

Energy neutral house – The residential House+ concept

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Abstract

The Residential House+ concept (called Bolig+ in Danish) is developed in cooperation with many different parties in the building sector.

The House+ is an attractive house - beautiful, functional and inspiring. The House+ is very energy efficient and it is energy neutral (year to year), which means that it produces the same amount of energy as it consumes.

The House+ dogmas are:

- energy neutral (yearly basis) (Low energy class 1 – min. 50 % better than the demand in the DK building regulations 2006)
- intelligent and user-friendly
- flexible – in use and over time
- good and healthy indoor climate
- adapted to local surroundings

An international contest (project contest) will be carried out in 2007. A jury will evaluate the proposals according to the House+ dogmas.

The conceptual winning House+ projects (3 categories: Single-family house, high-density/low-rise housing, block of flats) will be published as “freeware” on the web.

The concrete winning projects will be carried out on a high quality level, technically, functionally, aesthetically and environmentally.



The concrete winning projects will be built in 2008-2009 and a comprehensive programme for measuring and evaluating the indoor climate and the energy consumption will be implemented in the houses.

The measurements will be performed with measuring devices communicating by an open and wireless standard, which means that installation of sensors and data gathering will be very simple and cheap.

The measuring and evaluation results from the house+ buildings will be promoted widely and the public will be invited to visit the houses.

The Residential House+ initiative is expected to show the next generation of residential houses.

References: See www.boligplus.org

Introduction and background

EU's need for a stable energy supply, the CO₂ abatement efforts and the global climate challenge has been implemented in EU-directives, climate strategies, national action plans for the energy sector, and parallel initiatives for reduction of energy consumption and greenhouse gases. Energy efficiency in building is in focus both at a national level, at the EU level and at a global level. Lately the EU-Commission's proposal for a

strategy for the climate and energy politics has set a target including a 20 %'s reduction of the energy consumption in 2020. A major part of this reduction will be realized through energy efficiency in buildings.

Regarding new buildings major improvements have been made in national building regulations, and a number of initiatives, such as low energy buildings, "Passiv Haus" and energy neutral buildings influence the development year by year.

The development of new buildings is important for two reasons: in the first place the development is both a cultural and technical challenge, secondly the targets, results and experiences from new buildings are used in action plans and policies for energy efficiency in existing buildings.

The dogma on energy neutrality in House+ should be seen in this context.

The Residential House+ concept is developed in cooperation with many different parties in the building sector in Denmark. The concept development started at an Energy Camp including representatives from many relevant parties and the process – defining the content and details – took place in 2006. In 2007 an international contest (project contest) will be carried out.

The House+ is an attractive house - beautiful, functional and inspiring. The House+ is very energy effective and it is energy neutral (year to year), which means that it produces the same amount of energy as it consumes.

The House+ dogmas are:

- energy neutral (yearly basis)(Low energy class 1 - min. 50 % better than the requirement in the DK building regulations 2006)
- intelligent and user-friendly
- flexible – in use and over time
- good and healthy indoor climate
- adapted to local surroundings

It is very important that a House+ is both an attractive house – beautiful, functional and inspiring – and very energy efficient. The house+ is energy neutral (year to year), which means that it produces the same amount of energy as it consumes. Furthermore it is Low energy class 1 – that means min. 50 %



Architecture and Energy. The Danish Building Research Institute (2006)

better than the minimum requirements in the DK building regulations 2006 – and remark: Based on calculations without adding the energy-production from the house itself, e.g. electricity from solar cells etc.

Overall general demands to House+ project

The House+ concept includes the five dogmas implemented in an architectural, functional and comprehensive design fit into the local context, considering local infrastructure, climate, geology, topography and ecology. At the same time the concept includes five overall demands:

- Building of high architectural quality, including design, function and materials
- Realistic and sturdy designs and solutions based on current practice
- A reasonable total-economy including implementation, operation and decommissioning
- Operational reliability and long life for systems, installations and constructions
- Simple and well-arranged interplay/symbiosis between constructions and installations (– and end-user) minimizing the energy consumption.



Arkitema(2006), The Ecological Council.



Architecture and energy. Rie Øhlenschlæger(2006)

The House+ dogmas

DOGMA 1: ENERGY NEUTRALITY

Annually, an energy neutral building does not use more energy from the outside than it returns. The returned energy has to be of the same or of a higher quality than the energy that is used (e.g. electricity supplied to the grid as compensation for purchased heat) and it should also have at least the same applicability (the building can e.g. not receive heat during winter and return it during summer).

In accordance with the Danish energy regulations and matching calculations, electricity is as a principle regarded to be 2½ times more valuable than other types of energy consumed or produced in the building.

Electricity produced using smaller PV-systems (< 6kW) can be delivered to the electricity network in Denmark, at the same price as the received electricity. If the “exported” production exceeds the “imported” electricity the difference has unfortunately no value. For larger PV-systems/plants a special agreement will be developed between the PV-owner and the energy company

Energy neutrality can be ensured through the design of the building, constructions and installations, including the utilisation of solar energy. The requirement to energy neutrality includes that each building must fulfil the energy framework for low energy buildings, class 1, calculated with the calculation program Be06, however not including possible electricity production in connection with the building, e.g. from solar cells.

Energy neutrality can apply to:

Buildings without common local energy system:

The individual building observes the definition of energy neutrality. The individual buildings observe the upper limits for low energy class 1 buildings.

Buildings with common local energy system:

The building incl. common energy system observes the definition of energy neutrality. The individual buildings observe the upper limit for low energy class 1 buildings.

Energy neutrality is documented via Be06 and the House+ toolkit by assembling of an energy balance that month pro month in a normal year shows:

- The monthly energy consumption divided on space heating, DHW and electricity.
- Energy received from the outside: from the local grid (electricity, district heating or gas) or as oil or biomass (e.g. wood, biofuels or biomass pellets).
- Energy that is returned to the local grid.

DOGMA 2: INTELLIGENT AND USERFRIENDLY

A House+ dwelling is equipped with systems that via control, measurements and demand control contribute to energy neutrality but also to increasing the utility value of the dwelling.

For instance – electric light only has to be on when natural daylight is insufficient and also only when users are present. The same conditions go for a number of other “energy services” – heat and indoor climate and electricity consuming equipment, e.g. PCs, TVs, radios etc.

In addition, a number of services interact – e.g. by switching off/limiting unnecessary artificial light combined with optimum use of solar shading it is possible to reduce the need for ventilation and at the same time obtain an improved indoor climate by avoiding excess heating. Optimized, intelligent use of the services can give reduced energy consumption and an improved indoor climate.

Simple and continuous feedback about the energy consumption and energy production to the users of the individual dwellings combined with control via a pedagogical user interface can contribute to: improved user patterns, a more appropriate control of heat and ventilation system and improved use of flexible components in the thermal envelope. In short – improved interplay between buildings, installations and users.

In addition to energy related functions the systems can fulfil other objectives such as local control, entertainment and communication.

When the conditions concerning energy tariffs and control of electricity consumption in the long run are provided, the systems can be equipped with an “Energy trader” that to a possible degree controls the electricity consumption and sale according to varying electricity prices. The “Energy trader” can give a possible financial advantage and also be an asset in connection with the visualisation of the energy users. The system can form part of the intelligent control of a dwelling but in principle it is not necessary in order to obtain energy neutrality as it does not by itself lead to a reduced energy consumption.

Well-documented combinations of known solutions are important. As far as possible the systems have to utilize open standards (plug and play suited) with expansion possibilities and wireless communication is preferred.

It will be possible to upload the collected data to the server of the Danish Electricity Saving Trust: www.sparel.selvcheckbolig.dk

DOGMA 3: FLEXIBLE – IN USE AND OVER TIME

This includes flexibility for use, flexibility for renovation and flexibility for adapting to different climatic conditions during the year.

The House+ has to be the physical frame related to the opportunities for various family structures - the traditional family etc. Flexibility means that the house can be adjusted to new conditions, e.g. the number of occupants, young families, families with grown up children, old and not so mobile people etc.

The flexible climatic shield can be replaced currently due to wear and tear and due to the fact that new technology gives new opportunities for more energy-optimized solutions. All components with a life time shorter than the building itself is replaceable in a simpel way in a House+. The basic constructions in a House+ have a long life time and are made in sturdy materials.

The climatic shield in a House+ is dynamical and varies during the year. The design of a flexible climatic shield is very close connected to the decisions regarding energy consumption, utilization of the house and habits of the occupants.

The agents can be dynamical facades, windows with shutters, sunshadings, double-facades, flexible utilization of the rooms, replaceable components of the building, flexibility in utilization of the installations (electricity, heating, water supply etc.).

DOGMA 4: GOOD AND HEALTHY INDOOR CLIMATE

This includes: Indoor air quality, daylight quality, thermal conditions and noise.

Building materials must not liberate gasses, solid polluting particles or ionizing radiation, which can result in unsatisfactory and unhealthy indoor climate conditions. Indoor air humidity has to be kept at a reasonable level. The daylight conditions in a House+ has to assure good and sufficient daylighting in a big part of the daytime. Draught etc. must not occur, uncomfortable temperatures must be avoided. Noise nuisance from outside and internal noise is minimized in a House+.

DOGMA 5: ADAPTATION TO LOCAL SURROUNDINGS

A House+ is adjusted to the local conditions, e.g. public and private energy supply, local drain off etc., sun and wind conditions, noise influence, air quality, surroundings and scenery. A House+ is low energy class 1 and has no compulsory energy supply.

A House+ building is situated, designed and shaped so that the local micro climatical conditions at the house are optimized. The daily experiences both inside and outside the house are very important.

Documentation of energy neutrality

The documentation of the buildings' and installations' performance (including renewable energy) is provided through input data and calculation results using the official and latest version of the Danish calculation tool Be06, while the documentation of fulfilling the overall demanded energy neutrality is provided using the House+ toolkit. Be06 is the official Danish tool for proving that a new building meets the requirements in the Building code (BR) regarding energy performance. Compliance with the demands in the BR is a necessity to obtain a building permit. Be06 also calculates compliance with the two low energy classes defined in BR.

The House+ toolkit is an Excel-tool used for verification and calculation of energy neutrality for a building, month by month and on a yearly basis.

The energy neutrality can be obtained through low energy class 1 buildings including thermal solar energy and photo-voltaics, glasshouses, flexible components (shutters, season insulation, ...), and temperature zoning.

LOW ENERGY CLASS 1

In the Danish building regulations BR95 addendum 12 and BR-S 98 addendum 9 the total energy consumption providing heating, ventilation, cooling (real and virtual), domestic hot water in low energy buildings is defined. The total energy consumption in a low energy class 1 building must not exceed:

$$35 + \frac{1100}{A} \quad kWh / m^2 \text{ per year}$$

where A is the heated gross floor area of the building.

Each House+ building must meet the low energy class 1 requirement without production of electricity.

OVER-HEATING PENALTY

If there is a calculated (Be06) indoor temperature above 26 °C, an over-heating penalty will be calculated as the amount of electricity needed to remove the excess heat by a mechanical cooling system having a COP of 2. The electricity consumption for this virtual cooling system is, as all other consumption of electricity, multiplied by a factor 2.5 before it is added to the calculated total energy consumption.

VENTILATION

Ventilation is one element where House+ deviates from the minimum requirements of the Building regulations. In House+ it will be allowed to use conditional ventilation as long as the indoor air quality and the moisture conditions is proven to be of a sufficient quality that causes no health risk or provokes decreased indoor air quality in terms of smells or mould growth.

Conditional ventilation will often require zoning of the ventilation system to ensure the largest possible efficiency, and have though impact on the lay-out of the ventilation system.

AIR-TIGHTNESS

The minimum requirement in BR is that the building does not have an uncontrolled air-change of more than 1.5 litres per m² heated gross area at a pressure difference of 50 Pascal.

The actual building will be subject to a blower door test when it is finished to prove its air-tightness. Both over- and under-pressure situation will be tested. The air-tightness demand must be fulfilled by the mean value for the two tests.

DOMESTIC HOT WATER

Domestic hot water (DHW) is included in the total energy consumption of the building.

The total DHW consumption must though be in the range from 15 to 60 m³ per dwelling per year. The consumption of domestic hot water is determined to be 45 litres per person per day. This equates to approximately 3 500 kWh/year for a family of four persons.

USE OF ELECTRICITY – LIGHT AND APPLIANCES

The electricity consumption for each house / flat is limited to 520 kWh (basic consumption) + 335 kWh/person + 1,6 kWh/m²

This equals approximately 2 100 kWh/year for a one family House+ of 150 m² with a family of four.

This relatively low consumption is obtained through (existing) energy efficient equipment combined with reasonable end user patterns. The 2 100 kWh covers: washing, dishwashing, combined refrigerator and freezer, cooking, light, IT, multimedia, TV and recording, and various smaller appliances.

International project contest

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References

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Acknowledgements

Many warm thanks to the whole House+ group with representatives from many different parties in the building sector in Denmark.