability in regard to the houses through the permanence of the buildings (eg use of concrete, brick, stone) or their potential for partial recycling (eg reuse of timber), and their relatively low energy demand in use.

Building construction

• Despite this variability, all perform better, or much better, than contemporary dwellings because of their design. There is a very close correlation between temperature swings within these houses and the amount of thermal mass, as would be expected.

• House costs reflected the individual self-build content and design complexity, and varied between modest to average in terms of the prevailing construction rates; however, all houses are built into the ground to a significant extent, which added unusual costs and this offset some of the savings achieved elsewhere. Three of the sites were excavated simultaneously, along with much of the roading, and the costs of this were shared based on machine hours. This led to significant savings.

• Some of the road construction and surfacing, and much of the excavation for and laying of services made use of the group's own manual labour.

Building Construction

• All five houses have a predominance of glazing orientated towards solar north, the midday solar position in the southern hemisphere. Three of them have very high mass (using concrete), the other two have a reasonable amount. The three still to be built are expected to have high or very high amounts of thermal mass.

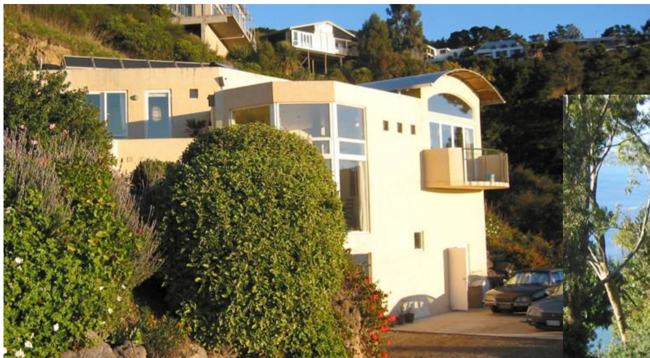
• Insulation levels were reasonable at the time of design by NZ standards (but relatively poor by international standards: houses range between R1.8 - 3.0 m^2°C/W (walls), R2.0 - 3.5 (roofs), R0.6 - 2.0 (floors) – these were individual owner-influenced decisions); three have double glazing throughout, two have less than 50%. Four have timber window frames, one has pvc. The three planned houses will have higher insulation levels and full double glazing.

Technical systems

All the houses use passive solar effects for space heating purposes, optimised by their design. One has a Stirling engine, used experimentally (it burns gas, which produces electricity and hot water); this same house has a heat recovery shower base. Another has a ducted air heat recovery system, taking warm air from the highest part of the house and circulating it under the ground slab of the lowest part. The three solar water-heating systems are pump assisted (two houses do not have solar hot water installations). All houses are grid-connected; waste water is piped to the city system (done today, on-site treatment would have been considered); potable water is obtained from the normal city supply.

Energy performance

Note that the New Zealand climate is mild, and rarely extreme. Christchurch has periodic relatively high temperatures, but this is usually associated with low humidity and light-to-moderate winds. Winter temperatures are relatively mild – the site microclimate (close to the ocean, north west facing and 26deg slope) means that sub-zero ground surface temperatures (ie frosts) are rare. Sunshine hours average more than 2,000hrs a year, and are spread fairly evenly through the seasons. These conditions make the job of using natural effects very easy: mechanical cooling is unnecessary, and heating loads can be greatly reduced by designing to use these natural effects efficiently.



None of the houses has been subject to a formal analysis of any type. Only one has been monitored. Energy used for all purposes by this house has varied according to occupation over twenty years, and has ranged from approximately 7,000kWhr/yr (two adults) to 12,000kWhr/yr (four adults). The entire house (240m2) is maintained continuously at comfortable temperatures, but it is zoned to have warmer living areas and cooler bedrooms. A trombe wall and conservatory are presently being added, and the effects of these will be measured. Most lights are now of the low-energy type.

Costs

Costs were comparable to, or below prevailing construction rates for flat site houses.

Innovative products

Structure

+ Polyblock walls and roof formwork (Supplier Insulform - www.insulform.co.nz/)

Ventilation and cooling
+ Entirely passive mechanisms: thermal mass; natural ventilation

Controls
+ Temperature control: Trombe wall, and conservatories

Space heating and DHW
+ WhisperGen - hot water (engine coolant) used for space heating (Supplier WhisperTech Ltd. - www.whispergen.com)

+ Heat recovery shower base - tempers incoming water (Canterbury University, Don Clucas)

+ Embedded electric wall heating ('Thermofloor' system - www.homeideas.co.nz/floor/thermofloorframe.htm)

Site Development

+ Water saving: All stormwater is retained - total capacity 250,000litres in tanks and dams - and is used for irrigation and as bushfire standby. Computer managed disposal system. Designers: Roger Buck (architect), Harman Halliday (civil and structural engineer), Simon Sloane (electronics engineer)

Planning tools

For the houses design was based on intuition, experience, and reference to/involvement with studies conducted, in particular, by Dr Alan Tucker (Canterbury University), and Dr. Breuer (NZERDC contract 3420).

For the development as a whole the aim was to create a comparatively benign urban environment using simple techniques that could be adopted readily by others. Principal amongst these were the on-site stormwater management, the provision of beneficial microclimates through the introduction of appropriate planting, and the construction of reasonably low-energy buildings. No particular planning tools were required for this as it is mostly common sense.

Other

No formal research has been conducted, and therefore no academic papers have been produced, but various articles have been written, and the development is occasionally visited by interested outside parties.

The project has been self-financed and managed by the owners – the site collectively and the houses individually. Three sites have been sold to outside parties, all known to members of the development group.

The low cost/affordability side of the development is obscured by the natural characteristics of the site which has views across the city to the mountains, and out over the Pacific Ocean. This adds a perception of value that is unrelated to the actual development costs. It is worth noting that, at the time of purchase by the group the site was regarded as too difficult to develop conventionally and its price reflected that.

Contact Person

Architect: Roger Buck, Roger Buck and Associates, PO Box 1232, Christchurch, NZ, bucrl@clear.net.nz (joint owner).

Project team: the group of five families.

Budstikka 18
Kongsberg, Norway

International Energy Agency

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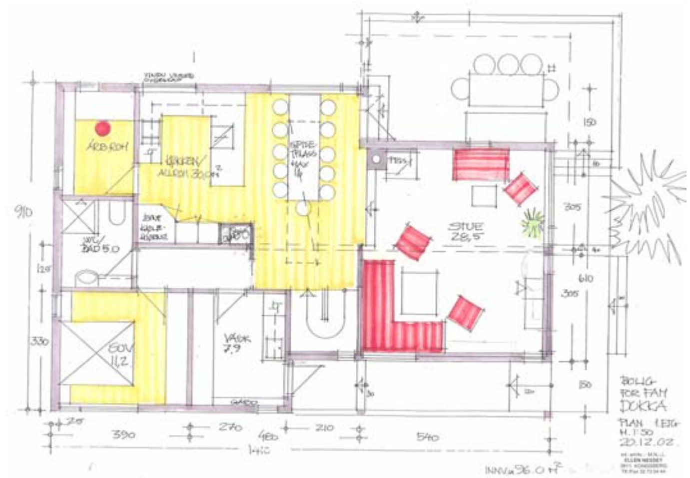


Plan of main floor.

The project

A single family house is being built in the central eastern part of Norway. The house is 300 m^2 including the main part, a small apartment for rent, and a home office. The construction will be completed during summer 2004.

The house is situated in a family friendly area with limited traffic. As many trees as possible are being kept on the site as part of the green design of the building.

Objectives

Low energy demand and low environmental impact has been focused from the start of the planning phase. Auxiliary energy demand should be less than half of average energy demand for the same type of houses built according to the Norwegian building code. The energy demand for room heating should be reduced with 75%. The climate is typical inland climate with low humidity, little wind, cold winters and fairly warm summers.

The energy design should also result in a robust and user friendly home with good indoor climate. The project should be cost effective in a way that make the concept interesting for other builders.

Building construction

Several measures will be carried out to improve the building envelope compared to normal building standard. All of these actions are optimized in the regard of energy and cost efficiency, and the total concept is crucial for the good result.

Windows are triple glazed with argon gas and two low emission coatings, wooden frame and a total U-value of 0.95 W/m^2K. Two large windows have krypton gas and a U-value of 0.85 W/m^2K.

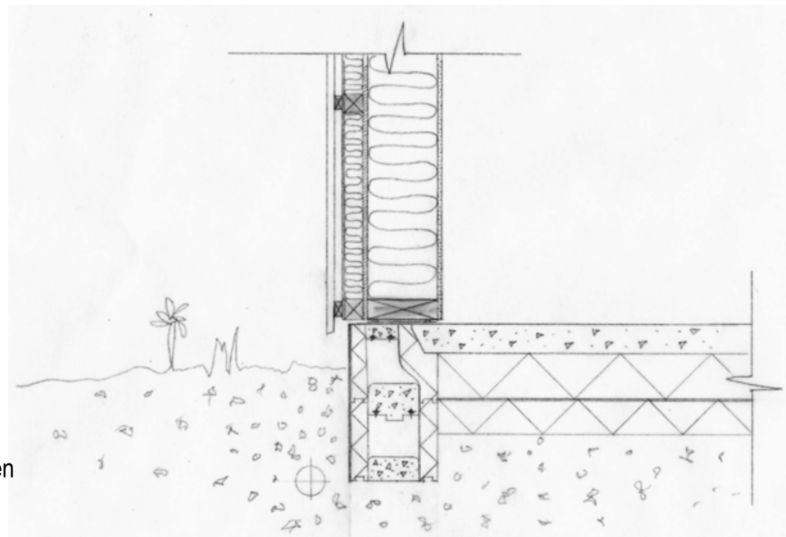
Entrance doors have a U-value of 0.8 W/m^2K.

Exterior walls have 250 mm insulation and a U-value of 0.16 W/m^2K.

Roofs have up to 400 mm insulation and a U-value of 0.10 W/m^2K.

Floors on the ground are insulated with 250 mm expanded polystyrene and have a U-value of 0.11 W/m^2K.

Thermal bridges are minimized by the use of 50 mm insulation on wooden construction details and 100 mm insulation on concrete details. The infiltration loss is minimized by the use of double wind proofing and focus on air tight details between wood and concrete and round the windows.



Detail from connection between Foundation and exterior wall.

Technical systems

Ventilation is provided by a building integrated mechanical ventilation system with a rotating heat recovery unit with an efficiency of 82%. The ducts are short and placed in inner walls to prevent that the exterior walls are weakened. Electricity use for fans is low. SFP is 1.5 – 1.8 $kW/m^3/s$.

To reduce the electricity demand, A-labeled equipment for washer, refrigerator and lighting are used.

A user friendly and simple control system is installed. For each floor all the lighting can be turned of or dimmed with one switch. A display with possibility to turn down the ventilation is located by the entrance door.

Energy demand for heating will be very low and the heating installations are reduced to a minimum. Only one electric heater is located in the living area, and bathrooms has electric floor heating. This simple heating installations will be sufficient because the ventilation system will distribute the heat to all rooms and there is no need for heaters under the super insulated windows.

Wood from the building site will be used for heating on very cold days. This free wood should be enough for about ten years of consumption. The fireplace is energy efficient and result in clean combustion.

Energy performance

The net energy use for the main dwelling of $223m^2$ is calculated to be 50% lower than for a similar dwelling built according to the Norwegian building code.

Energy use (net)[1]

Heating of space and ventilation air: 16 kWh/m^2a

Domestic hot water: 30 kWh/m^2a

Fans and pumps: 5 kWh/m^2a

Lighting and appliances: 34 kWh/m^2a

Total net energy use: 85 kWh/m^2a

Delivered energy[2]

Calculated delivered energy: 85 kWh/m^2a

1] The efficiency of the energy deliverance system is not taken into account.

[2] Energy supplied to the building, in form of electricity, oil, bio-fuel, gas, district heating, etc., taking into account the efficiency of the energy systems. The energy produced by the building itself, for example using solar water heater, photovoltaic systems, heatpump or co-generation and delivered back to the market is subtracted.

Planning tools

Simulations of energy demand and indoor climate are done with the simulation tool SCIAQ Pro 2.0. (ProgramByggerne, www.programbyggerne.no)

Costs

The extra costs are estimated to be 2% higher than for a standard house, taking into account reduced cost for heating system. With the reduced energy cost the payback time will be 3-4 years.

Innovative products

Building envelope

WIndow: NORDAN: 3 pane, 2 low-e coatings, krypton gas and stainless steel spacer. www.nordan.no

Ventilation

Air hanling unit: Villavent VR 400 EV,

Rotary wheel exchanger with 82 % recovery rate,

www.villavent.no

Financing

The energy design is carried out and financed by the builder and owner of the house. No financing support is given. Results from the project IEA SHC task 28, Solar Sustainable Housing have been important for the pre design, though. IEA Task 28 was financed by NFR (The Norwegian Research Council), Enova, The Norwegian Housing Bank and SunLab/ABB. This brochure is financed by the same project.

Project team

Owner: Hanne and Tor Helge Dokka

Builder: Tor Helge Dokka

Architect: Ellen Nesset, M.N.I.L.

Contractor electricity: Forenede montører AS, Kongsberg

Contractor Plumbing: Rørleggermester Roar Omholtl

Ground work: Terje Sollid AS

Masonry work: Murmester Hellik Dokka og Kjell Dokka

Contact person

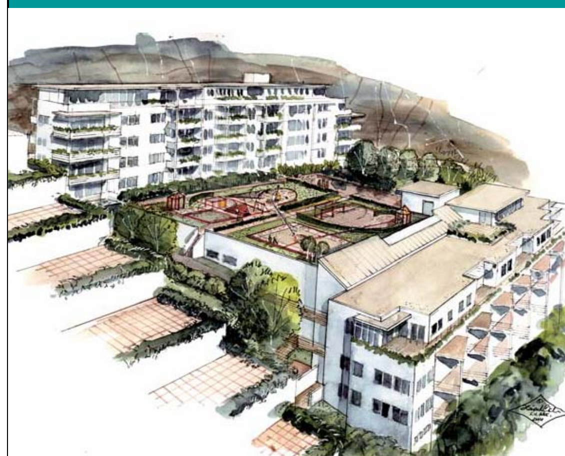
Tor Helge Dokka, SINTEF (tor.h.dokka@sintef.no)

Literature

T. H. Dokka, T.D. Pettersen, B. Helleren, “Forslag til energimerkeordning for nye boliger - forprosjekt”, SINTEF Rapport STF A03503, March 2003.

Husby Amfi

Stjørdal, Norway



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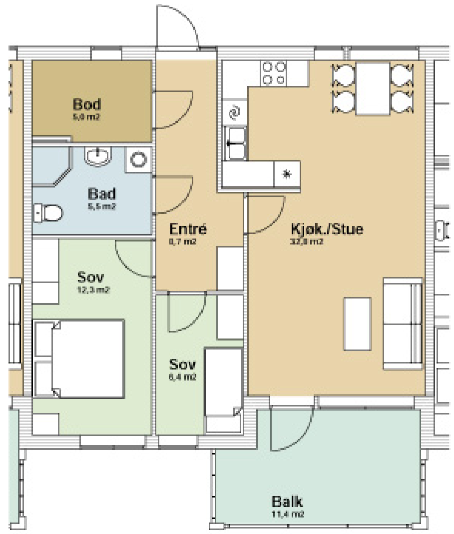


Three room apartment, 73 m2

The project

Two buildings with a total of 51 apartments are being built in Stjørdal north of Trondheim in central Norway. The buildings are owned by a housing cooperative presently consisting of three buildings from 1970. The existing buildings have 110 apartments. The construction of the new buildings started in March 2004 and will be completed during the fall of 2005.

The apartments are planned for wheelchair users and the buildings have lifts and parking spaces in the basement. Most of the apartments have two or three bedrooms, some have three bedrooms and one apartment has four bedrooms. The average size is 72 m^2. The buildings are south facing with a nice view and are not exposed to any kind of shading from hills or other buildings.

Objectives

Low energy demand and low environmental impact have been focused from the start of the planning phase. Auxiliary energy demand should be less than half of average energy demand for the same type of apartments built according to the Norwegian building code. Energy demand for room heating should be very low and heating of domestic hot water should be covered with renewable energy.

The energy design should also result in robust and user friendly homes with high quality indoor climate. The project should be cost effective in a way that make the concept interesting for other builders.

Building construction

Several measures will be implemented to improve the building envelope compared to normal building standards. These measures are optimized as regards energy and cost efficiency.

Windows are triple glazed with argon gas and have two low emission coatings, wooden frame and a total U-value of 1.0 W/m^2K.

Entrance doors have a U-value of 0.8 W/m^2K.

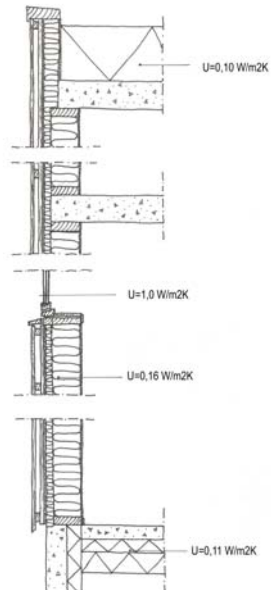
Exterior walls have 250 mm insulation and a U-value of 0.16 W/m^2K.

Roofs have up to 400 mm insulation and a U-value of 0.10 W/m^2K.

Floors on the ground are insulated with 250 mm expanded polystyrene and have a U-value of 0.11 W/m^2K.

Thermal bridges are minimized by the use of 50 mm insulation on wooden construction details and 100 mm insulation on concrete details. The infiltration loss is minimized by the use of double layers of wind proofing on exterior walls and focus on air tight details between wood and concrete and around the windows.

Wall: 250 mm mineral wool
Roof: 400 mm mineral wool
Slab on ground: 250 mm EPS
Floor against parking garage: 300 mm mineral w
Air tightness: below 0.8 ach
Thermal bridge value: below 0.03 W/mK



Technical systems

All apartments have mechanical ventilation and heat recovery with 75% efficiency or better. To reduce the electricity demand, A-labeled equipment for washing machines, dryers, refrigerators and lighting are used. Electricity use for fans are low **(**specific fan power: 2.0 kW/m^3/s).

The building site is south oriented and the solar energy is passively exploited. Most of the windows are south facing, extra heat will be stored in exposed concrete in ceilings and interior walls. Exterior shading and overhangs is used to avoid overheating and need for cooling. Cross ventilation can be carried out by opening windows that are located on the upper parts of the walls.

A user friendly and simple control system will be installed. A display with possibility to switch between “home” and “not home” is located by the entrance door. The “not home” position will result in lower temperature, less ventilation and that light and electric equipment is turned of. The display will also show the actual energy use compared to the calculated energy use.

Energy need for heating will be very low and the heating installations are reduced to a minimum. Only one electric heater is located in the living area, and the bathroom has electric floor heating. These simple heating installations will be sufficient because the ventilation system will distribute the heat to all rooms and there is no need for heaters under the super insulated windows.

To supply hot water, a heat exchanger and a heat pump will use heat from the grey water. This system reduces the electricity demand by 80% compared to a conventional electric hot water heater.

Energy performance

The net energy use for an average apartment of 73 m^2 is calculated to be 40% lower than for the same apartment built according to the Norwegian building code. The delivered energy use, with the free heat from the gray water taken into account, is reduced by 60% and the heating energy is reduced by 75 %.

Energy use (net)[1]
Heating of space and ventilation air: 16 kWh/m²a
Domestic hot water: 35 kWh/m²a
Fans and pumps: 5 kWh/m²a
Lighting and appliances: 33 kWh/m²a
Total net energy use: 89 kWh/m²a
Delivered energy[2]
Calculated delivered energy: 61 kWh/m²a

1] The efficiency of the energy deliverance system is not taken into account.

[2] Energy supplied to the building, in form of electricity, oil, bio-fuel, gas, district heating, etc., taking into account the efficiency of the energy systems. The energy produced by the building itself, for example using solar water heater, photovoltaic systems, heatpump or co-generation and delivered back to the market is subtracted.

Planning tools

Simulations of energy need and indoor climate are done with the program SCIAQ Pro 2.0. (ProgramByggerne, www.programbyggerne.no)

Simulations of daylight levels are done with the program Leso-Dial 3.1.

Costs and benefits

The extra costs for the energy concept, taking into account reduced costs for the heating system, is calculated to be 4-6% higher than for standard apartment buildings. This extra costs has a payback time of 5 to 10 years.

Innovative products

Building envelope

Window: www.nordan.no

Door: www.nordan.no

Ventilation and cooling

Heat recovery unit: Villavent VR 400 EV, www.villavent.no

and Flexit K3, www.flexit.no

Controls

Unit for control of lighting, heating and ventilation and visualization of energy use, www.ctm.no

Space heating and DHW

Heat pump: Gray water heat exchanger and heat pump, www.menerga.no

Financing

The energy concept design is financed by The Norwegian Housing Bank. Results from the project IEA SHC task 28, Solar Sustainable Housing have been important for the pre design. This project is financed by NFR (The Norwegian Research Council), Enova, The Norwegian Housing Bank and Sivilarkitekt Røstvik AS/SunLab/YIT (ABB). Results from the project "Passive Climatization" is also used and this project is financed by NFR. This brochure is financed by Enova.

Project team

Builder: Husby borettslag, Stjørdal

Architect: Arkideco AS, Stjørdal

Main contractor: Primahus AS, Stjørdal & Frost Entreprenør AS, Trondheim

Contractor electricity: Siemens, Trondheim

Contractor HVAC: ELNAN AS

Project leader: Prosjektutvikling Midt-Norge AS, Stjørdal

Building Consultant : Reum & Laugtug (Siv.Ing. Bjørseth AS), Stjørdal

Energy consultant: SINTEF avd. Arkitektur og byggteknikk

Contact persons

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Grethe Mahlum, Arkideco AS (gm@arkideco.no)

Literature and links

T. H. Dokka, G. Mahlum, M. Thyholt, "*Forslag til energikonsept for Husby Amfi"*, SINTEF Rapport STF22 A02520, September 2002.

T. H. Dokka, G. Mahlum, *"Valgte tekniske løsninger og simulering av energibruk og inneklima ved Husby Amfi.*", SINTEF rapport STF22 A03508, May 2003.

Enovas Byggoperatør, "*Bygningsnettverkets energistatistikk, Årsrapport 2001"*, June 2001.

Landskrona, Sweden

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing

The project

In the south of Sweden, 35 apartments have been built during 2003-2004. The municipal housing company, AB Landskronahem, had an architectural contest in 1999, and in 2003 a project team was formed. One and a half year later, tenants were moved in.

The team, that designed the apartments, consisted of: project leader from the municipal housing company, an external project leader, an architect, a building physicist, a structural engineer, a technical engineer, a electric engineer, a landscape architect , a contractor and two tenants.

The layout of the apartments are quite traditional. All apartments have a living room, a kitchen, a bathroom and a storage. The number of bedrooms vary between one and four. The sizes of the apartments vary between 70 and 115 m^2 usable floor area.

The apartments are for rental, and the tenants were moved in during the summer of '04.

Objectives

The goal of the project was:

• to get a rental cost for the apartments of maximum 100 €/m^2 usable floor area during the operation period

• to use highly thermal performance of constructions in order to exclude conventional heating i.e. radiators or floor heating systems

• to secure moisture proof buildings

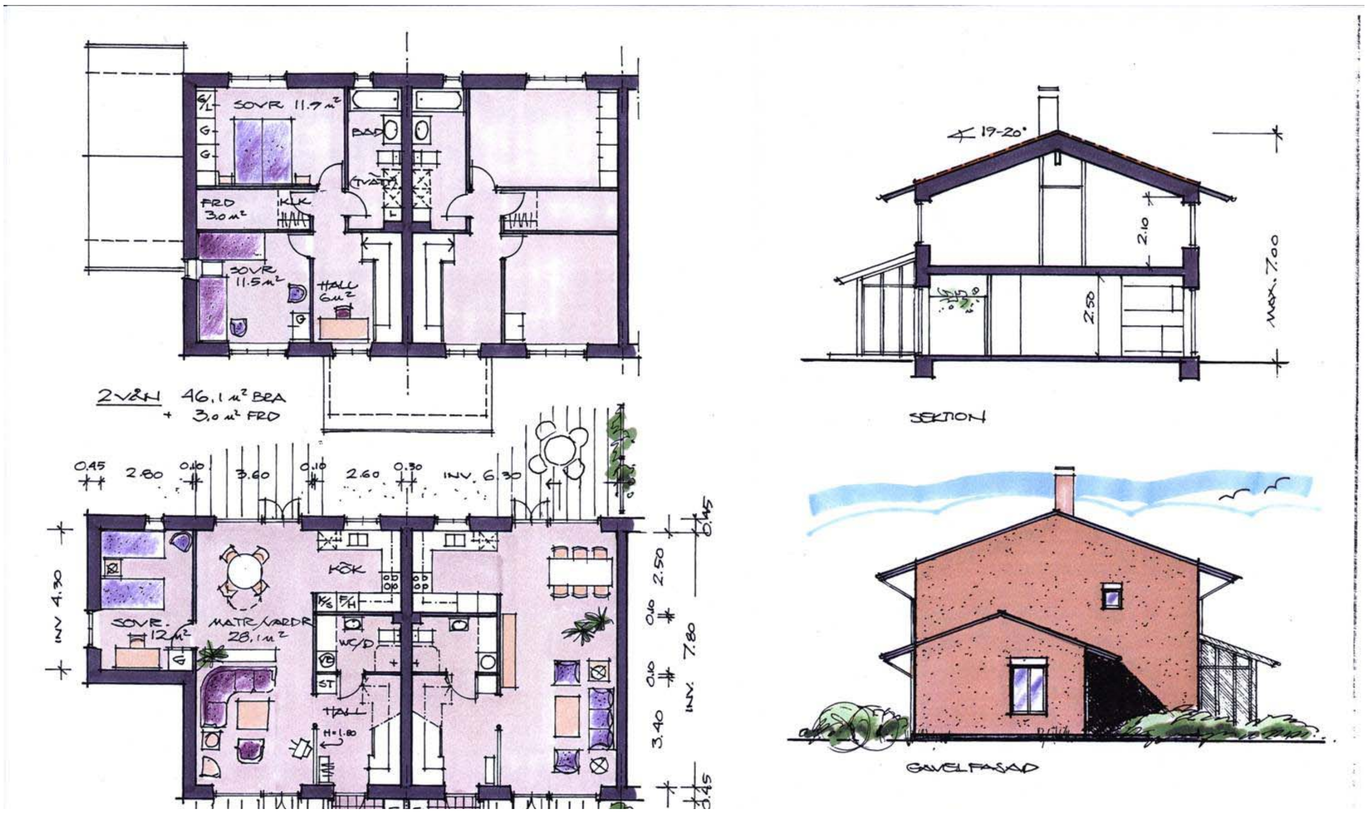
• sustainability e.g. special solution for achieve good air tightness, choice of materials.

Building construction

The floor construction consists of 100 mm concrete, 350 mm polystyrene and 200 mm macadam. The U-value is approx. 0,10 $W/(m^2 \cdot K)$.

The external walls consist of 450 mm polystyrene and mineral wool divided in four different layers. The external layer of polystyrene has a cement plaster making up the façade. The framework is made up by wooden studs and aluminum profiles. The internal surface is covered with gypsum board. In the wall there is also a plastic sheet in order to make the house air tight. The external wall has a U-value of 0,10 $W/(m^2 \cdot K)$.

The external roof is made up by light weight roof trusses filled with 550 mm loose filled mineral wool. The roof is covered with tongued and grooved timber, asphalt impregnated polyester felt, batten and finally roofing tiles. The internal surface is covered with a plastic sheet, a thin polystyrene board, mineral wool and finally, gypsum board. The U-value is 0,08 $W/(m^2 \cdot K)$.



The windows are triple-glazed with low emission coating and gas in between. The windows facing south and west have also an extra coating in order to decrease the solar radiation through the windows. The g-value is 0,34. The U-value for the windows, including frames, varies between 0,9 and 1,0 W/(m²·K) depending on window size. The glassed area corresponds to approx. 20% of the floor area.

The window area facing south-north and east-west are 50/50% respectively. The reason for this is that the houses do not need a special orientation to take care of the solar gains since the constructions are highly insulated combined with high performance of windows and heat recovery from ventilation.

When we need solar energy for space heating, i.e. during winter, the gains are low. In opposite, when we do not need space heating, i.e. during summer, the solar gains are high. The consequence is that the orientation of windows is of minor importance when it comes to space heating. Instead it is important to reduce solar radiation during late spring, summer and early fall to prevent overheating problems. The apartments have been equipped with windows with low g-value and a large roof overhang, 1 m. In this way the solar gains will be limited. All windows are operable in order to give the tenants freedom to open them whenever they want.

The project has besides energy efficiency, dealt with moisture and dehydration issues. The construction has during the design phase been examined and improved concerning moisture prevention (rain, moisture in air, moisture from the production phase, surface water, water in soil). The goal has been to dehydrate the concrete constructions to 85% relative humidity and wooden constructions to a moisture content by mass below 18%. Measurements and mechanical dehydration have also been made during the construction phase.

The apartments are planned, designed and built with high quality concerning air tightness. Special drawings and instructions were made. Also, two carpenters were specially engaged to explicitly work with the plastic sheet making the apartments air tight. A blower door test was carried out after the plastic sheet was fixed. The air tightness was measured as 0,1 litre/(m²·s) at 50 Pa differential pressure – Swedish record in air tightness!

In order to prevent the tenants from penetrating the plastic sheet during the occupation phase, the sheet has been placed inside the construction, i.e. nails and screws may be fixed in the gypsum wallboard without penetrating the plastic sheet. This sheet is placed approx. 70 mm into the construction from the inside of the wall.

The heat capacity of the apartments are fairly low. The reason for this is to be able to receive a good thermal comfort even if the sun will affect the indoor temperature. Being able to open windows, the indoor temperature will decrease faster than having a medium or high heat capacity.

Technical systems

Each apartment has a supply and exhaust air ventilation system with heat recovery (air-to-air heat exchanger). The efficiency is approx. 85% depending on the outdoor temperature.

The very limited space heating demand is covered by electric resistance heating, 700 W, in the supply air.

The air flow rate is according to the Swedish Building Code and corresponds to approx. 0,5 ach, depending on the size of the apartment.

Household appliances, e.g. refrigerator and freezer, as well as the hot water boiler are energy efficient. The domestic hot water is heated by electricity.

Energy performance

The total energy demand is calculated as approx. 50-60 kWh/(m²·a). Modern apartments built during the end of the '90s and beginning of 2000 use approx. 120-150 kWh/(m²·a), whereas 30-50% stands for space heating. The savings in these 35 apartments are therefore approx. 70-90 kWh/(m²·a).

Calculated energy demand

Space heating demand	0-5 kWh/m²a
Domestic hot water demand	25-30 kWh/m²a
Household electricity	20-25 kWh/m²a

Planning tools

The indoor temperature and space heating demand were calculated with the computer program IDA Indoor Climate and Energy 3.0 (Equa, 2003).

Costs and benefits

The apartments cost not more than conventional apartments. The cost for heating system has been saved, and instead put on the insulation thickness and window quality.

The minimal space heating demand reduces the operational costs with approx. 25 %, giving a renting cost of approx. 100 €/(m²·a).

Modern apartments built during the end of the '90s and beginning of 2000 have a renting cost of approx. 130 €/(m²·a).

Financing

The project is commercial and the owner is the municipal housing company AB Landskronahem in southern part of Sweden. No special subsidies were received.

Project team

Concept self heating houses : W Strolz, K Adalberth

Project leader	W Strolz, prime project ab
Building Physicists	K Adalberth, prime project ab
Architecture	Mernsten Arkitektkontor AB
Structural engineer	B Ekström/H Larsson, WSP
Technical engineer	G Nyberg, EVP i Helsingborg AB
Electric engineer	J Viberg, Elteknik AB
Landscape architect	C Högard Landskapsgruppen Syd
Main contractor	B Ravemark, Skanska

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Literature and links

www.primeproject.se

Göteborg, Sweden

International Energy Agency

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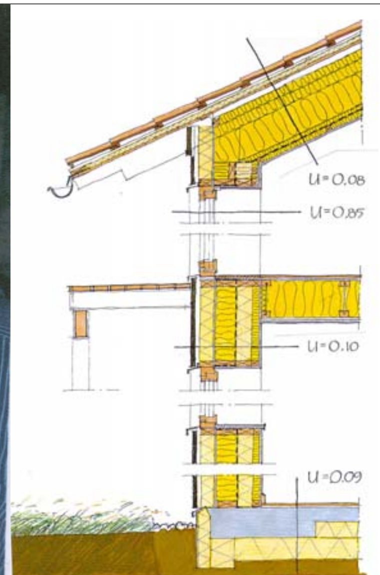

Air tightness 0.3 ach at +/-50 Pa

Air heat exchanger, η=80 – 85% P=70 W

The project

In an environment of great natural beauty at Lindås, 20 km south of Göteborg, the city owned company Egnahemsbolaget has built 20 terrace houses in which a traditional heating system has been replaced by a heat exchanger in combination with an exceptionally well insulated construction. Solar collectors on the roof provide half the energy needed for the supply of hot water.

The terrace houses were designed by EFEM arkitektkontor, and are the result of a research project extending over four years, carried out in cooperation with Chalmers University of Technology, Energy and Building Design at Lund University, the Swedish National Testing and Research Institute (SP) and the Swedish Council for Building Research (Formas).

The buildings were designed to provide a pleasant indoor environment with minimum energy use. The courtyard facade towards the south has large windows to make full use of solar heat. Balconies and roof overhang provide protection against excessive solar radiation during the summer. Owing to the terrace construction with houses of 11 m depth, there are few external walls, and these are exceptionally well insulated and airtight. The roof window above the staircase gives light in the middle of the house, and is also used for effective ventilation in the summer.

Objectives

The goals were to show that it is possible to build houses in a Scandinavian climate with no special heating system and to normal costs.

Marketing strategy

There were no special efforts done to market the houses. They were advertised as “Comfortable row houses in a beautiful nature with a low energy demand.”

Building construction U- value: W/m^{2}K

External wall: 0.10

Framed construction with 43 cm insulation.

Roof: 0.08

Masonite beams with 48 cm insulation.

Floor: 0.11

Concrete slab laid on 25 cm insulation.

Windows: 0.85

Three pane windows with two metallic coats and krypton or argon fill. Energy transmittance is 50% and light transmittance is 64-68%.

External door: 0.80

Technical systems: Ventilation and Heating

The exhaust air in a counter flow heat exchanger heats supply air. It provides 80% heat recovery. In the summer the heat exchanger can be turned off (automatic bypass) and the house ventilated without preheating of the supply air and by opening windows.

Part of the space heating demand is covered by heat gains from the occupants, ca 1200 kWh/year and energy efficient appliances and lighting, 2900 kWh/year which partly is useful to heat the building. The remaining space heating demand is covered by electric resistance heating, 900 W, in the supply air.

The houses have been designed for normal Scandinavian climatic conditions. Very low outdoor temperatures over extended periods are rare and are regarded extreme. In such cases the indoor temperature may drop by a degree or two.

The houses are neither more nor less complicated to live in than ordinary houses. If it is cold outside, the occupants do not open the windows to create a through draft. If it is warm and sunny, they lower the blinds or the awnings outside the southerly windows.

Hot water supply

Solar collectors of 5 m^2 per house provide the energy for half the hot water demand. The 500 l storage tank is equipped with an electric immersion heater to cover the rest of the demand.

Energy performance

The energy performance of the buildings are as calculated. The average energy consumption is higher than the calculated according to user habits (higher indoor temperature, more TV-sets, home computers, stand by appliances). The variation in energy use for the house units is large. The total delivered energy demand varies between 45 and 97 kWh/m²a for different households. Savings compared to houses built according to the national building code and practice is 50 – 75%.

Heating of space and ventilation air: (electricity)	14.3 kWh/m²
Domestic hot water (electricity):	15.2 kWh/m²
Fans and pumps:	6.7 kWh/m²
Lighting and appliances:	31.8 kWh/m²
Delivered energy demand:	**68.0 kWh/m²**
Domestic hot water (solar energy):	8.9 kWh/m²
Total monitored energy demand:	**76.9 kWh/m²**

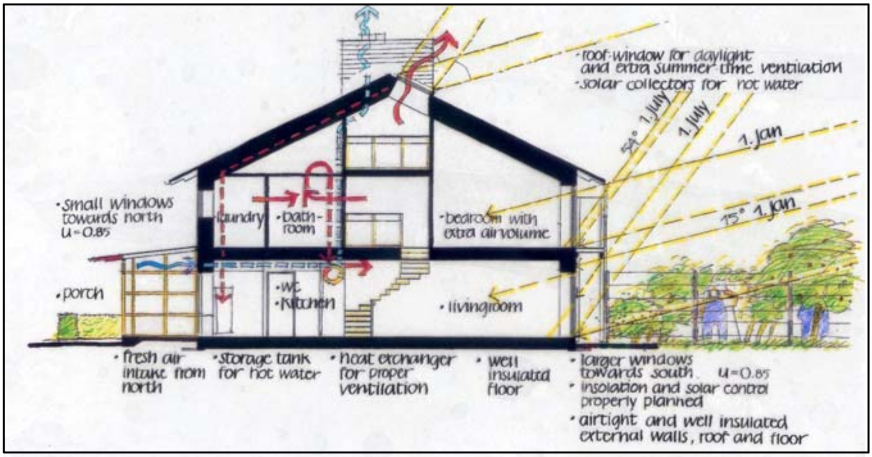

Illustration: Hans Grönlund, EFEM arkitektkontor

Planning tools

For the energy performance, passive solar energy design and for the indoor climate the computer program DEROB – LTH was used (Maria Wall).

Cost and benefits

Building costs are estimated to be normal. The extra measures in the form of greater air tightness and insulation, adaptation to "passive solar heating" and heat recovery in the ventilation are paid for by the much lower costs of the heating system and the savings in energy costs .

Financing

The project was in the planning and evaluation phase financed by Formas and EU (through the CEPHEUS project). Investment costs were carried by Egnahemsbolaget, Göteborg.

Innovative products

Swedish standard products have been used.

Project team

Client:Egnahemsbolaget
Contractor: PEAB
Architect: EFEM arkitektkontor, Göteborg
Constructional engineer: WSP, Göteborg
HVAC consultant:
Bengt Dahlgren AB, Göteborg
Electrical services consultant:
Probeko, Göteborg
Site works consultant:
Landskapsgruppen, Göteborg

Those in charge of the different areas of the research project:
Project manager: Hans Eek,
EFEM arkitektkontor, Göteborg
Energy and Building Design LTH: Maria Wall
Building Physics CTH: Carl-Erik Hagentoft and Fredrik Ståhl
The Swedish National Testing and Research Institute: Svein Ruud and Leif Lundin

Contact person

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Maria Wall (maria.wall@ebd.lth.se)

Literature and links

http://www.ebd.lth.se click "Research"
http://www.goteborg2050.nu

formas

EGNAHEMSBOLAGET

efem arkitektkontor

www.iea-shc.org www.ecbcs.org

Buttisholz, Switzerland

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

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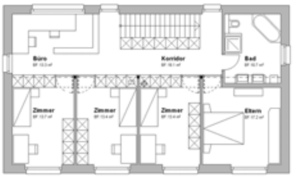
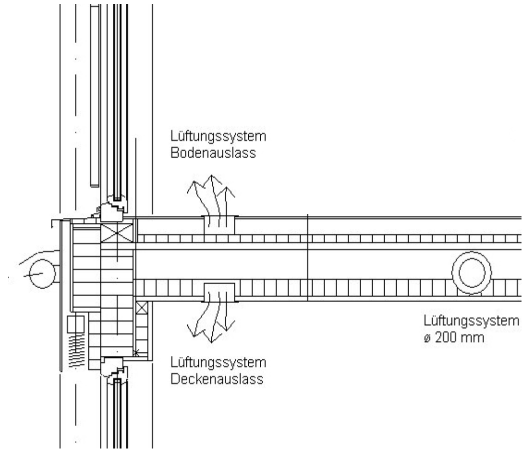
Cross section

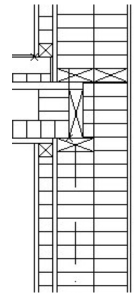


1st floor

Ground floor



Detail: wall - ceiling



Wall construction

The project

The first Minergie-P[1] certified building in the canton of Lucerne (CH) was built by the Swiss architect Norbert Aregger in 2003. The building is located in the small rural village Buttisholz, 20 minutes away from the city centre. It is a privately built single family house situated on a south-west facing slope.

The ample separation from neighbours and hillside site afford good daylight and optimal conditions for passive solar use.

The house is characterised by its compactness, a large roof overhang and large windows on the south side where all main rooms are situated.

The heated floor area SIA[2] amounts to 257 m^2 (including exterior walls). The ground floor contains a spacious living area with an open kitchen and a wood stove as well as a workroom. All rooms have direct access to the terrace. On the first floor there are four bedrooms and an open working space.

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[1] Swiss equivalent to the “Passivhaus” standard

[2] Swiss Society of Engineers & Architects

Objectives

The objective of this project is to minimise the energy consumption of the building while providing a living space with highest comfort and quality. The building is planned as a complete system including all necessary energy measures for a passive house.

Building construction

Roof (50 cm)

Wooden planking, vapor barrier, insulation (30cm polyurethane) with double-sided Al foil, water-tight barrier (2 layers), protective felt, humus substrate (extensive planting).

Wall (46 cm)

Wooden lightweight construction, 36 cm mineral wool, back-vented fiber-cement exterior skin.

Floor (23.8 cm)

Cork, cement leveling grout, separating foil, acoustic insulation (4cm), 3-layered wooden sheet, ribs, mineral wool (8 cm), 3-layered wooden sheet.

Windows

Wooden-metal frames with triple glazing.

U-Values	*[W/m2K]*
Roof	0.071
Walls	0.146
Floor	0.124
Windows	0.8
Glas	0.7
(g-value:	65%)

Ground preheating

Solar thermal collectors and weather sensor on the roof

Heat exchanger

Technical systems

Ground pipe preheating of ventilation air

2 PE-pipes 160mm diameter, length: 43m

Mechanical ventilation system

The supply air from the ground pipe is further tempered by heat recovered from the exhaust air via a counterflow heat exchanger: 260 m^3/h (100 Pa), 3-step operation.

Heating

Heat is distributed by the fresh air supply, heated with the heat exchanger. There is a wood stove backup heating: 80% efficiency, 11 kW, 6-8 hours burn time.

Solar thermal system

4.5 m^2 collectors with an efficiency of 80% cover the domestic hot water demand with 71%. The remaining coverage of 29% is assured by an electrical back-up.
The Boiler contains 400l and has a maximal temperature of 97°C.

Controls

The project is prevented from overheating by sensor-controlled sun shading.

Extras

The green roof and a rainwater cistern are two additional ecological elements in the project

Energy performance

The Buttisholz project fulfills the new Swiss MINERGIE ®-P standard. This standard is comparable to the German Passivhaus Standard.

A MINERGIE®-P certified building uses around 10% of the energy of a conventionally built house in Switzerland.

Space and ventilation heating 13.3 kWh/m²a

Energy source:
Electricity, wood stove backup

- calculated -

Domestic hot water 13.7 kWh/m²a

Energy source:
Solar thermal system 71%, electricity 39%

- calculated -

Pressuration test 0.3 h^{-1}

- monitored -

Maximal heating power 10.0 W/m^2

- calculated -

Open working space on the upper floor

Living room

View from the south-east

Innovative products

Building envelope

Window: Optiwin wooden-metal window (certified "Passivhaus" – window), 1.A Hunkeler, www.optiwin.ch, http://www.1a-hunkeler.ch

Ventilation

Heat recovery unit: Confoair G90, J.E.Storkair, http://www.jestorkair.nl/

Controls

Solar and shade control: Tebis components, Hager, http://www.hager.de/tebis/

DHW

Solar collectors: Rüesch Minisol, type BR 400, Rüesch, http://www.rueschsolar.ch/

Project team

Architect

Norbert Aregger, Buttisholz

Timber construction engineer

P. Jung, Ing für Holzbau GmbH, Rain

Heating ventilation sanitary planner

Grüter AG, Schenkon

Controler engineering

E. Häller, Elektrotechnik, Buttisholz

Civil engineer

Weilenmann u. Blättler AG, Buttisholz

Contact person

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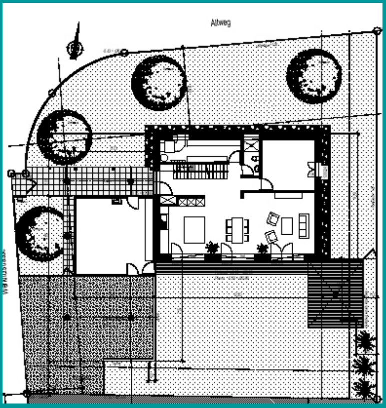
Daniela Enz, AEU GmbH (daniela.enz@aeu.ch)

Literature and links

www.aregger-architekt.ch



Dintikon, Switzerland

International Energy Agency

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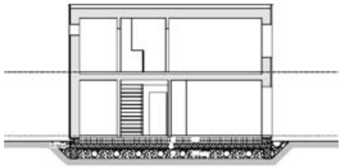
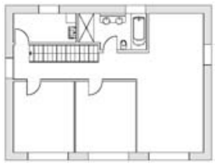
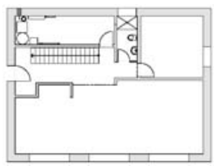
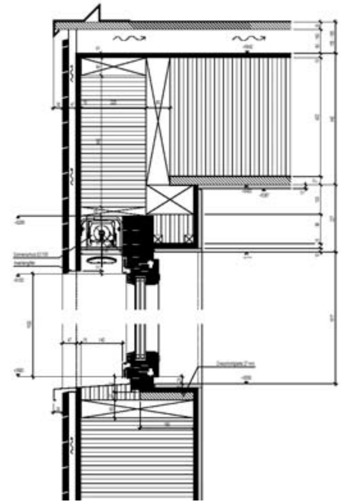
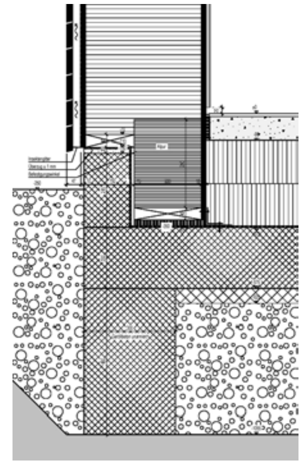

Cross section


First floor


Ground floor


Detail roof


Detail floor

The project

This first Minergie-P[1] certified house of Switzerland was built by the architect Werner Setz in 2003. It is a privately built single family house.

The building is located in a rural area in Dintikon, (CH). It is situated on a north-west street corner with a neighbour to the east. The main orientation of the building benefits from the spacious and open agricultural field towards south. The single family house is very compact. Two unheated outbuildings create a south oriented courtyard and offer storage space. This eliminates the need for a cellar.

The heated floor area SIA[2] is 220 m^2 (including exterior walls). All main rooms are oriented towards south. The ground floor contains a spacious living area with an open kitchen, a workroom/guestroom as well as a plant room. The first floor includes two bedrooms and an open space.

---

[1] Swiss equivalent to the “Passivhaus” standard

[2] Swiss Society of Engineers & Architects

Objectives

The builders requested an optimised annual energy balance, a smart combination of passive and active solar energy use, modern and ecological construction as well as a conservation -conscious design of the site.

Building construction

The walls, ceiling and flat roof are in wooden frame lightweight construction. The whole envelope is free of thermal bridges.

Roof

Gypsum board, wooden strapping, wind barrier, wooden beams, mineral wool insulation, wood chip panel, sloped air gap, flat roofing

Ceiling

Gypsum board, wooden strapping, wooden beams with cavity insulation between, acoustic insulation, cement grout, finish flooring

Wall

Wooden lightweight construction, back-vented untreated douglas fir exterior skin.

Windows

wooden-metal frames, triple glazing

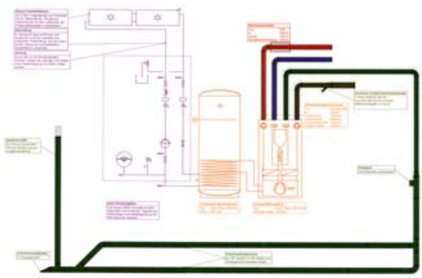
Floor

Reinforced concrete, insulation, cement grout, paving tiles

U-Values	*[W/m2K]*
Walls	0.113
Roof	0.108
Floor	0.083
Windows	0.74
(g-value:	52%)

Photovoltaics installation on the roof

Plant room: Expansion tank of the solar collectors, boiler, compact ventilation unit with integrated mini-heatpump and controller for the solar system.



Technical system

Technical systems

Ground ventilation preheating

2 BP-pipes, 200mm diameter, 40m length

Mechanical ventilation

The supply air from the ground pipe is further tempered by heat recovered from the exhaust air via a counterflow heat exchanger.

Heating

Heat is distributed by the fresh air supply, heated with a compact counter flow heat exchanger unit supplied by the exhaust air heat pump. There is an electric powered radiator in the bathroom.

Solar thermal system

4.5 m^2 flat plate collectors, 320 l storage tank, 60% coverage, heat pump and electric resistance backup.

Photovoltaics

49.5 m^2 grid connected, 100% coverage of annual electricity and domestic hot water demand.

Controls

Sensor-controlled sun shading system.

Energy performance

Space and ventilation heating 12.5 kWh/m²a

Energy source:

Electricity

- calculated -

Domestic hot water 13.6 kWh/m²a

Energy source:

Solar thermal system 60%, electricity 40%

- calculated -

Electricity for technical systems 17.0 kWh/m²a

Energy source:

Photovoltaics

- calculated -

Pressurization test 0.35 h^{-1}

- monitored -

Maximal heat capacity 9.67 W/m^2

- calculated -

View from the terrace towards south

Living room

South-west façade

Innovative products

Building envelope
Window: Passivhaus-windows DW-Plus, Wiegand, http://www.wiegand-info.de
Door: Passivhaus-door DW-Plus, Wiegand, http://www.wiegand-info.de

Ventilation and cooling
Combi unit: Aerex BW 225/2, Drexel-Weiss, http://www.drexel-weiss.at

Controls
Shade and wind control: Hager Tebis TS, Hager, http://www.hager-tehalit.ch

Space heating and DHW
Heat pump: combi unit: Aerex BW 225/2, Drexel-Weiss, http://www.drexel-weiss.at
Solar collectors: Rüesch, Typ Terza, Rüesch, http://www.rueschsolar.ch

Electricity
Solar PV: Typ Shell Solar SM 110-24, Rüesch, http://www.rueschsolar.ch

Project team

Architect / site engineer
Architekturbüro Setz, Rupperswil
www.setz-haus.ch

Interior designer
Merz + Isler AG, Rombach

HLKK- engineer and blower-door-test
Otmar Spescha, Schwyz

Building physics
Ragonesi Strobel und Partner AG, Luzern

PV, solar thermal system planner
Ingenieurbüro Hauri, Schwyz
Rüesch Solartechnik AG, Dottikon

Contact person

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Daniela Enz, AEU GmbH (daniela.enz@aeu.ch)

Literature and links

www.setz-haus.ch

Konstanz

Rothenburg, Switzerland

International Energy Agency

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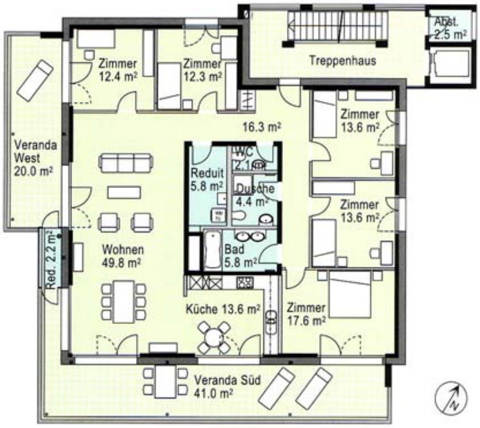

Standard floor plan
(Ground floor, 1st floor, 2nd floor)

6 ½ rooms: 167.3 m² net living area
Veranda: 61.0 m²

Living room

The project

The Konstanz project was built by Anliker AG in 2002 / 2004. From the thirteen apartment buildings seven are built to the Passivhaus standard. The housing estate is situated in the suburbs of Lucern, a few minutes away from the city center.

The building site is well tied into Rothenburg's utilities infrastructure. It is surrounded by a green belt of natural spaces which offers a high living quality. The plan is based on the historic "Garden City" concept. The generous separation between buildings affords good daylighting and natural ventilation for each apartment. The outdoor spaces are restricted to pedestrian and bicycle traffic.

A very flexible floor plan can be easily adapted to fulfil the individual buyer's needs. The living area of around 170 m² can be used as 6 ½ rooms, 5 ½ rooms, a loft or be divided into two apartments of 4 ½ rooms and 2 ½ rooms.

Objectives

The aim of the project is to provide affordable, ecological housing with a minimum of energy requirement. To achieve this, a conventional structural system was modified to include all the features of a passive house.

"Why build energy efficient housing when you can't sell it because the units are too expensive or architecturally unattractive?“ The response was to design a conventional building where energy features are unobtrusive.

The goal was to provide living space with good architecture. Spacious and bright rooms are created which are easily marketed.

Marketing strategy

The housing estate is promoted in a brochure using the slogan "Rothenburg Konstanz c'est la vie" Living in Rothenburg Konstanz - that's life! A large photo of a happy young girl, playing on a swing in a summer meadow is the logo of the campaign addressing young families. This promotional material emphasizes that the buildings are very ecological providing a healthy place to live.

Anliker AG selected the target group amongst young families as the ones who were "forward thinking". When developing the marketing- and communication plan, however, other factors than environment were emphasized.

The project was wrapped in: good architecture, trendy design, way of living, family values, happy and healthy children, a lot of green spaces, health focus and being responsible for the next generation.

Using trend issues both in developing the apartment concepts and later communicating with the customers Anliker AG achieved an extra promotion/marketing effect in the market for their product – several forces stimulated the market niche and finally resulted in good sales for the company.

The units have been awarded the "Passivhaus Certificate" the Swiss "Minergie-P Certificate" and the "Swiss Building Award". These awards gave Anliker AG a lot of publicity in the newspapers winning both the company and the product extra attention in the market.

Solar collectors

Special (Hilti) construction from wall to wall without penetration of insulation

Technical system

Building construction

The bearing wall construction consists of masonry and reinforced concrete.

Roof

Plaster, concrete, vapor barrier, insulation (36 cm) with aluminium backing, water-tight barrier, protective felt, extensive green roof.

Walls

The walls are built with clay masonry units, exterior insulation (28cm mineral wool), and a back-vented wooden skin (S-W façade) or exterior insulation (30cm Neopor), with plaster(N-E faceade).

Windows

The windows are triple glazed.

Floor to cellar

Floor covering, levelling cement grout, PE foil, polystyrene insulation (3 cm), acoustical insulation, concrete, polystyrene insulation (30 cm).

U-Values

Walls	0.104 - 0.129 kWh/m2a
Floor	0.089 kWh/m2a
Roof	0.076 kWh/m2a
Window	0.72 – 0.78 kWh/m2a
g-Value	0.43 %

Technical systems

The Konstanz project was optimized for passive solar energy use. The highly insulated and very tight building envelope has no thermal bridges. The building uses around 10% of the energy of a conventionally built house in Switzerland.

Ground pipe preheating of ventilation air

4 PE-pipes, 160mm diameter, 35 - 40m length

Mechanical ventilation system

Supply air from the ground pipe is further tempered by heat recovered from the exhaust air via a counterflow heat exchanger.

Heating

Heat is distributed by the fresh air supply, heated with the heat exchanger and a central condensing gas furnace.

Solar thermal system

Solar collectors on the roof cover the domestic hot water demand with 60%. The Boiler contains 1000l.

Controls

The project is prevented from overheating by sensor-controlled sun shading.

Energy performance[1]

Space and ventilation heating 10.8 kWh/m^2a

Energy source:
central condensing gas furnace

- calculated-

Domestic hot water 20.4 kWh/m^2a

Energy source:
solar thermal system 60%, gas furnace 40%

- calculated-

Maximal heat capacity 7.9 W/m^2

Pressuration test 0.25 h^{-1}

- monitored -

1 All values refer to the Swiss Minergie-P calculations

Planning tools
"Zertifizierungsheft"
(Passivhausinstitut, passivhaus@t-online.de)

Innovative products

Building envelope

Windows: Plastic window system CMS SIGNUM, Kronenberger AG, www.kronenberger.ch

Doors: Thermicum 68 (vacuum insulated), Brunegg AG / 5505 Brunegg, www.brunex.ch

Exterior Walls: Insulation Neopor, Sarna Granol / 6060 Sarnen, www.sarna-granol.ch

Walls cellar: Misapor (insulating concrete), Misapor AG / 7302 Landquart; www.Misapor.ch

Ventilation and cooling
Heat recovery unit: Type 7-Air, Habitus SHG 1.2, Gebr. Meyer AG / Luzern, www.seven-air.ch/

Domestic appliances
Kitchen appliances: Elektrolux AG, www.electrolux.ch

Space heating and DHW
Solar: Solar combi boiler UFW/2, Ernst Schweizer AG/ Metallbau/ Bahnhofplatz 11/ CH-8908 Hedingen

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Wyss Bauingenieure AG, Rothenburg

Electrical engineering

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Heating ventilation sanitary planning

Partnerplan AG Ing. Büro für Haustechnik und Energieberatungen, Littau, info@partnerplan.ch

Landscape architecture

Dové plan AG, Luzern, www.doveplan.ch

Sanitary planning

Josef Roth, ing. Büro für Industrie- u. Haustechnik, Malters

Literature and links

www.konstanzrothenburg.ch

Monte Carasso, Switzerland

International Energy Agency

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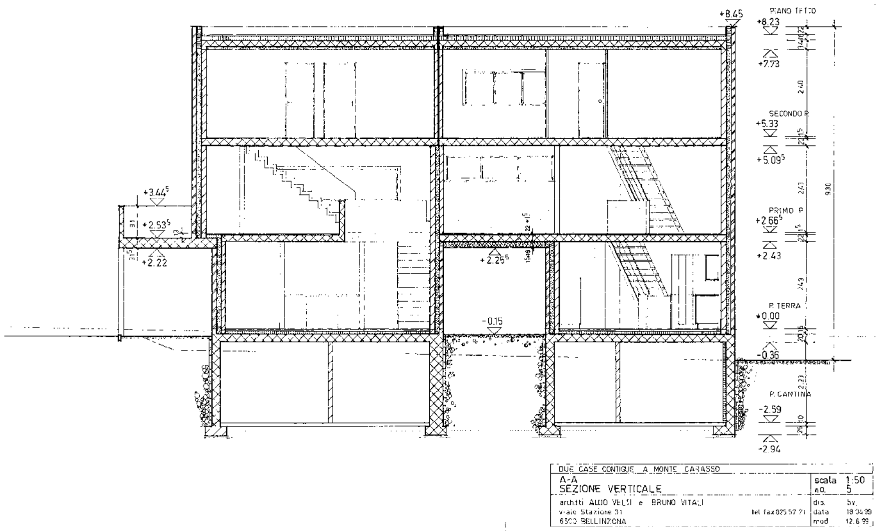

The project

The "Vitali-Velti house", designed by the two architects A. Velti and B. Vitali; is located in the village of Monte Carasso, near Bellinzona, south of the Alps in Switzerland. The site is in a densely built-up area at the bottom of a south-facing valley. The project demonstrates that low energy housing can and has to take into account local limitations (shape, orientation, local and distant shadowing, etc.). Architecture, aesthetics, costs, reliability and simplicity were all carefully considered in evolving the design.

The house is a massive construction, two-family semi-detached house. Each house half has approximately 200 m^2 of net heated floor area (5 ½ rooms on three floors). The main house entrance is on ground floor. This level includes the kitchen – dining area, which also have direct access to the garden. The living room / office is on the first floor. The three bedrooms on the second floor are separated from the rest of the house. Each house has an individual, unheated basement for the laundry, the utility room and the storage room. The basement is only accessible from the inside of the house.

The house was built privately under the supervision of the two architects that now live in it. The financing was provided by the owner and a bank, as is normal done for private housing.

The house was completed in 1999.

Objectives - Goals

The main motivation of this demonstration project is to prove that it is possible to achieve superior performance at no additional investment cost compared to standard construction. The design should also demonstrate that such constructions can also be good architecture. Drastically reducing energy consumption and environmental impact guided their choices during the design of the house.

Building construction

The structure of the house is massive. Each floor is a concrete slab construction. Part of the walls is also made of concrete. In order to reduce the number of thermal bridges, the house bearing structure is built inside the polystirol insulation envelope (13 to 20 cm of insulation thickness). The exterior of the wall is a brick masonry construction. The overall wall construction achieves a calculated U-value of 0.25 W/m^{2}K. Special care was given to reduce the remaining thermal bridges.

Large windows have been integrated in the south-east façade. Windows have a global U-value of 1.1 – 1.3 W/m^{2}K (frame included). They are made of two panes (selective surface / filled with argon gas) and a wood frame.

The flat roof was partially prefabricated (10%) and includes two layers of polystirol and foamglass insulation . The resulting construction U-value is about 0.15 W/m^{2}K.





Technical systems

Fresh air is provided by means of a two-flow ventilation system with a cross-flow heat recovery unit, each house having an independent system. The system operates with a constant airflow rate in the incoming and exhaust air channels. The simplicity of the design and its ability to guarantee good air quality in all conditions were the reasons for its selection.

The southeast facade has a large window area for spaces mainly used during the day (i.e. kitchen, dining-room, living-room and office). This provides large passive solar gains as well as daylight. The solar heat gains are stored in the extensive building mass. Indoor curtains control glare. External louvered blinds provide an effective solar overheat protection.

The remaining heating requirement is covered by a wood stove in each house. Heating is distributed simply by free radiation and room air convection, thanks to openings in the south and north areas of the first floor.

Hot water is produced with two independent solar hot water systems, one in each house. Each system is sized at one square meter flat plate solar collectors per person (4 people per house). An electric resistance heating element in the hot water tank delivers auxiliary heat as needed.

Energy performance

The annual heating demand of the Velti house, referred to the energy reference area (determined to 260 m^2 with outside dimensions), is measured for the Velti house to 50 MJ/m^2y for the 2001-2002 monitored year. The electric energy indexes for ventilation, hot water and domestic use were measured to 0.7, 6 and 34 MJ/m^2y respectively.

Costs

The house construction costs no more than that of a conventional house. The cost saving from not installing a conventional heating system offsets the extra cost for the superior envelope of the building, the two air controlled ventilation units and the two solar hot water systems.

Energy saving resulted in substantial immediate reductions in operating costs.

Planning tools for LCA, energy performance, solar energy design and more

Performance indicators and quality labels were the determining factors for the choice of appliances. Environmental aspects were considered when information was available. The annual heat demand of the house was calculated with LESOSAI. Possible moisture problems in the construction were analysed with the program LESOKAI. Shading calculations were performed to address the problem of summer overheating.

Marketing strategy

Thanks to the monitored project, the house is documented with architectonic, energy, economical and environmental aspects. This documentation is used for the information of the Swiss Minergie Standard in Tessin.

Innovative products

The innovative features of this project are the large mass inside the insulated building envelope and the natural distribution of heating energy inside the house (natural air convection). Another point are the solutions found to reduce thermal bridges.

But the main innovation seems to be that the project works with very simple measures and doesn't need any specific innovative products.

List of publications

- B. Vitali (1999) Costruire case secondo i principi dello sviluppo sostenibile: è possibile ! Cantieri & Abitare, n° 7, pp. 33 – 36.

- A. Velti (2000) Casa calda a basso prezzo. Spendere meglio, n°4, agosto 2000, pp. 6 – 8.

A. Velti e B. Vitali (2000) Ecco la casa che si calda da sola. Casa Nostra, n° 58, Dezembrer 2000, p. 11.

-D. Pahud, M. Generelli, A. Velti e B. Vitali (2003) Low Energy Housing in Ticino. The "Vitali-Velti" house. Final report, Swiss Federal Office of Energy, to be published (in Italian).

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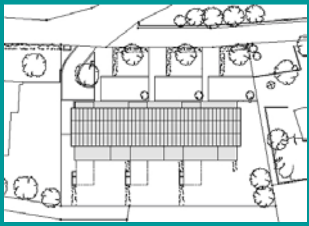

Sunny Woods

Zurich, Switzerland

International Energy Agency

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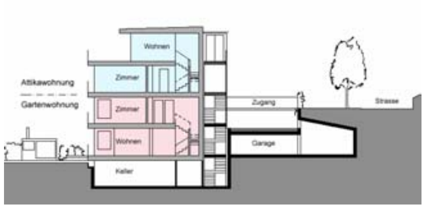
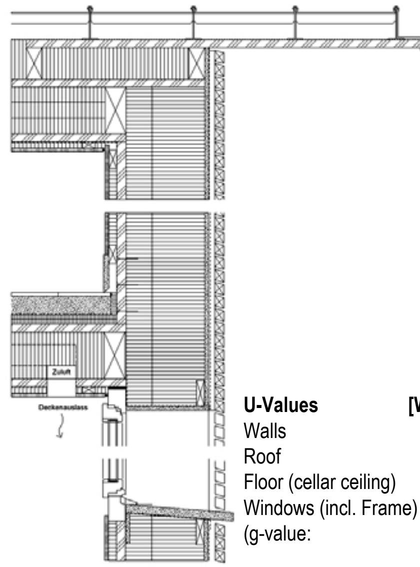
attic

2nd floor



Cross section



U-Values	[W/m²K]
Walls	0.12
Roof	0.10
Floor (cellar ceiling)	0.16
Windows (incl. Frame)	1.00
(g-value:	60%)

Detail roof - north facade

The project

The Passivhaus *Sunny Woods* was built in 2000/2001 by the Swiss architect Beat Kämpfen. The name of the building explains its concept. The six-family dwelling is located on a south facing hill close to the woods in a residential area of Zurich. Solar energy and wooden construction were the themes of the design.

The building consists of six spacious (200 m^2), legally and technically almost autonomous maisonette units with an elevated standard and price. The lower units have a small garden, upper units have a large roof terrace. Each dwelling has the character of a single family house and is directly accessible from the street with a level difference of half a storey up or down.

Parking is available in the underground garage.

Objectives

Sunny Woods", winner of both Swiss and European solar prizes, is the first apartment building in Switzerland designed to achieve an annual zero energy balance. The project is based on passive-solar design combined with the following technical features:

- Highly insulated, airtight building envelope
- Minimised thermal bridges
- Energy efficient windows
- Efficient ventilation with heat recovery and ground preheating
- PV-roof, grid connected thin film solar cells
- Vacuum collectors for dhw and heating
- Efficient appliances

Building construction

The walls, ceiling and flat roof are of wooden frame lightweight construction. The entire envelope is free of thermal bridges. Cellar, underground parking and the staircase for the exterior access are built in concrete.

Roof

Back-vented PV panels, back-vented aluminum sheet metal roof, sloped mineral wool, glued wooden block panels, wooden block framing, mineral wool, glued wooden block panels, moisture barrier, wooden furring strips, gypsum board.

Wall

Gypsum board, wooden furring strips, with mineral wool in between, moisture barrier, glued wooden block panels, wooden block framing, mineral wool, wooden composite panels, moisture barrier, wind barrier, larch battens, cedar siding.

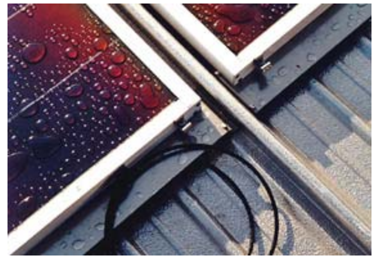
Windows

Triple glazing, solarglas, krypton.

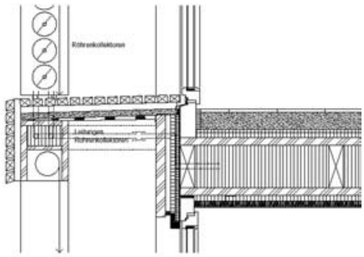
Floor

Natural stone paving tiles, levelling cement grout, PE foil, acoustical insulation, glued wooden block panels, wooden block framing, mineral wool, glued wooden block panels, metal spring hangers, mineral wool, gypsum board, sound deadening foil, gypsum board.

South facade with vacuum collectors as balcony railing



Photovoltaic: (thin film silicon cells



Detail ceiling - south façade with collectors

PV installation on the roof

Technical systems (per living unit)

Ground pipe preheating of ventilation air

2 PE-pipes 150mm diameter, 30m length.

Mechanical ventilation

The supply air from the ground pipe is further tempered by heat recovered from the exhaust air via a cross counterflow heat exchanger.

Heating

Heat is distributed by the fresh air supply, heated with a water-air heat exchanger supplied by the solar collectors or heat pump. There are radiators in the bathrooms.

Solar thermal system

6 m^2 vacuum collectors serve as the balcony railing, the storage tank contains 1400 l (combined domestic hot water and space heating).

Photovoltaics

201.6 m^2 grid connected, thin film silicon cells, 80 - 100% coverage of annual domestic electricity and electricity for domestic hot water and space heating back-up demand.

Financing

-Swiss Federal Office of Energy:
Pilot- and demonstration project
"Passivhaus" and "Photovoltaik"
-Electric power company of Zurich:
Stromsparfonds

Costs and benefits

A big part of the additional costs of *Sunny Woods* compared to other buildings was due to the photovoltaics installation on the roof. The heating system with extra costs of around 30-40% and the system autonomy for each apartment increased costs as well. For the homebuyers, however, having an individual technical system was very attractive.

Everything considered, the pure construction costs exceeded the costs of a conventional building by around 5 %.

Energy performance

Space and ventilation heating 14.7 kWh/m²a

Energy source:
solar thermal system, electricity
- calculated -

Domestic hot water 8.4 kWh/m²a

Energy source:
solar thermal system, electricity
- calculated -

Living room

Entrance north facade

Innovative products

Building envelope

Walls:Wooden block panels, Pius Schuler AG
www.pius-schuler.ch

Space heating and DHW Solar

Vacuum collectors: B. Schweizer Energie AG, Chnübrächi 36, CH-8197 Rafz

Electricity Solar PV

Unisolar-Baekert standard photovoltaic panels à 32 Wp (amorphous silicone triple thin film cells), Fabrisolar AG,
www.fabrisolar.ch, www.flumroc.ch/photovoltaik

Project team

Architect / site engineer

Beat Kämpfen, Kämpfen Bau GmbH, Zurich

Energy planning and domestic technique

Naef Energietechnik, Zürich
Ganz Installationen AG, Volketswil

Timber construction engineering

Makiol + Wiederkehr, Beinwil am See

Concrete engineering

Federer & Partner, Zurich

Simulations air heating system

Air Flow consulting, Dr. Alois Schälin, Zurich

Contact person

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Literature and links

www.kaempfen.com

The Zero-Heating House, Peterculter, Aberdeen, Scotland

International Energy Agency

IEA – SHC Task 28 / ECBCS Annex 38:

Sustainable Solar Housing

The project

In Aberdeen, Scotland, a private development was built in 2000. On a small semi-urban site surrounding by conventional homes, the client desired a home which would meet the needs of the environment and there family in the future.

The design team were set a low budget for the design of a four bedroom family house but were keen for the building to compliment sustainable targets. In the UK there have been a plethora of showcase environmental housing yet this building aimed to achieve an affordable yet environmentally friendly home.

The building is an evolution of a design used previously by the design team and this gives it a key advantage. The building holds a specific grid layout and has a habitable roof space to reduce costs and reduce site waste. The building has an open plan main area encompassing living, dining and kitchen with an open landing area to circulate passive heat gains vertically.

Sustainable Objectives for the design

The sustainable targets set by the design team will be met by:

• Ensuring that environmental gain is not created through additional expense. This is mostly achieved by a compact design and passive means of heating.

• The typical dedicated central heating system is not included in the design. The money saved from the omission of this feature is given over to the additional cost of environmental features. This includes:

a) Elimination of dedicated heating system

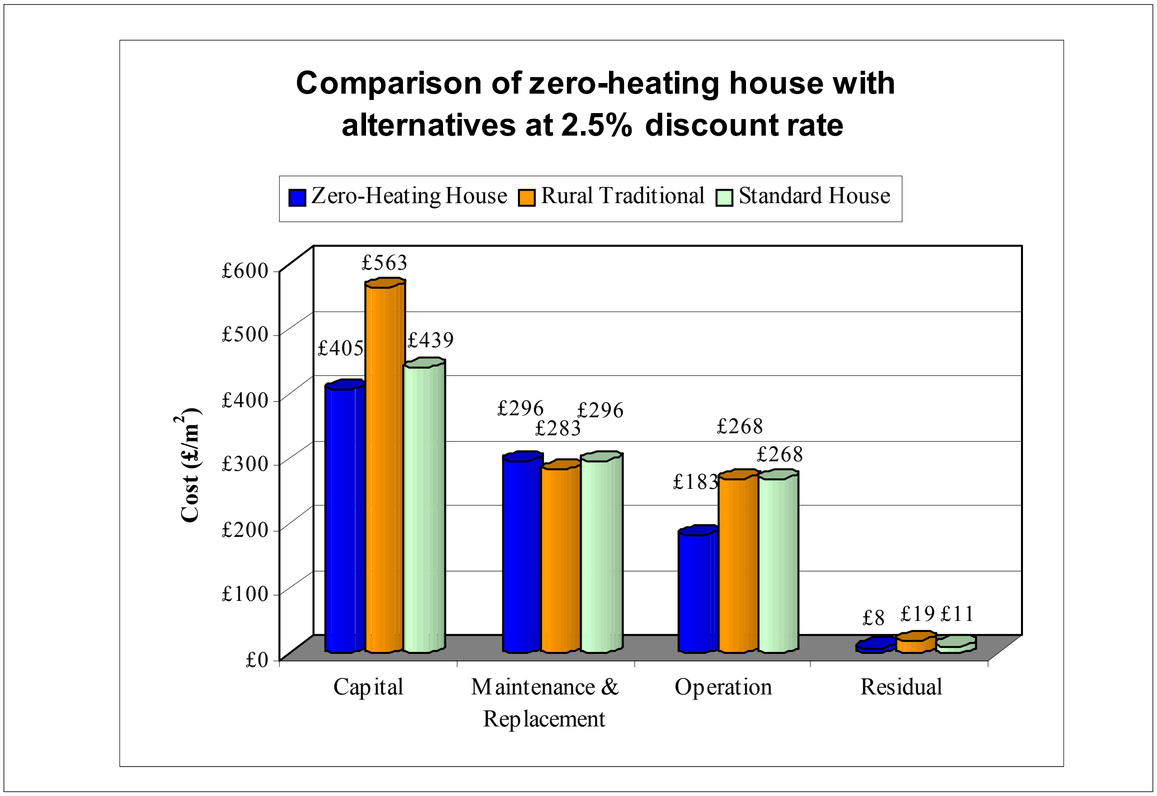
b) Heat recovery ventilation units at points of pollution.

c) Super-insulation in the depth of timber "I" beams using vacuum packed recycled insulation. (U value: 0.10 W/m2K)

d) Passive solar design with thermal mass on the floor.

e) Low E triple glazing on all windows. (U value: 1.1 W/m2K)

f) Sustainable materials, locally sourced and from renewable sources as far as possible.



•Make best use of the available technology and design to reduce energy use, waste and embodied energy in buildings to a minimum during construction and during occupation.

• Use local resources (human and materials) to support the development as far as possible.

• Finally, create an acceptable and successful design aesthetic and innovation.

Building Construction

Much of the design is not a new concept yet there is not much residential housing in the UK which achieves sustainable concepts affordably. The main thrust of the idea for this building was the need for a dedicated heating plant to be eliminated offset by the use of between 300-400 mm insulation.

The '*zero heating*' family home is built using timber "I" beams that simultaneously quick to install, allow a large depth for the insulation and are less expensive than traditional construction. Glue has also eliminated from the construction. The external wall has a U-value of 0.12 W/m²·K and the roof has a 0.10 W/m²·K.

Externally, the building is clad in locally purchased larch cladding with clay pantiles, chosen through an environmental life cycle analysis.

The glazing is mostly south facing, with most of the north, east and west glazing eliminated. This will allow daylight to enter on the south facade while reducing the risk of heat loss on the remaining facades. The glazing is also triple glazed, krypton fill with low E and the roof-lights are double glazed low E. The triple glazing has a U-value of 1.1 W/m²·K and the roof-lights have a U-value of 1.4 W/m²·K

The interior floor is exposed concrete 250mm thick, insulated by 100mm of polystyrene insulation so as to act as thermal mass. The floor has a U-value of 0.14 W/m²·K

The interior of the building is far more open than would be expected, so as to allow the heat to circulate, but the real innovation is in almost eliminating dedicated circulation space by allowing all rooms to run of the central living space and balcony. As a consequence most of the interior space is two story, which allows light to flood in for vast periods of the day.

In addition to the added insulation, passive solar design, thermal mass, mechanical heat recovery fans and triple glazing a solar panel was also installed to aid the water heating of the house. A wood stove is also included in the central living space as a back up during winter, though preliminary calculations suggest that internal temperatures inside the house over the year should not fall below 14ºC.

Analysis

The project was completed in 2000. The three phases of research included:

1) Life Cycle Cost Analysis of the whole building, giving priority assessment to the energy efficient features of the design.

2) Environmental monitoring and assessment of the interior with emphasis on heating and ventilation.

3) Post Occupancy Evaluation, for assessing the environmental comfort of the building.

Results from the three phases has been used for adapting later projects for the greater use of simple energy efficient design.

In its primary aim of reducing heating costs the '*zero heating*' house succeeds in reducing annual heating costs. This equates to an 80% saving over current 'standard' housing designed in accordance with modern building regulations, before discounting.

Total energy costs for the '*zero heating*' family home, including all the energy efficient features, succeeds in reducing combined annual energy and maintenance bills by £300 per year (at 2.5% discount rate). This represents a 21% saving over current 'standard' housing designed in accordance with modern building regulations.

The additional fabric insulation, triple glazing, heat recovery ventilation units and solar powered water heating allow for a 80% reduction in the heating CO_2 emissions between the alternatives. The use of a wood fire also complements this environmentally as the fuel is from a sustainable source, termed as biomass energy.

With all the energy saving features combined, savings of up to 21% at a discount rate of 2.5% may be obtainable on the operational costs only, and have a quicker overall payback period of 19-21 years.

Technical systems

Mechanical Heat recovery on points of pollution, all other systems are passive.

As a back-up system a wood fired fireplace in located in the main living space. During analysis this system was only used during the coldest winter nights.

Project team

Client

Architect

QS

Engineer

Contractor

Contact person

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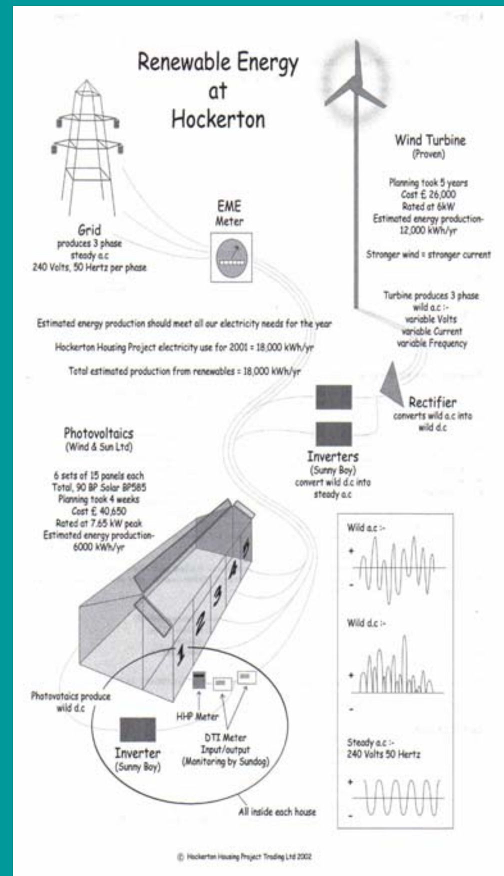

Hockerton Housing Project, UK

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing

 

The project

The Hockerton Housing Project (HHP) is an innovative residential sustainable development in the village of Hockerton near Nottingham, UK.

Completed in 1998 after three years of planning and 18 months of construction, it has been designed as one of the first zero energy residential systems in the UK, reducing life cycle energy to a minimum. Maximum use of benign, organic and recycled materials has been made in the construction and the development is designed to be, to a large extent, self-sufficient. The houses are earth covered and have passive solar heating without a space heating system. A wind turbine and photovoltaic system provide all of the energy required to run the homes. The water and sewage system is self-contained.

It is the UK's first earth-sheltered, self-sufficient ecological housing development. Project members live a holistic way of life in harmony with the environment, in which all ecological impacts have been considered and accounted for. The houses are amongst the most energy efficient, purpose built dwellings in Europe.

The Project consists of a terrace of five single storey dwellings which are earth-sheltered at the rear (North), such that the ground surface slopes and blends smoothly into the field at the back. Each house is 6 m deep with a 19 m south-facing conservatory running the full width of each dwelling. A repeated modular bay system of 3.2m in width was used for ease of construction. Most internal rooms have 3 m high French windows so they are not so dependent on natural light.

The development is located on a 10ha site that has a slight slope just to the south west. Previous use of the land was essentially agricultural. The large area has allowed incorporation of features that enable the occupants to live in a sustainable and self-sufficient way. This includes crop cultivation and the rearing of small animals. It has also allowed for large water catchment for the homes and waste disposal via a reed-bed system.

Objectives

There were several key design objectives regarding energy performance and sustainability:

- To reduce space heating requirement by artificial means to zero
- To reduce CO_2 emissions incurred by the existence of the development, to zero
- To be as autonomous as possible in terms of provision of utilities, including water
- To use renewable energy sources to meet the energy requirements of the development
- To use easily transferable construction techniques and ready available, environmentally responsible materials
- To provide competitive costing to conventional housing (in the short term) with demonstrable savings (in the medium-long term)
- To provide occupier control of infrastructure and services with minimal maintenance
- To increase biodiversity and enhanced landscape associated with the project
- To offset all energy requirements (including those embodied within materials) and CO_2 emissions incurred during construction work
- To achieve all of the above with no loss of comfort or modern amenities.

Building Construction

The development is of high thermal mass construction with 200mm concrete block internal cross walls on a 300mm concrete slab, a concrete beam-and-block roof and 500 mm thick external walls of two skins of concrete blockwork used as formwork to contain mass concrete.

The adoption of a single sub-slab 200mm in thickness, simplified the construction of the superstructure as there are no movement joints. A polyethylene waterproof geomembrane was laid on the upper blinding slab.

Walls, slab and roof are super-insulated with 300 mm of expanded polystyrene (cfc free) with the mass on the inside of the insulation. The roof is covered with 400 mm of topsoil and the north side and terrace ends are buried in the ground.

The building envelope is clay brick for exposed exterior walls, using bricks fired from waste methane gas. All of the internal walls are wet plastered. There are no holes through the main slab for soil pipes or services so the insulation and membranes are not perforated.

The main doors and windows opening into the conservatory are triple glazed with low-e glass and argon filling, whilst the conservatory has double low-e glazing.

The solar space heating is completely passive; heat transfer from the conservatory to the house can be facilitated by opening windows if required.

The roof, walls and floor have a U-value of 0.11 W/m^2K and the triple glazed units 1.1.

Technical Systems

Ventilation is provided by opening windows in the external wall and glazed doors between the house and the conservatory. In addition, each house has a mechanical ventilation heat recovery (mvhr) system that supplies fresh air to living/bed rooms and extracts from the kitchen and bathroom.

Water is heated using an air-to-water heat pump and is stored in a heavily insulated 1,500 litre plastic tank in the utility room. The system is maximised by drawing air from the top of the conservatory to gain the benefit of solar heating and uses less than a third of energy required for a conventional system.

Other energy conservation measures include predominant use of low energy light bulbs, laptop computers and purchase of appliances that are highly energy-efficient. Appliances are not left on standby and clothes dried on conservatory racks rather than tumble-dryers.

Space heating relies totally on heat from solar gain and incidental gains from occupation. The heat is stored in the mass of the buildings (e.g. concrete/ blockwork) and released when the air temperature drops below that of the building fabric.

The elevation design makes good use of low winter sun penetrating to the back of the dwellings and provides good internal daylighting as well as maximising on passive solar gain through the conservatories. The trees on the southern boundary are all deciduous so do not block sunlight once they lose their leaves in autumn. During the summer, shading is created within the homes due to the high angle of the sun - this reduces thermal gain and brightness inside, when it is least wanted.

A 5kW wind turbine and a 7.65kW array of photovoltaics generate almost as much energy as used by the homes. The HHP wind turbine is one of very few examples in the UK of a community owned wind turbine, whereby the owners are supplied directly with the 'clean' renewable energy produced.

Energy performance

The Government sponsored monitoring programme [New Practice Profile 119] was conducted over the 1st year of occupation only (1998/1999), as part of the Energy Efficiency Best Practice Programme. The total energy consumption of the 5 homes during the monitoring period was 20,500 kWh. This represents just over 4000 kWh per house and around 11kWh per house per day. This compares to an energy use of about 25% of conventional new UK housing, and only about 10% of current UK building stock.

Some of the internal monitoring has continued by HHP occupants themselves.

Max/ min temps [in one house] for porch, conservatory, main house and main house ground slab have been recorded together with an 'ambient' internal air temp [taken approx. 8am each morning] in order to give a realistic picture of the dynamics of temperature fluctuations in the houses. These are cross- referenced with temperature readings in the other houses. The energy consumption of each of the five houses is monitored on a quarterly basis. Note the lower usages compared to the monitored data.

	House				
	1	2	3	4	5
Occupation profile					
Adults	2	2	1	2	1
Teens	0	0	1	2	0
Children	3	3	0	0	0
Key variability of facilities between homes					
TV[s]	0	1	1	2	0
Heat pump [water]	Yes	Yes	No	Yes	Yes
Home working	Yes	Yes	No	Yes	No
Energy use (average over period – 1998 -2002)					
kWhr/year	**3002**	**3625**	**3482**	**4027**	**2743**
kWhr/day	8.22	9.93	9.54	11.03	7.51
[a]kWhr/m ^{2}/year	17.65	21.3	17.5	23.68	16.25
[b]kWhr/m ^{2}/year (internal)	23.69	28.6	23.55	31.78	21.65

Marketing Strategy

The homes were self-built by the occupants. Since 1998, only one house has changed ownership. In 2002, one of the homes was sold within months of becoming available. Due to the unusual nature of the project, estate agent services were conducted by the project itself who contacted people that had expressed an interest in joining HHP. The house sold within weeks and the new occupants have happily settled in. It is unlikely that any other homes will be sold in the foreseeable future.

More recently the builder associated with HHP has gone on to build a pair of similar earth-sheltered dwellings on land adjacent to the site. These were commissioned by the landowners. HHP continues to be contacted weekly by individuals wanting to live in similar properties.

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Information (Publications:)

Hockerton Housing Project Information Pack – includes project details and its history, principles, design, construction methodology, services and also sections on autonomous housing and earth-sheltering to set the project in context.

Background Document - enshrines the foundation of the project, laying out its aims and objectives at the earliest stage.

Land Management Plan - an operational document, describing current usage and status (including records of biodiversity) of the land. It defines how the land must be developed in a sustainable way.

HHP Project Brochure - details of key aspects of project and suppliers.

The Sustainable Community – A Practical Guide (Hockerton Housing Project). Based on the experience of the Hockerton Housing Project (HHP), this 52-page guide aims to help others plan and set up their own sustainable projects.

Sustainable Housing Schemes in the UK – A guide with details of access (Hockerton Housing Project)- Profiles over 30 schemes as key case studies with details of access arrangements and further information.

Foley House, Rothesay, Isle of Bute, Scotland

International Energy Agency

IEA – SHC Task 28 / ECBCS Annex 38:

Sustainable Solar Housing

The project

In the western isles of Scotland, 14 flats have been built in 2003-04. After a protracted feasibility stage, where numerous housing alternatives for the site were, this low-impact design for the site was chosen.

The project team, the client and local planning were keen for the natural environment and the long standing hardwood trees on the site to remain but for the site to have a useful purpose in providing homes in the local area.

The building, which is circular, is not contemporary to the area but has a key advantage. It has a low impact on the surrounding area as it has a small and compact plan area. It is also reminiscent of Brochs and medieval tower designs prevalent around Scotland. The building houses 14 flats with either two or three bedrooms. It has an open plan main area encompassing living, dining and kitchen areas which lead to a terrace.

The apartments are for rental, and the tenants were moved in during the summer of '04.

Sustainable Objectives for the design

The sustainable targets set by the design team and the client will be met by:

• Protecting wildlife habitat and respecting the landscape and the distinctive identity of the proposed location.

• Provide and encourage genuinely participative forms of local democracy where citizens 'own' the ideas and the objectives and can work actively towards those objectives. We have adopted and promoted a holistic approach to the design, including the wider environmental and visual impact of the development on Rothesay, and have fully involved the Rothesay community in the process of design and planning.

• Strike the right balance between a reasonably high density of activity and dwellings necessary to support services and to provide green space and a feeling of well being.

• Make best use of the available technology and design to reduce energy use, waste and embodied energy in buildings to a minimum during construction and during occupation.

• Maximise accessibility paying particular attention to the importance of walking and cycling activities.

• Make a positive and quantifiable contribution to the reduction of greenhouse gases (CO2 and others) by using,

a). Triple glazing with super low-E and argon gas infill (Uvalue : 1.0 W/m2K)

b). Max levels of insulation and airtight construction. (U value: 0.12 W/m2K)

c). Heat recovering mechanical whole house system

d). Elimination of the dedicated central heating system

e). Additional insulation to Hot water tanks (100mm rather than 50mm)

• Use local resources (human and materials) to support the development

• Adopt best practice for sustainable development in the UK by DETR, 1999 through partnering etc.

• Contain the right ingredients to trigger and encourage a reduction in car dependency

• Finally, create an acceptable and successful design aesthetic and innovation.

Building Construction

The floor construction consists of 215 mm concrete base, 150 mm extruded polystyrene and 200 mm macadam. The U-value is approx 0.12 $W/m^2 \cdot K$.

The external walls consist of 300mm cavity with 275mm Fibreglass 'Dritherm' cavity insulation or equal with 25mm cavity . External walls are 100mm block with render, with 140mm dense concrete block internally. Brickwork externally to the stair areas. The internal surface is covered with foil-backed plaster board. The external wall has a U-value of 0.14 $W/m^2 \cdot K$.

The roof is finished with 0.7mm preformed zinc roofing trays with standing seam joints at 600cts fixed with stainless steel clips on ventilated 25x100 pine sarking boards (untreated) on timber roof trusses to SE details at 600cts. 400mm insulation quilt and vapour barrier at ceiling level. Zinc lined internal gutters laid to falls with proprietary rainwater roof outlets and leaf guard. The U-value is 0.12 $W/m^2 \cdot K$. On the terraces an Inverted roof comprising 50mm conc paving and gravel ballast verges on 150mm (roof) / 50mm (balcony) extruded polystyrene insulation on geotextile membrane on 20mm roofing asphalt, sheathing felt on screed. The U-value is 0.16 $W/m^2 \cdot K$ (roof terrace).

All windows to flats to be 'high performance triple glazed type timber casement window with external aluminium facings. Pre-stained finish. 25mm marine plywood box construction around window wrapped with vapour barrier. All joints sealed with tape. The U-value is 1.1 W/m²·K with the total amount of glazing approximately 15% of the floor area.

The flats main glazing is in the living area leading to the terrace, for passive solar gains. The balcony/ terrace above each flat has an overhang allowing an element of shelter from the summer solar gains as will the site which has, predominantly, mature broad-leaf trees that will provide shelter from the sun during the summer. Alternatively, the overhang is such that the flats may gain solar benefits during the winter.

It was important for the flats to be airtight during construction. With this in mind the architect placed special emphasis during construction on this issue, especially on details around the windows and the balconies.

Technical systems

· Passivent AV continuously operating ventilation system is used in the building powered by continuously running roof mounted extract fans within Passivent louvred terminal comprising :

Extracts – Ceiling mounted extract fixed to a ductwork system linked to a continuously running central extract fan. Extracts provide continuous extraction dependent upon relative humidity response. Min extract 8m^3/hr at 30% RH. Max 65m^3/hr at 90% RH.

Inlets – window mounted humidity responsive inlets complete with external canopy grille sited in habitable rooms only.

Space heating is provided by electric Duplex dual control heaters connected to a separate reading meter from the common electrical mains.

Energy Performance

Dunno

Costs and benefits

The passive systems in the building as well as the extra insulation aims to reduce space heating demand by 40% over a building meeting the current Scottish regulations.

Financing

Dunno

Project team

Client

Architect

QS

Engineer

Contractor

Contact person

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International Energy Agency

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	U-values (W/m2K)	Building Regulation requirements at time
Roof	0.2	0.25
Exposed external walls	0.2	0.45
Windows	2.16	3.0
Ground floor	0.35	0.45

The project

The project of 27 dwellings consists of six two-bed houses, two three-bed houses and 19 one-bed flats. Located on a brownfield site in the centre of Maidenhead, it was originally a car park with concrete garages that were mostly no longer in use. The site is ideally located for housing, being only five minutes walk from a railway station and ten minutes walk from the town centre.

The project was jointly funded by the Royal Borough of Windsor and Maidenhead and the Housing Corporation. Work on site began in 1999 and development was completed in September 2001.

Objectives

In 1998, housing association 'Housing Solutions' approached INTEGER with a scheme for a site in Maidenhead. The aim was to incorporate as many INTEGER elements of innovation in design, intelligence, environmental performance and construction process as possible in order to maximise the benefits to the future occupants. The design incorporated many innovative environmental features in which low energy use, and therefore low bills for tenants, was a central theme.

Building construction

Timber frame was the selected method of construction as it is sustainable and inherently thermally efficient. The timber frame was a 170mm engineered timber I-beam, which was filled with recycled cellulose insulation. I-beam construction offers additional thermal benefits as the beams prevent cold bridging.

All the ground floors were v313 chipboard on rigid insulation on a sand base. The upper floors were 30mm dry flooring, 22mm OSB (oriented strand board) on engineered timber joists with 100mm glass fibre quilt between joists for sound insulation. The ventilated roof spaces have 250mm recycled cellulose insulation fully covering the ceiling joists.

U-values of the houses and flats were well in excess of the Building Regulations at the time. These are shown in the table above.

For prefabrication of pods to be cost-effective, multiples of the same unit needed to be produced. In this scheme, plans for the 19 flats were amended at the design stage to enable repetition of the bathroom and part of the kitchen.

Building construction cont …

The kitchen was also altered so that all the mains services were located on the wall between the kitchen and the bathroom. This gave rise to a combined kitchen and bathroom open-ended pod with kitchen units already attached to one external pod end wall. A central service core was also included.

Although prefabricated pods were used for the flats, they were not considered cost effective for the houses because of the smaller number of units required. Using the pods saved an estimated £1,000 per flat.

The use of this type of pod system was reasonably successful, although the way in which the kitchen end of the pod was left open made it vulnerable to damage during storage, transportation and installation giving rise to issues of responsibility. It was also considered preferable to leave off the external linings in future pods, allowing a better finish to be achieved. The central service core was a success, although lessons were learnt about making clear the division between prefabrication plumbing and electrics and their on-site equivalents.

The dwellings were clad in Western Red Cedar. This is a low maintenance material requiring no preservative treatment. It contains natural oils and can be left without painting or varnishing for a natural look. It also changes colour to a more subtle silver shade; this should be considered when specifying, and explained to clients.

In this scheme the external cladding alternated between vertical and horizontal orientation to give each tenant in the flats a visible exterior boundary.

Cedar Cladding

This variation of orientation does mean high levels of wastage and it was recommended that this should only be carried out in future if there is an overriding rationale for doing so, rather than purely aesthetic reasons.

'Living' Green Roof

Another low maintenance sustainable feature was the 'green' roof. The roof is planted with chives, saxifrage and sedum, which are all tough flowering alpine plants with short roots. The roof is grown off site and is simply rolled out over a base. The sedum offers extra protection to the waterproofing layer and can extend the roof's lifetime by a factor of up to four. The plants are able to survive in periods of drought without extra attention.

The roof requires annual maintenance, and this is carried out by the supplier until it is established. The waterproofing system used is guaranteed for 20 years.

Passive stack ventilation extracts and light pipes were easily incorporated into the gently sloping green roof – whilst the steeper rear up-stand allowed for easy integration of the photovoltaic and solar water panels.

Technical Systems

Heating and Hot Water

A 3.3m² Solar Hot Water (SHW) panel was provided for each house. As there was insufficient space on the roofs of the flats for both photovoltaic and SHW panels, the PV potential was maximised instead.

The SHW panels have an efficiency rating of 80% and expected average output of 1.126 kW/h in the summer and 0.926 kW/h in the winter.

Each SWH panel is connected via a pressurised circuit into a copper double feed pre-insulated 160 litre storage cylinder with double primary coil for solar and boiler water heating. The life expectancy of these SWH panels is in excess of 25 years, with a five year guarantee.

Energy performance

The SAP ratings on this development ranged from 90-100 (this scheme was built prior to the raising of the maximum SAP rating from 100 to 120).

Gas provides all the heating and hot water needs; cooking is electric. The annual gas bill for the one-bed flats is currently £55 all-inclusive. This cost is less than for a typical one-bed flat partly due to the excellent energy performance of the buildings, but also due to the fact that Housing Solutions buy gas at a commercial rate through a bulk contract covering this the Greenfields project and another 20 sheltered schemes.

Dwelling Type	No. of dwellings	SAP rating	Annual predicted heating & hot water cost
One-bed flat	19	100	£97 (ground floor flat)
Two-bed house (mid terrace)	4	92	£184
Two-bed house (end terrace)	2	96	£181
Three-bed house (end terrace)	1	90	£209
Three-bed house mid terrace)	1	100	£197

Planning tools

An analysis was made of the site's relationship to the path of the sun and it was decided to place the buildings in a linear form close to the north-west boundary. This configuration enabled all of the homes to take advantage of the sunny aspect and of passive solar gain. There is a contrast in appearance between the sunny side of the buildings, south-west elevation, which is glazed and open and the north-east side, which has a denser exterior with fewer and smaller openings to minimise heat loss.

Costs and benefits

Total build costs of this project were approximately £2.4 million.

A further cost breakdown showing the cost of innovative features used in the project is shown below. To help meet some of these additional costs, Housing Solutions were able to secure DTI funding from the 100 Roofs PV Domestic Field Trial and the SMART Metering Programme.

Building Elements	**Inclusive Costs**
Kitchen / bathroom / airing cupboard / central service riser pods (15 flats)	£97,000
PV system (8 houses, 7 top floor flats)	£150,000
SHW system (8 houses)	£18,000
Passive stack ventilation vents (all 27 units)	£22,000
Grey Water System (all 27 units)	£46,000
Remote Monitoring (all 27 units)	£35,000

Marketing Strategy

INTEGER is the UK's leading action-research network promoting innovation in buildings using intelligent and green technologies. Since 1996, over 100 organisations have joined INTEGER as partners to find ways of delivering better performance and value in buildings. These organisations include designers, contractors and suppliers as well as housing providers, government agencies and research groups.

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The INTEGER Millenium House, Watford, UK

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing

Interior of INTEGER House

The project

The INTEGER Millennium House went from design to construction to completion to occupation within a period of eighteen weeks. There were no contracts involved and no budget as suppliers donated materials, expertise and time free of charge. This was a real team effort with the task of building one of the most innovative houses in the world. The process was captured for posterity by the BBC in the six-part, prime-time 'DreamHouse' series.

Since it opened in 1998, the INTEGER Millennium House has functioned as a demonstration house, showcasing the origins of the INTEGER concept. To date, over 5,000 people have visited it, with glowing commendations such as "I love it! Where can I buy one?" It is a house which has reached iconic status in Britain and around the world.

Objectives

Following a seminar entitled "Intelligent & Green?" in May 1996, a design team was formed to evaluate available design and technical solutions to improve housing performance. This culminated in the production of a model house and specification which has toured the world, showcasing what is possible in introducing innovation to housing.

During 1998, the design team set out to turn this model into reality. The project involved a wide range of partners from all areas of the housing sector, including materials and product suppliers and building professionals. They all contributed expertise, time and materials to the construction of a real intelligent and green house.

The house aimed to incorporate innovation in design, intelligence, environmental performance and the construction process, turning a dream of what was possible into the reality of a three-bedroom house.

Building construction

Materials for the building fabric were selected for sustainability, low embodied energy, long life and low maintenance.

A low maintenance turf roof provides good insulation, is visually attractive and provides a natural alternative to conventional roof materials.

Off-site fabrication of components included pre-cast concrete floor slabs and timber panels for the superstructure insulated with 170mm of cellulose recycled paper.

Integrated design and procurement. CAD drawings were issued by e-mail from designers to manufacturers. Pre-fabricated components were designed and agreed in a matter of days.

Standard components from the commercial glasshouse industry were used to construct the conservatory.

Bathroom modules similar to those originally designed for the off-shore oil industry were craned into the site as fully completed timber-framed rooms.

A central service core was used to distribute all of the pipework and cabling services vertically through the house. Structured cabling hidden behind removable skirting, and service voids behind the internal plasterboard walls allow for easy access for maintenance and upgrade.

Technical systems

A heat pump extracts energy from water circulating in a 50m deep borehole. Although the heat pump runs on electricity, it is very efficient using only one unit of electricity for every three units of heat provided.

Heating is delivered through under-floor trench heaters. Water is pumped at 50°C to bring the temperature up to that set by the individual room thermostat.

Solar water heaters mounted on the roof can provide free hot water at up to 95°C which is then pumped to a highly insulated hot water tank at 77°C. This water is then supplied at mains pressure around the house as required.

A grey water system treats and recycles water used for washing and bathing and re-uses it for flushing the toilet, reducing water usage by around 30%

Rainwater is collected, treated and stored in an underground tank for garden irrigation and car washing.

Soil humidity is monitored to ensure that the automatic garden irrigation systems only waters plants which need it.

Energy performance

The sophisticated yet user-friendly building management system ensures that the performance of the heating system is optimised, only operating it when heat is required.

An intelligent security system not only picks up intruders but also interacts with the lighting, heating and door control systems to ensure that no energy is wasted while the house is unoccupied. On returning home, all of the systems within the house 'wake-up' automatically to provide safety and comfort as soon as you step in the front door.

Marketing strategy

Many of the 5,000 visitors to the house have wanted to know where they can buy an INTEGER house, and why housebuilders are not offering this kind of product to the public. In this way, the INTEGER Millennium House has succeeded in creating an example of what is possible and also permitted people to raise their expectations of what housing quality can be. Not merely three bedrooms under a roof, but a tool through which lives can be improved.

The INTEGER House has received widespread media coverage - the most obvious example being the "Dreamhouse" series on BBC1 prime time and in forthcoming repeats.

INTEGER is the UK's leading action-research network promoting innovation in buildings using intelligent and green technologies. Since 1996, over 100 organisations have joined INTEGER as partners to find ways of delivering better performance and value in buildings. These organisations include designers, contractors and suppliers as well as housing providers, government agencies and research groups.

Planning tools

The construction of the INTEGER Millennium House was monitored by the BRE Calibre programme and some valuable lessons were learnt. As the House was so unique, it is difficult to make comparisons with a conventional housebuilding programme, but high measures of productivity, good teamwork, a non-confrontational approach, joint ownership of problems and good levels of interdependence between team members were noted.

Costs and benefits

The project was carried out as a demonstration with no budget. With suppliers donating their materials, expertise and time free of charge, it is difficult to make realistic cost assessments on this project.

Project team

Architects : Cole Thompson Associates, Bree Day Partnership, Paul Hodgkins Associates

Intelligent Systems : i&i limited

Building Services : Oscar Faber

Structural Engineer : Anthony Ward Partnership

Cost Consultant : The Andrews Partnership

Performance Measurement : Centre for Performance Improvement in Construction, BRE

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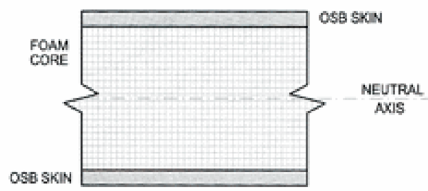
Demonstration houses in

Kansas City, MO USA

International Energy Agency

IEA – SCH Task 28 / ECBCS Annex 38:

Sustainable Solar Housing



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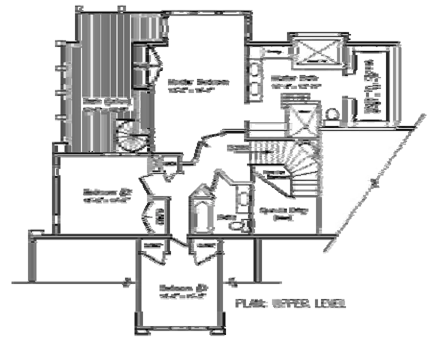


The project

Four single family detached homes built by Envision Development Corporation, a private corporation, are located in Raintree Lake Estates, Lee's Summit Missouri, USA. These homes were build in the estate section of this community and were built to accommodate the infill lot cost and up-scale location.

These homes are speculative homes and are for sale. They have also served as successful models for prospective clients who desire building.

They range in size from 3600 to 6300 square feet of conditioned space with 2200 to 4750 square feet of finished area. The fourth home was finished in September 2003.

Currently "Vision Homes" is breaking ground on a 70 acre private forest preserve near Lawson, Missouri. This new construction is a direct result of using the existing homes as a demonstration or showcase for the builder.

Objectives - Goals

The goal of was to construct platinum level "Build Green" homes as defined by local Home Builders Association (KCHBA) utilizing Energy Star (US EPA) and Health House (American Lung Association) standards with universal design elements.

A whole systems approach looked at site, energy, materials, Indoor Air Quality (IAQ) and Recycling opportunities.

For these Missouri (USA) homes with about 5400 heating degree days we considered construction costs, longevity, remodeling ease, maintenance and energy usage.

Building construction

4" Structural Insulated Panels (SIPS) along with 1" EFIS (exterior finish insulation system) were selected for wall panels because they were less expensive to build and were 15% more energy efficient than standard stick built 2X 6 construction. Walls as constructed have a U value of .05 or R-22. ICFS with non heat conducting ties were used below grade with a standard 8" concrete wall thickness. 2nd generation SIPS with fiber concrete outer walls is being used on current and future build jobs to reduce labor costs

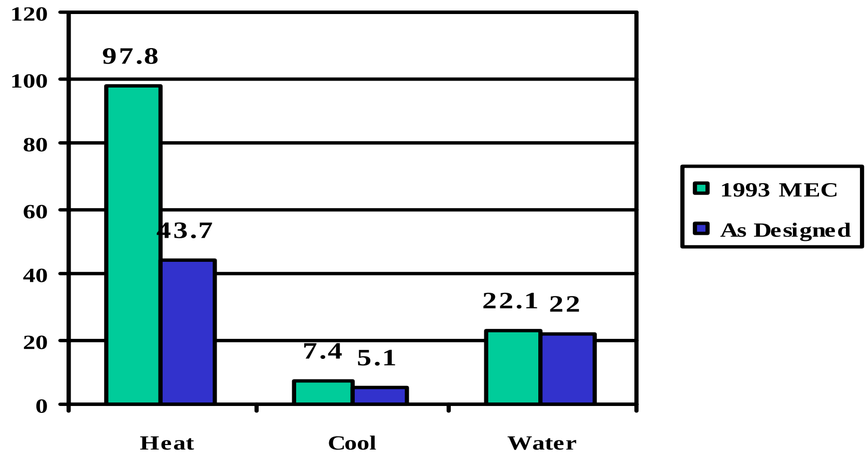
Basement insulation is 2-2" layers of R-Control EPS treated for termites with perform guard, R-value 3.85 per inch plus 8" concrete and ¼" air space and ½" gypsum board waterproofed with Platon for a total U value of .06 or R-17 (there is a capillary break between the foundation wall and the footing)

Roofs are of truss construction and insulated with 2.5" of icynene air tight spray-on insulation around perimeter and 10.5 inches (30.45cm) blow-in 85% recycled cellulose for a total U value of .02 or R-50.

Rim joists have 5" of icynene air tight spray-on insulation everywhere plus 3.5" of fiber-glass in unfinished areas for fire protection.

Windows are thermo-pane (2 panes), low-E, argon filled. U value ranges from .29 to .35, SHGC is .31 to .34 All windows were then sealed between the window and sill/jambs/head from the inside with 2.5" of icynene air tight spray-on insulation, R-3.85 per inch.

Savings in material usage was created from the use of engineered wood. We used OSB sheathed SIPS, OSB, fifty year warranted flooring, engineered floor joists, finger jointed studs, parallam beams and engineered roof trusses. the deck is a composite material made of recycled plastic and wood fiber and all of the carpet is PET recycled carpet.



Technical systems
Ventilation system, energy saving appliances, controls, energy supply system, solar energy utilization.

HVAC system is for 3608 sq. ft. of conditioned space on three floors, a heating load of 33,000 BTUs and a cooling load of 27,000 BTUs.

The heat source is a 66,000 BTU, 65 gallon gas fired sealed combustion, boiler rated, hot water heater with an 82 AFUE. This unit provides all domestic hot water and is also connected by pump to a coil heat exchanger in the air handler. Should it be desired this system could be attached directly to solar thermal panel. The fireplace (when used) is utilized for auxiliary heating.

Air ducts are installed in conditioned space. They are sealed with painted on water-based sealant.

The cooling units are typically 18 SEER 1 ½ - 3 ton variable speed electric air conditioner. The fresh air is supplied by a energy recovery ventilator that operates continuously and is ducted from the kitchen, baths and laundry. The air handler has a variable speed fan which runs continuously supplying from 700 cfm to 1500 cfm.

As the return air enters the air handler it passes an ultraviolet air treatment system and enters an electronic air filter which removes particles down to .3 microns, This system is expected to have purified the air to 99.75% germ/mold/bacteria free and filtered out all particles down to .3 microns.

Energy performance
Energy performance for the Ward Road house is based on the 1993 Model Energy Code, Section 402 that is typically better than the average home and is shown above. This is a one-of-a-kind custom “site” designed home built to accommodate the view. Solar orientation was not feasible. Other models show energy results of 50% less usage because of proper orientations.

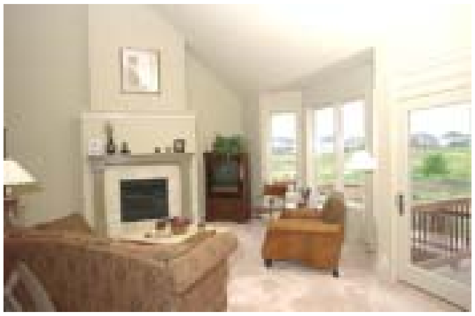
Annual energy consumption (MMBtu) and was verified as 5 Stars + with an energy rating point of 91.1

Total energy demand/yr kWh/m-sq. = 78.64
Heating and ventilation used/yr kWh/m-sq. = 46.45
Natural gas and electricity
Domestic hot water used/yr kWh/m-sq. = 17.14
Natural gas
Fans and pumps-in above numbers
Lights and appliances used/yr kWh/m-sq. = 15.04
This is from HERS calculations with defaults for appliances.

Costs
The construction costs for the Ward Road Home (not including land and sales fees are $107 per sq ft or $1151/ m^2. These homes are upscale homes with added costs for trim and décor’.

Planning Tools
REM DESIGN was used to develop our building envelope and REM RATE calculations were performed on six different plans before construction.

Air Ducts were tested tight with an air blaster and stage smoke and visible leaks were sealed during the test.



Market communications (MC) strategy

NeXus Environmental Consulting was retained in late 2003 to market the existing speculative homes as well as attract buyers for additional building throughout the greater Kansas City Region.

A Core Value Mosaic was developed along with consumer Benefit Ladders and SWOT analysis. Key demographic and psychographics sectors were identified. Most notably the growing influence of the emerging Cultural Creative (CC) consumer segment [1] was considered.

Competitive benefits and pinpointing branding opportunities has been the thrust of this campaign. An Integrated Market Communication strategy that uncovers these consumers is the focus of the execution strategy. It is primarily a relationship driven strategy.

The Execution Strategy:

Highly selective advertising aimed toward the local publications that the LOHAS [1, 2] consumer may read have been targeted. Advertisements have accompanied articles targeted to specific readership profiles. Advertisement in mainstream (Real Estate) publications are producing poor results.

Direct marketing has been limited (due to unavailability of appropriate list s for this segment), however, medical doctors, doctors of chiropractic as well as other "holistic" health care practitioners have been targeted for direct mail. Health clubs, gardening organizations and other selected affiliations are also being targeted.

Public relations programs include a series of articles in local publications along with local and national press release. Recent contacts from nationally syndicated TV shows and local newspapers have been forthcoming. The articles feature a small footer with contact points and web addresses have been successful.

Logo design is deemed extremely important to the Cultural Creative. Symbols are used to help brand the technical benefits of sustainable housing. Brand apostles among diverse CC companies have been recruited.

Current price points and floor plans were decided upon before NeXus was retained. There is a stronger demand toward the median price in the area. This is driven by demographics, but value based decisions are the primary reason customer contacts have been made for new construction.

As of this writing, trade presentations are planned. Cost sharing for publications will be among companies who supply materials as well as the builder and a local remodeled. After sale follow up consists of a newsletter periodically sent to homeowners.

References and Further Information

1. *A Compendium of Surveys in the US*, Guy Holt, November 2002 Update April 2004

2. The Natural Marketing Institute, *Understanding the LOHAS Consumer Group: A Focus on Green Building*

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Future Construction using these systems will be developed by Vision Homes.

Common text about Task 28