State of art in bioclimatic architecture and integration of renewable energies in buildings

Denmark, Norway, Spain and Sweden

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REGULATIONS

EUROPE

European regulations

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Report

To fulfil the objectives set out by the Kyoto Protocol, the European Community has established a series of energy and environmental policies. One of the actions undertaken is based on promoting energy efficiency, which also favours a more sustainable energy policy and constitutes an important element in the European Community's safety of supply, a subject which has aroused uneasiness in the last few years.

The service and housing sector, mainly made up of buildings, absorbs over 40% of the end consumption of energy in the Community and is in an expansion phase, a trend which will most likely augment energy consumption, and therefore, carbon dioxide emissions. The estimated energy savings potential in this sector is over 20%.

Directive 2002/91/CE of the European Parliament and the Council of 16 December 2002, relating to the energy performance of buildings, keeps with the framework of the Community's initiatives against climate change (Kyoto protocol obligations) and the safety of supply (the Green Book on the safety of supply).

The aim of this Directive is to establish a common framework destined to promoting the improved energetic performance of buildings, taking into account the exterior climactic conditions and local peculiarities, as well as the required interior environments and the cost-effectiveness relation.

This Directive's field of application refers to the residential and tertiary sectors (offices, public buildings, etc.). Nevertheless, some buildings are excluded from regulations relating to the certification, examples are historical buildings, industrial buildings, etc.

The Directive establishes requirements relating with:

- The general framework of a methodology to calculate the energy efficiency integrated into buildings.
- The application of minimum energy efficiency requirements for new buildings.
- The application of minimum energy efficiency requirements of existing large buildings which are the object of important renovations.
- The energy certification of buildings.
- The periodic inspection of boilers and air conditioning systems of buildings and the evaluation of the state of the heating installation with boilers over 15 years old.

The transposition of this directive in consortium countries has varied in rhythm and form. Below are the details on how it was conducted and what the current situation in each of the countries is: Denmark, Norway, Spain and Sweden.

DENMARK

Local regulations

General information

Regulation	Danish Building Regulations (BR), (2008) Danish Building Regulations for Small Dwelling (BR-S), (2006)
Source	www.buildup.eu www.en.sbi.dk http://vbn.aau.dk

Report

In 2005, the Danish Government presented an action plan for the energy field. This action plan will have an impact on Danish energy-saving initiatives in the years to come. The action plan includes a description of the Danish energy sector in the years leading up to 2025. One subject of the strategy is the climate policy related to the Kyoto Protocol, which entered into force on 16 February 2005. Signatory industrialized countries to the Protocol are obliged to limit their emissions of greenhouse gases between 2008 and 2012. As part of the internal distribution of obligations within the EU, Denmark must reduce its emissions by 21% before 2012 compared with 1990 emissions. Furthermore, the draft action plan contains energy saving initiatives that are intended to reduce domestic energy consumption by an average of 1% per annum from 2006 to 2012. In addition, the action plan also signals that long-term efforts must be made to keep energy consumption at current levels in the run-up to 2025.

The draft plan in particular focuses on energy consumption in buildings, where the largest and most cost-effective potential for energy savings lies. The new and most important initiatives are tightened energy provisions, introduced in 2006, in the Danish Building Regulations, an improved energy-labelling scheme, enhanced supervision of boilers and ventilation installation systems, and finally a number of energy-saving initiatives within the public sector.

The tightened energy provisions in the Building Regulations will apply both to new and existing buildings. Besides the strengthening of current regulations from 2006, the plan paves the way for a further strengthening in 2010, 2015 and in 2020. The tightened energy provisions in the building regulations of 2006 will result in an energy reduction of 25% for new buildings compared with the former Building Regulations. The new Building Regulations have had an impact on energy consumption in buildings, in that the regulations focus on the thermal envelope as well as the individual building components.

Energy Consumption in Danish Building Regulations, BR08

General

- Buildings must be constructed so as to avoid unnecessary energy consumption for heating, hot water, cooling, ventilation and lighting while at the same time achieving healthy conditions.
- Building elements facing the outside, including windows and doors, may only comprise negligible thermal bridges. The energy impact of thermal bridges must be factored into calculations of heat loss from each building element.
- Buildings and building elements, including windows and doors, must be built such that the heat loss is not significantly increased as a result of moisture, wind or unintended passage of air.
- Heat loss through building elements in buildings heated to a minimum of 5°C must comply with the provisions of 7.5.
- Building elements limiting rooms which are subjected to significant heat waste, such as boiler houses and bakeries, or which are only briefly, if ever, heated to above 5°C, must be thermally insulated as appropriate for their function.
- DS 418 Calculation of heat loss from buildings must be used when calculating transmission losses. The insulation properties of materials must be determined in accordance with relevant DS/EN standards.
- The provisions of this part do not apply to horticultural hothouses or greenhouses.

Energy performance frameworks for new buildings

- 7.2.1. General:
  - 7.2.1(1) The energy performance framework covers the total needs of the building for supplied energy for heating, ventilation, cooling, domestic hot water and, where appropriate, lighting. Energy provided by different types of energy supply must be weighted. Appendix 6, containing design assumptions, must be used to demonstrate compliance with the energy performance framework.
  - 7.2.1(2) Buildings heated to a minimum of 15°C must be designed such that the energy demand pursuant to 7.2.1(1) does not exceed the energy performance framework set out in 7.2.2 and 7.3.3.
  - 7.2.1(3) In mixed use buildings to which different energy performance frameworks apply, the overall heated floor area of the building must be subdivided into building sections with the same usage. This subdivision must be used to determine the energy performance framework for the whole building.
  - 7.2.1(4) Air changes through leakage in the building envelope may not exceed 1.5 $l/s/m^2$ of the heated floor area when tested at a pressure of 50 Pa. The result of the pressure test must be expressed as the average of measurements using overpressure and under pressure. For buildings with high ceilings, in which the surface area of the building envelope divided by the floor area is greater than 3, air changes may not exceed 0.5 l/s per m^2 of the building envelope.
  - 7.2.1(5) If air changes have been tested, the test results may be used to calculate the energy consumption through ventilation. If there is no documentation, 1.5 $l/s/m^2$ at 50 Pa must be used.
  - 7.2.1(6) Insulation of individual building elements in the building envelope must, however, be at least on a par with the values stated in 7.5.

- 7.2.1(7) Even if the energy performance framework has been complied with, the design transmission loss from single storey buildings, excluding the loss from windows and doors, may not exceed 6 W/m² of the building envelope, excluding windows and doors. For two-storey buildings, the corresponding transmission loss may not exceed 7 W/m², and for buildings of three or more storeys, the corresponding design transmission loss may not exceed 8 W/m² of the building envelope.

- 7.2.2. Energy performance frameworks for dwellings, student accommodations, hotels etc.
  - 7.2.2(1) The total demand of the building for energy supply for heating, ventilation, cooling and domestic hot water per m² of heated floor area may not exceed 70 kWh/m²/year plus 2200 kWh/year divided by the heated floor area.
  - 7.2.2(2) In buildings where the requirement of 6.3.1.2(1) for mechanical extraction from bathrooms, lavatories and kitchens leads to air changes exceeding 0.3 l/s/m² of heated floor area, the energy performance framework may be increased.

- 7.2.3. Energy performance frameworks for offices, schools, institutions, etc. not covered by 7.2.2:
  - 7.2.3(1) The total demand of the building for energy supply for heating, ventilation, cooling, domestic hot water and lighting per m² of heated floor area may not exceed 95 kWh/m²/year plus 2200 kWh/ year divided by the heated floor area.
  - 7.2.3(2) For buildings or building sections which need, for example, a high level of lighting, extra ventilation and high consumption of domestic hot water, or which are used for extended periods; or buildings with high ceilings, the energy performance framework may be increased by the resulting calculated energy consumption.

- 7.2.4. Low energy buildings:
  - 7.2.4.1 Low energy performance framework for dwellings, student accommodation, hotels, etc.
    - 7.2.4.1(1) A low energy performance framework for residential buildings, student residence halls/dormitories, hotels, etc., i.e. a building whose total demand for energy supply for heating, ventilation, cooling and domestic hot water per m² of heated floor area does not exceed 35 kWh/m²/year plus 1100 kWh/year divided by the heated floor area may be classified as a class 1 low energy building.
    - 7.2.4.1(2) A building whose total demand for energy supply for heating, ventilation, cooling and domestic hot water per m² of heated floor area does not exceed 50 kWh/m²/year plus 1600 kWh/year divided by the heated floor area may be classified as a class 2 low energy building.
  - 7.2.4.2 Low energy performance framework for offices, schools, institutions etc. not covered by 7.2.4.1.
    - 7.2.4.2(1) Offices, schools, institutions and other buildings not covered by 7.2.4.1 may be classified as class 1 low energy buildings if the need for supplied energy for heating, ventilation, cooling, domestic hot water and lighting per m² heated floor area does not exceed 50 kWh/m² per annum plus 1100 kWh per annum divided by the heated floor area.

- 7.2.4.2(2) Offices, schools, institutions and other buildings not covered by 7.2.4.1 may be classified as class 2 low energy buildings if the need for supplied energy for heating, ventilation, cooling, domestic hot water and lighting per m² heated floor area does not exceed 70 kWh/m² per annum plus 1600 kWh per annum divided by the heated floor area.

Minimum thermal insulation

- If the energy performance framework set out in 7.2 and the heat loss framework set out in 7.3.3 are used, the insulation of the individual building elements must at least correspond to the heat loss levels in the table below. Building elements around rooms that are heated to more than 5°C must also have thermal insulation which at least corresponds to the values shown in the table:

Table 1.1. U-values (W/m^2 K):

	W/m^2 K
External walls and basement walls in contact with the soil.	0.40
Partition walls adjoining rooms that are unheated or heated to a temperature more than 8 K lower than the temperature in the room concerned.	0.50
Suspended upper floors to rooms that are unheated or heated to a temperature more than 8 K lower than the temperature in the room concerned.	0.40
Ground slabs, basement floors in contact with the soil and suspended upper floors above open air or a ventilated crawl space.	0.30
Suspended floors below floors with underfloor heating adjoining rooms that are heated.	0.70
Ceiling and roof constructions, including jamb walls, flat roofs and sloping walls directly adjoining the roof.	0.25
Windows and external doors, including roofl ights, glass walls and hatches to the outside or to rooms that are unheated or heated to a temperature more than 8 K below the temperature in the room concerned.	2.00

Table 1.2. Linear losses (W/mK):

	W/mK
Foundations around spaces that are heated to a minimum of 5°C.	0.40
Foundations around floors with underfloor heating.	0.20
Joint between external wall and windows or external doors and hatches.	0.06
Joint between roof construction and windows in the roof or roof lights.	0.20

Energy certification

The requirements regarding the energy labelling (certification) of buildings (Article 7) has been adopted by the Danish Parliament by Act no. 585 of June 24, 2005 on Energy Savings in Buildings. Based on the act by Parliament the Danish Energy Authority has issued Decree no. 1294 of December 13, 2005 on Energy labelling of

Buildings (in Danish). Minor adjustments to the original decree are in decree no. 218 of March 20, 2006 and in decree no. 339 of April 19, 2006.

In the new energy labelling scheme buildings need an energy label:

- When they are new constructions.
- When they are sold.
- If rented out.

In the case of new buildings, the building needs to have a sufficient energy label to fulfil the energy requirements in the building regulations to be granted a permit for use. In the case of existing buildings being sold or rented out, the buildings must have an energy label of not more than 5 years old. This also applies to blocks of flats, where individual flats are rented out or sold. In blocks of flats the labelling is done on the building, but with an individual sub label for each flat stating the heating demand.

There are 14 classes on the labelling scale from A1 to G2, where A1 is the highest. The decision to have 14 classes on the labelling scale is based on the need to have a sufficient number of classes to make it possibly to improve the label by performing relevant energy saving measures in buildings of different ages and energy standards. New buildings must at least be labelled as class B1 to get the permit for use. Class A1 and A2 are for low energy buildings class 1 and 2.

Energy labelling of existing buildings must conform to the new standards from September 1, 2006. Until then, the energy labelling conformed to the existing Danish energy labelling scheme. The reason for a transition period was to allow time needed to incorporate the labelling system into computer programs.

Inspection of boilers and heating systems

The requirements regarding the inspection of boilers and heating systems (Article 8) are in Decree no. 1296 of December 13, 2005 on Inspection of Boilers and Heating Systems in Buildings from the Danish Energy Authority (in Danish) in addition in Decree no. 217 of March 20, 2006. The inspections of boiler and heating systems are based on the same act as the energy labelling scheme.

The inspection of boilers and heating systems were implemented on September 1, 2006, on the same date as the energy labelling plan. Denmark had already an inspection plan for oil-fired burners.

Inspection of air conditioning and ventilation systems

It is expected that the new scheme for inspection of air conditioning (Article 9) will also include inspection of large ventilation systems. The new plan is expected to be implemented from January 1, 2007.

Future energy saving in building

Irrespective of the EPBD the Danish government and parliament has had for many years ongoing plans for energy savings in buildings. According to the latest plan, decided in the Danish Parliament on June 10, 2005, further energy saving must be achieved in new buildings by 2010 and 2015. The target is to save an additional 25 % and 50 % compared to new buildings fulfilling the requirement from April 1, 2006. This corresponds very well with the definition of low energy building Classes 1 and 2. The aim is also to achieve further savings in existing buildings.

NORWAY

Local regulations

General information

Regulation	TEK (2007)
Source	www.buildup.eu www.be.no

Report

Energikravene i tekniske forskrifter til plan-og bygningsloven (TEK)

The national building regulations in Norway have been revised and tightened several times since the first numerical requirements were introduced in 1949. The purpose of the recurrent upgrades has basically been to reduce the heating demand, thus reducing the overall energy use in buildings.

As a consequence of the Norwegian partnership in the EEC, Norway is obliged to implement the EU Energy Performance of Buildings Directive in the national laws and regulations. Thus, the new building codes and guidelines are also revised. While the former regulations concerned buildings' heating energy demand, the new regulations incorporate all energy needed to operate the building.

There are two ways to fulfil the new energy regulations for a building:

- Energy measure method (Energitiltak).
- Energy frame method (Energirammer).

The so-called Energy measure method (Energitiltak) has set requirements for certain building elements and installations.

Table 1.1. The measures of the new building regulations for commercial and residential buildings:

	TEK 2007	
	Commercial	**Residential**
Glass and door area [a]	20 %	20 %
U-value external wall (W/m^2K)	0.18	0.18
U-value roof (W/m^2K)	0.13	0.13
U-value floor on ground (W/m^2K)	0.15	0.15
U-value windows and doors [b] (W/m^2K)	1.20	1.20
U-value glazed walls and roofs (W/m^2K)	same as for windows	same as for windows
Normalized thermal bridge value (W/m^2)	0.06	0.03
Air tightness [c] (ach)	1.5	2.5
Heat recovery [d] (%)	70	70
Specific fan power (SFP) ($kW/(m^3/s)$)	2.0/1.0 [e]	2.5
Local cooling	shall be avoided [f]	shall be avoided [f]
Temperature control	night set-back to 19°C	night set-back to 19°C

[a] maximum percentage of the buildings heated floor area as defined in NS3031.

[b] incl. Frames.

[c] air changes per hour at 50Pa pressure.

[d] annual mean temperature efficiency.

[e] SFP day/night.

[f] automatic sun shading devices or other measures should be used to fulfil the thermal comfort requirements without use of local cooling equipment.

Alternatively, if the net energy demand for the building, calculated according to the methodology established in the new Norwegian Standard prNS3031 (2007), is within the energy frame for the building's category, the regulations are also satisfied. The frame for aggregate net energy demand for different building types is shown in Table 1.2. Since the frame is based on net specific energy demand per year, the efficiencies of the energy systems are not taken into account. This means that for example the coefficient of performance of a highly efficient mechanical cooling system is not rewarded. However, passive measures that reduce the net cooling demand will contribute to satisfy the energy frame. This has led to a renewed interest in utilizing passive measures to decrease the total energy used in buildings.

Table 1.2. Energy frame according to TEK § 8-21 b:

	kWh/m² (heated floor area)a /yr
Small house	125 [b]
Apartment building	120
Kindergarten	150
Office building	165
School	135
University / High School	180
Hospital	325
Nursing home	235
Hotel	240
Sport arena / Stadium	185
Commercial building	235
Cultural building / Museum	180
Light industry / Repair shop	185

[a] heated floor area as defined in NS3031.

[b] +1600/m² (heated floor area).

However, there still exist minimum requirements concerning the U-values and air tightness of the building envelope which help to maintain a good insulation standard.

Table 1.3. Minimum insulation requirements:

	Usual buildings
U-value external wall (W/m²K) [a]	0.22
U-value roof (W/m²K)	0.18
U-value floor on ground (W/m²K)	0.18
U-value windows and doors [b] (W/m²K)	1.60
Air tightness [c] (ach)	3.0

[a] maximum percentage of the buildings heated floor area as defined in NS3031.

[b] incl. Frames.

[c] air changes per hour at 50Pa pressure.

Definitions of a Passivhus

The concept "passivhus" for a building in Norway is relatively new. It has been imported from Germany and the requirements that have to be fulfilled have been adopted. The standard is voluntary with the Passivhaus-Institut in Darmstadt, Germany as the certifying institution. In the definition of a *passivhus,* the German requirements have to be fulfilled. Recently, it has been discussed to adjust it to the Nordic climate.

Spain

Local regulations

General information

Regulation	Building Technical Code (CTE), (2006) Regulations on Building Heating Installations (RITE), (2007) Basic Procedure for the Certification of Energy Efficiency in Newly Constructed Buildings (2007)
Source	www.buildup.eu www.mviv.es www.idae.es

Report

The transposition of this directive has been conducted through the approval of three laws: the Spanish Building Technical Code, the basic Procedure to certify energy efficiency in newly constructed buildings and the RITE (Regulations on Building Heating Installations).

Building Technical Code

The Building Technical Code is the newly structured regulation framework which identifies, orders and completes the existing technical regulations in Spain and intends to facilitate its application and compliance, all in harmony with the European regulations. It was approved on the 17 March, 2006 in Royal Decree 314/2006 and published in the Official Gazette on 28 March.

The Building Technical Code complies with the basic building requirements established in the Building Standards Law, with the aim to guarantee the safety of individuals, the wellbeing of society, building sustainability and the protection of the environment. It also intends to comply in part with Directive 2002/91/CE, corresponding specifically with the energy efficiency requirements (articles 4, 5 and 6).

The Code is divided into two parts; both are of a regulatory nature. The first contains the regulations of a general nature (field of application, structure, classification of uses, etc…) and the demands which buildings must comply with to satisfy the safety and habitability requirements of the building.

The second part is made up by the Basic Documents which guarantee compliance with the basic requirements. It contains procedures, technical regulations and examples of solutions which determine if the building complies with the established levels of compliance. Said Documents are not exclusive. To compliment the application of the Code, the Recognized Documents were created like those independent and external technical documents from the Code which are used to comply with certain requirements and contribute to promoting quality in construction.

The objective of the CTE's Energy Saving DB-HE Basic Document is to obtain a rational use of the necessary energy to be used in buildings, reducing their energy consumption and using renewable energy sources. It establishes limitations which lead to controlled demands; to do this it proposes two options: a simplified option and a general option:

- The so called simplified option, based on an indirect control of the building's energy demand, the characteristic parameters of the enclosures and partitions which make up its thermal envelope are limited.
- The general option evaluates the energy demand of the building by comparing it with a corresponding building of reference which defines the option itself.

The evaluation of the general option is done with a software program which develops the calculation method outlined by the Basic Document. The official version of this program is called Energy Demand Limitation, LIDER, and is a recognized document by the CTE, being available to the public.

The energy demand of buildings is limited by the climate of the area where it is located and the internal load of its spaces. 12 climate zones have been established and identified by means of a letter, corresponding to the division in winter, and a number, corresponding to the division in summer.

The energy demand will be inferior to a building's in which the characteristic parameters of the enclosures and interior partitions which make up its thermal enclosure are the limit values established in table 1.1.

Table 1.1. Transmittance limit (W/m^{2}K):

Climate Zone	A3	A4	B3	B4	C1	C2	C3	C4	D1	D2	D3	E1
Façade walls and enclosures in contact with the terrain	0.94	0.94	0.82	0.82	0.73	0.73	0.73	0.73	0.66	0.66	0.66	0.57
Floors	0.53	0.53	0.52	0.52	0.50	0.50	0.50	0.50	0.49	0.49	0.49	0.48
Roofs	0.50	0.50	0.45	0.45	0.41	0.41	0.41	0.41	0.38	0.38	0.38	0.35
Solar factor modified skylight limit	0.29	0.29	0.30	0.28	0.37	0.32	0.28	0.27	0.36	0.31	0.28	0.36

In the case of the spaces, the transfer limit depends on the climate zone, the percentage of openings in the façade and the orientation of the openings. That way, the limit values oscillate between 1.9 W/m^{2}K in the spaces with a percentage between 51-60% oriented to the north in an E1 climate zone to 5.7 W/m^{2}K for any orientation in the A3 and A4 zones with percentages between 0 and 10%.

To avoid imbalances between the thermal quality of different spaces, each of the interior partitions and enclosures of the thermal envelope will have a transmittance no greater than the values indicated in table 1.2. in terms of which climate zone the building is located in.

Table 1.2. Maximum thermal transmittance of interior partitions and enclosures of the thermal envelope (U en W/m″ K):

Climate Zones	A	B	C	D	E
Façade walls, interior partitions in contact with non-living spaces, first metre of the floor perimeter resting on the terrain (1) and the first metre of walls in contact with the terrain	1.22	1.07	0.95	0.86	0.74
Floors	0.69	0.68	0.65	0.64	0.62
Roofs	0.65	0.59	0.53	0.49	0.46
Glass and frames(2	5.70	5.70	4.40	3.50	3.10
Party walls	1.22	1.07	1.00	1.00	1.00

(1) Including slabs or bottom plates buried at a depth no greater than 0.5 m

(2) Thermal transmissions from glass and frames will be compared separately.

The Building Technical Code also includes the minimum solar contribution of domestic hot water (HE-4) and the minimum photovoltaic contribution of electric energy (HE-5).

The minimum solar contribution of domestic hot water is applicable to new constructions and renovated buildings of any use in which there is a demand for domestic hot water and/or the heating of an indoor pool.

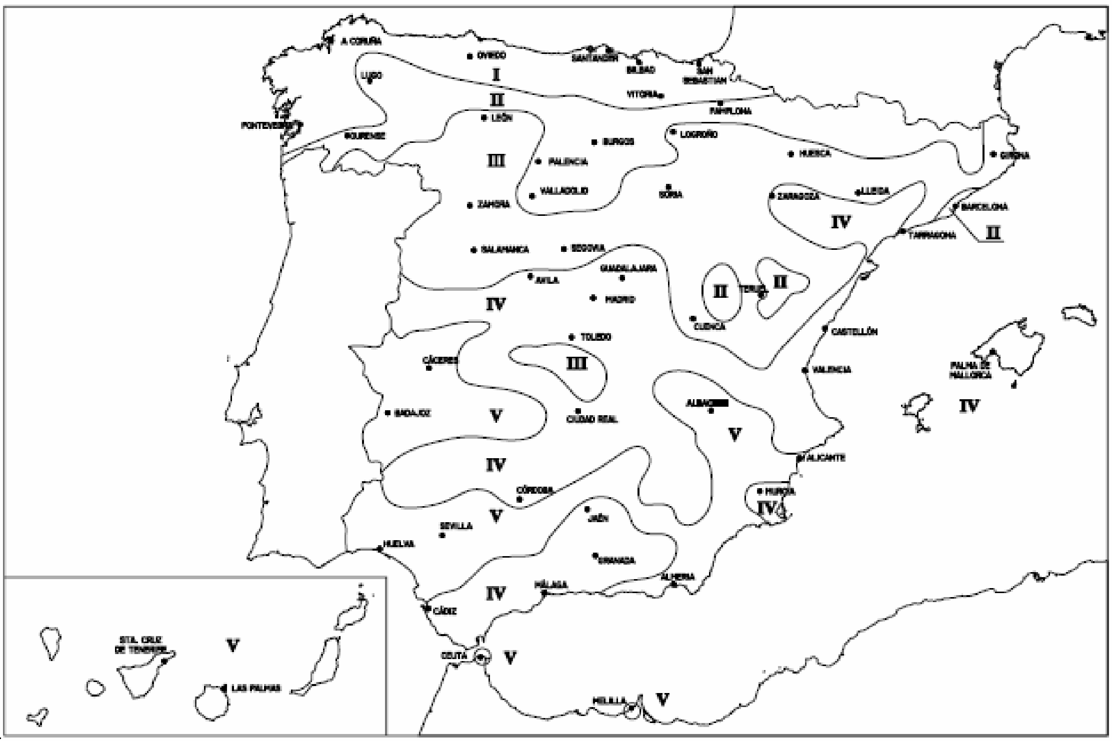
The minimum annual solar contribution is the fraction between the annual values of the solar energy contributed and the annual energy demanded, obtained from monthly values. This demand varies in function of the climate zone, the demand for domestic hot water (DHW) and the support system: general (diesel, propane, natural gas or others) or the Joule effect (electricity).

This percentage varies between 30% in climate zone I for a demand between 50-5,000 litres/day at 70% of zone V for any DHW demand.

The zones have been defined by taking into account the annual daily average of the Overall Solar Radiation on a horizontal (H) surface.

Table 1.3. Overall solar radiation:

Climate Zone	**kWh/m^2**
I	$H < 3.8$
II	$3.8 \leq H < 4.2$
III	$4.2 \leq H < 4.6$
IV	$4.6 \leq H < 5.0$
V	$H \geq 5.0$



The minimum photovoltaic contribution of HE-5 electrical energy establishes that the buildings destined to certain uses will incorporate solar energy transformation and capture systems through photovoltaic procedures when they exceed the limits established in said table.

Table 1.4. Field of application:

Type of use	Limit of application
Hypermarket	5,000 m^2 constructed
Department stores and entertainment centres	3,000 m^2 constructed
Warehouse	10,000 m^2 constructed
Administrative	4,000 m^2 constructed
Hotels and hostels	100 rooms
Hospitals and clinics	100 beds
Pavilions and fair grounds	10,000 m^2 constructed

The minimum electrical power to install is determined by the building's use, surface and climate zone it is found in. In any case, the peak minimal power to install will be 6.25 kWp.

Royal Decree 47/2007: Basic procedure to certify newly constructed buildings' energy efficiency.

This royal decree establishes the Basic Procedures which must fulfil the methodology to calculate the classification of the Buildings' energy efficiency which will initiate the certification process, considering those factors which most effect the consumption of energy in buildings. It also establishes the administrative and technical conditions for the certification of energy efficiency in projects and finished buildings.

Royal Decree 47/2007 of 19 January, will be in force 3 months after its publication, its application will be voluntary during a 6 month period. From that point on (31 October, 2007) the building projects which solicit a building license must comply with the regulations set out in this Royal Decree.

The energy efficiency classification will be calculated in accordance with the method of calculation established below. The simplified prescriptive option can be used, or the general performance option, by means of a software of Reference (called CALENER) or by means of alternative software which comply with the technical specifications of the calculation method and are recognized by the Ministry of Industry, Tourism and Commerce and the Ministry of Housing, at the proposal of the Advisory Committee.

This programme has two versions:

- CALENER_VYP, for Housing and Small and Medium Tertiary (autonomous teams).
- CALENER_GT, for large buildings in the tertiary sector.

Its method of use is based on the system named «auto-referente» (*self-reference*), by which the building to be certified is compared with another of reference which fulfils certain regulatory conditions and is evaluated to see if it has the same or superior energy efficiency.

The building to be certified will be considered as it was projected in geometry (shape and size), orientation and installations.

The building of reference, which will serve to compare with the building to be certified, must have the following characteristics among others:

- The same shape and size as the building to certify.
- The same interior zoning and the same use in each zone which the building to be certified has.
- Construction qualities which guarantee compliance with the minimum requirements of energy efficiency which figure in the simplified option in section HE1 –Limitation of Energy Demand– from the basic energy saving document of the Building Technical Code.
- The thermal installations of reference in function of the use and service of the building will comply with the minimum requirements of energy efficiency which figure in section HE 2 –Performance of thermal installations developed in the Regulations on Building Heating Installations (RITE) and in section HE 4 –Minimum solar contribution to domestic hot water – from the energy savings document from the Building Technical Code.

The calculation of the energy efficiency classification will be done by considering the building's normal conditions of use and occupation; these will be included in a recognized document, in function of the buildings' different uses.

When software is used, it must calculate the final energy consumption hour by hour by calculating the hourly demand and the calculation of average hourly demand and the calculation of the hourly output of the systems which cover the needs previously outlined.

The reach of the software, both those of Reference and Alternatives must contemplate the following aspects:

- Distribution and orientation of the building.
- Interior environmental conditions and exterior climate conditions.
- Thermal characteristics of the enclosures.
- Solar protection and passive solar systems.
- Thermal installations of collective and individual buildings (heating, refrigeration, ventilation and hot water production) and urban refrigeration and heating systems; including the characteristics of conduit and pipe insulation.
- Natural ventilation.
- Installation of artificial interior lighting.
- Natural lighting.
- Active solar systems or other heating or electricity producing systems based on renewable energy sources.
- Electricity produced through cogeneration.

The energy efficiency grade assigned to the building will correspond with the energy efficiency grade index it has obtained, within a scale of seven letters which goes from letter A (the most efficient building) to G (the least efficient).

Regulations on Building Heating Installations (RITE)

The Regulations on Building Heating Installations (RITE) establish the conditions which the heating, air conditioning and domestic hot water installations, destined to fulfil the hygiene and thermal wellbeing conditions, must comply with to achieve a rational use of energy. These regulations were approved by Royal Decree 1027/2007 of the 20 July, 2007.

The new regulations have a new focus based on performance or objectives, expressing the requirements that the thermal installations must satisfy without obligating the use of a determined technique or material, or impeding the introduction of new technologies and design concepts, rather than the prescriptive regulations which consisted in a group of detailed technical specifications which present the inconvenience of limiting the range of acceptable solutions and impede the use of new products and innovative techniques.

The greatest demands in energy efficiency established by RITE are specifically:

- Greater Energy Output of the equipment to generate heat and cold as well as those destined to the movement and transportation of fluids.
- Greater insulation of thermal fluid conduits and equipment.
- Better regulation and control to maintain design conditions in air-conditioned buildings.
- The use of renewable energies available, especially solar energy and biomass.
- The incorporation of energy recovery subsystems and the exploitation of residual energies.

- Obligatory consumption accounting systems in the case of collective installations.
- The gradual disappearance of more contaminating solid fuels.
- The gradual disappearance of less efficient generation equipment.

RITE also imposes the obligation to periodically update and review the demands of energy efficiency at least every 5 years.

SWEDEN

Local regulations

General information

Regulation	Boverkets Building Regulations (BBR), (2008)
Source	www.buildup.eu www.boverket.se

Report

Regulations set by the National Board of Housing, Building and Planning – BBR 2008

The implementation of the EPBD in Sweden is the responsibility of the Ministry of Enterprise, Energy and Communications and the National Board of Housing, Building and Planning (Boverket).

On June 21, 2006, the Parliament of Sweden adopted the Law regarding the transposition of the EPBD in national law, which came into force on October 1, 2006. The Government then adopted the ordinance, which came into force on February 1, 2007. On March 1, 2007, the regulations from the National Board of Housing, Building and Planning came into force.

On 1 April 2008 was 10 § of the construction regulation, BVF, with transitional arrangements until 1 January 2010. There are now including more stringent requirements on energy conservation and use of electricity, regardless of the type of heating used.

BBR08 entered into force 1 July 2008 and included new and stricter requirements. The section referring to energy indicates:

- General Buildings should be designed so that energy use is restricted by low heat loss, low cooling requirements, efficient heating and cooling usage and effectiveness electricity use. (BFS 2006:12).
- These rules apply to all buildings except for:
  - Greenhouse or similar buildings which could be used for its purpose if these requirements had to be met.
  - Buildings or parts of buildings used only for short periods.
  - Buildings with no heating or cooling demand exists for most of the year.

- Homes:

Housing should be designed so that specific energy consumption is less than or equal to 110 kWh per m^2 of floor area (Atemp) and years of climate and south 130 kWh per m^2 of floor area (Atemp) and years in northern climate zone.

For one and two dwelling buildings with direct electric heating as their main heating source, specific energy consumption may not exceed 75 kWh per m^2 of floor area (Atemp) and years in the south climate zone and 95 kWh per m^2 floor area (Atemp) and years in northern climate zone. (BFS 2006:12).

The building's energy consumption should be measured for a continuous 12-month period, completed within 24 months after the building is put into use. Normal correction and possible correction of abnormalities. The use of hot water and ventilation should be reported in a separate investigation. (BFS 2006:12).

- Premises:

Premises should be designed so that specific energy consumption amounts to 100 kWh per m^2 of floor area (Atemp) and years of climate and south 120 kWh per m^2 of floor area (Atemp) and years in northern climate zone. For rooms with an outdoor air flow of 0.35 l / s, m^2 may be a supplement equal to 70 (q-0, 35) per kWh m^2 floor area (Atemp) and years in the south and the climate zone 90 (q-0, 35) kWh per m^2 floor area (Atemp) and years in northern climate, where q is the average over outdoor air flor entire heating season (l / s, m^2). (BFS 2006:12).

The highest heat transfer coefficient (Ui) may, for immersive building components (AOM), not exceed the values in the Table 1.1.

Table 1.1. Maximum U-values:

	Ui (W/m²K)
Roof	0.13
Wall	0.18
Floor	0.15
Window	1.3
Front door	1.3

In cases where direct electric heating is installed as the primary source of heat in the two dwelling buildings, it shall not exceed the values in Table 1.2.

Table 1.2. Maximum U-values:

	Ui (W/m²K)
Roof	0.08
Wall	0.10
Floor	0.10
Window	1.1
Front door	1.1

The building's climate-screen should be as close to the average air leakage at + 50 Pa pressure difference does not exceed 0.6 l / s m^2. For this purpose, the area AOM used. (BFS 2006:12).

- Heating and cooling:

Installations for heating and cooling of buildings should be designed so as to provide good efficiency in normal operation. (BFS 2006:12). Heating and cooling installations and installations for domestic hot water preparation should be designed and insulated so that energy losses are limited. The need for cooling is minimized by the construction and installation of technological measures. (BFS 2006:12).

- Efficient use of electricity:

Architectural installations that require electricity, such as ventilation, solid installed lighting, heaters, circulation pumps and motors shall be designed so that the power requirements and limited energy is used efficiently. (BFS 2006:12).

- Measuring systems for energy:

The building's energy use should be continuously monitored by measurement systems. The measurement system should be able to be read so that the building's energy use for the desired time period can be calculated. (BFS 2006:12).

Definitions of a Passivhus

To be allowed to use the concept “passivhus” for a building in Sweden there are some requirements that have to be fulfilled. This is a voluntary standard that has been prepared by the Forum for Energy Efficient Buildings. In the definition of a passivhus, the German requirements have been taken into consideration but adjusted to the Nordic climate.

Requirements for existing buildings

The requirements for existing buildings are under revision. The existing regulations state that if the building is renovated or expanded, the changed part of the building should fulfil the requirements for new buildings. There may be exceptions from this for e.g. Cultural or listed buildings.

Certification of buildings

Certification is obligatory for new buildings after 1 January 2009. For public buildings and multi-family houses, a certification is mandatory from the 31st December 2008. Other buildings, when rented or sold must have an energy performance certificate from 1st January 2009.

Information about boilers and inspection of air conditioning

Information about boilers was done by The Swedish Energy Agency. The procedures for inspection of air conditioning systems started 1st January 2009. The size of the system, the cooling need of the building and cost-effective measures estimate the efficiency of the system and help the owner to improve the efficiency.

REFERENCES

DENMARK

Eco-neighbourhoods / Eco-cities

AGERNSKRÆNTEN

Denmark

General information

Name: Agernskrænten	**Location:** Ballerup, Denmark	**Year:** 1994
Architect: Hennings Larsens Tegnestue		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Good thermal insulation; heat recovery; solar thermal power; energy management system (EMS); new type of ventilation system (TermoVex).		
Prizes: _		
Sources: www.ecobuilding.dk/download/EHEN93-kort2310.doc		

Report

Agernskrænten is situated in a new town development area, Egebjerggaard, in the municipality of Ballerup near Copenhagen. The area is comprised of 800 housing units by different architects. The Agernskrænten project provides 43 housing units in the fourth phase of Egebjerggaard. Agernskrænten is a social housing estate, owned by Ballerup Housing Association. Dansk Boligselskab (Danish Housing Association) carried out the project in corporation with architect Henning Larsen and Cenergia Energy Consultants are the energy consultants.

The aim of the project is to demonstrate energy saving technologies in the housing sector. The estimated savings are 60% on space heating, 25% on water and finally 25% savings on electricity for lighting and electrical appliances. The plan is a low-energy urban-ecology project, carried out on the basis of a total economic analysis. The building structure is optimally insulated and tight. Solar heat is used for domestic hot water. The total low-energy system also includes ventilation with a heat recovery system. The project demonstrates space heating with an air-circulationhandling unit instead of traditional radiators.

AGERNSKRÆNTEN 1: GENERAL VIEW

Building envelope

The houses have additional insulation compared to the Danish building regulation demands. The insulation thickness in the walls is 150 mm and in the roof it is 350 mm. The measured U-value of the total window is 0.95 W/m²/K which is much lower than standard solutions. With these extremely good windows it is possible to utilise a high passive solar contribution without thinking of the window orientation. In northern climates, the perception of a good quality of day lighting is achieved when the sunshine shines through the windows about 25% of available sunshine time.

Table 1.1. U-values.

	BR82 [W/m²/K]	New BR [W/m²/K]	Thermie [W/m²/K]
Walls	0.35	0.30	0.23
Floor	0.30	0.20	0.23
Roof	0.20	0.15	0.11
Windows/doors	2.90	1.80	0.95

Solar

For the main part of the houses a common solar heating system for DHW is used. As a new feature, a new type of shared solar heating system for four housing units has been used, combined with individual "solar prepared" DHW tanks.

AGERNSKRÆNTEN 2: SOLAR THERMAL POWER

BEMS

A Building Energy Management System (BEMS) from Danfoss is used to optimise the control and ensure a good survey of all energy systems. Use of individual bills for heating, water and electricity will be based on individual meter readings.

Energy supply mechanism

All necessary heating is covered by a local combined heat and power plant owned by the local electricity company. The houses are heated by low-temperature heating (55/40°C) and most of the heat distribution lines are integrated inside the houses under the floor construction.

Ventilation

As a completely new feature, a new type of small ventilation system has been developed in cooperation with Danish company, TermoVex. A ventilation system with counter flow heat recovery on the ventilation air at the same time functions as air heating system for the houses. A frequency converter for high efficiency ventilators has been used to reduce the electricity consumption in the system.

Some houses are equipped with individual air heating systems and some have a shared air heating system for two to four housing units and, for comparison, some houses have been made with a normal radiator system. Special attention has been given to building integration and low electricity used in the design process.

Monitoring

The monitoring of the Ballerup project started in December 1994. The main results are given in the table below. The "Norms" correspond to the consumption in a standard house built according to the Danish Building Regulation BR82. The total yearly heat consumption for space heating and domestic hot water is reduced from 180 to 101kWh/m² for savings of 44%. The heat consumption includes space heating, domestic hot water and all losses in the distribution system.

One common meter monitors the total water consumption, which include 43 dwellings. One common meter also monitors the domestic hot water. The average per dwellings is 101 m³/year (276 litre/day) and 31 m³/year (85 litre/day) of hot water. The hot water is approximately 30% of the total water consumption. There is less consumption during summer because of the holiday's period. The average water consumption in Denmark is 1.3 m³/m² and in the Thermie project the corresponding monitored consumption is 1.27 m³/m². That means only slight water savings has been obtained. The electricity consumption has been monitored in 20 dwellings. The monitored electricity consumption is monitored between 2816 kWh (34 kWh/m²) and 1336 kWh (21.6 kWh/m²). Ventilation with heat recovery is introduced in some of the dwellings. There is no significant difference between dwellings with ventilation and without.

Table 1.2. Consumption monitoring:

Heating, kWh/m^2	**Estimated**	**Monitored**	**Norms**
Space heating	-	51.2	88
Domestic hot water	-	9.9	33
Losses	-	39.9	59
Total Heat	72	101	180
Electricity, kWh/m^2	**Estimated**	**Monitored**	**Norms**
Electricity	24	22 - 34	32
Water, m^3/m^2	**Estimated**	**Monitored**	**Norms**
Domestic hot water	-	0.4	0.39
Total water	0.98	1.27	1.3
Solar, kWh/m^2	**Estimated**	**Monitored**	**Norms**
Type 10m2	400	283	-
Type 9m2	400	329	-
Degree Days	**Estimated**	**Monitored**	**Norms**
TRY Copenhagen	-	-	3518

HAVREVANGEN

Denmark

General information

Name: Havrevangen	**Location:** Hillerød, Denmark	**Year:** 1994
Architect: Vilhelm Lauritzen		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; environmental respectful materials; heat recovery; solar thermal power; energy management system (EMS).		
Prizes: Winning project from a competition sponsored by the Nordic Council of Ministers and the Energy Commission (1991).		
Sources: http://cordis.europa.eu/opet/fiches/buw21.htm www.vla.dk/english/projekter_flash/Bolig_Havrevangen/index.htm		

Report

The complex is formed by fifty 1½ -2 storeys dwellings, placed in 5 rows with 8-12 houses in each row. Flat sizes vary between 65 and 104 square meters, and 16 flats are suited for disabled persons.

HAVREVANGEN 1: GENERAL VIEW

The 50 terraced houses have been designed with a complete approach, where the interaction between planning, contemporary architecture, technology, environmental choice of materials and social considerations has been given high priority.

The integration of energy saving and RES concepts are the basis of the whole concept of this project: the main feature is an active solar system with roof integrated solar collectors and a new storage system.

The main aim of the project was to focus the attention on resource consciousness and ecology, giving particular importance to the application of low energy technologies: in fact, the Municipality wishes to create new houses with a green and open quality in a park like setting.

For this reason, a strong effort has been put, during the building process, in flexibility and inventiveness to combine aesthetic and technical ambitions with the existing financial obligations.

On the other hand, the adopted energy conserving measures are expected to have beneficial effects on the running costs of the housing estates.

Technology references and integration concepts

One of the main technology references of the project is a conspicuous reduction of the heat consumption of the realized dwellings joined with other design and technological well integrated solutions.

- Passive solar design: special attention has been placed on maximizing the exploitation of solar radiation joined with avoiding shades, in a general topographic situation characterized by a constant exposition to the wind and no shelter trees.
- Solar system: the solar panels on the roof ridge are based on the air medium which transports heat through a heat exchanger coupled to a storage tank in the boiler room, to the heating and HW heating circuits.

  HAVREVANGEN 2: SOLAR PANELS

  The installed solar panels include 376 m^2 of roof integrated air solar collectors which mean 7.5 m^2 per dwelling.

  If no solar heating is available the heating requirement is satisfied by the municipal district heating station: the pipes from the boiler room to the dwellings are placed inside the external insulation of the buildings to utilise losses in the heating season.
- Solar collectors: special attention has been paid to the development of a Danish modular solar air collector which, by virtue of design, choice of material and construction, would be competitive with the liquid based collectors.

  The air system was chosen although it is not as effective as ordinary solar panels with liquid and needs a larger surface, but it does not cause any problem with the indoor climate and it is cheaper to operate.

  The resulting collector has also been very well designed to be easily integrated in the roof.
- Hybrid storage: the collected solar heat can be directed into the floor heating system and the thermostats controlling the floor heating can be overruled to allow for additional storage in the concrete walls; surplus heat is stored in a water tank and/or used for DHW.
- Improved insulation and windows: high insulation of the envelope construction has been applied; 70% of the windows are south facing and low energy glazed with a U value of 1.5 W/m^2/K.
- Heat recovery for ventilation: a mechanical ventilation system provides the necessary ventilation and includes an air to air heat exchanger recovering up to 80% of the heat in the ventilation air; a natural air exchange rate of 0.1 per hour has been foreseen.
- Energy management system (EMS) and local heat metering: it has been installed to control the total energy consumed for heating and domestic hot water in each dwelling.

  An EMS monitors the active solar system, the storage and distribution network and the outdoor and indoor conditions having the possibility to deliver data to a remote monitoring system.
- Choice of "green" materials: this attitude, although not directly involved in the total energy saving of the realized dwellings, gives this project added value in terms of global environmental consciousness.

Results and achievements

The project has been completely monitored, showing the following results:

- Total energy consumption for hot water and heating: 80 kWh/m^2/year.
- Energy saving for heating (DHW and space heating): 56%.

This result has been achieved thanks to the contribution given by each of the adopted energy measures, which can be detailed as follows:

- 44% energy conservation measures and passive solar utilisation.
- 12% active solar system.
- 44% district heating.

SKOTTEPARKEN

Denmark

General information

Name: Skotteparken	**Location:** Ballerup, Denmark	**Year:** 1992
Architect: Hanne Marcussen & Jens Peter Storgård		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Good thermal insulation; rainwater use; heat recovery; solar thermal power; energy management system (EMS).		
Prizes: The World Habitat Award, 1994		
Sources: www.ecobuilding.dk/downpdf.php3?ID=36 www.agores.org/Publications/CityRES/English/Ballerup-DK-english.pdf		

Report

It is an EU Thermie supported experimental building project with 100 solar heated - low-energy dwellings, where the aim is to reduce the gas consumption for heating and domestic hot water by 60% compared to normal building projects, and at the same time reduce the consumption of electricity and water.

SKOTTEPARKEN 1: GENERAL VIEW

The basis for the project was that extra investments in energy saving measures of approx. 8% of the normal building costs should correspond to savings in the operation. In this way the total rent including heating, water and electricity will not be higher for the tenants than in other building projects.

The chief energy-saving features

- Extra insulation, which is mostly added in the ceilings with a total thickness of 375 mm. The apartments are aimed at being airtight, making the natural air change as low as 0.1 times per hour.
- Thermo glazing is used everywhere with double paned windows with an air gap of 15 mm. The windows have a U-value of approximately 1.4 W/m^2K.
- Ventilation system with counter-flow, heat recovery is utilized as shared systems for 4-5 apartments. The system recovers approximately 80 % of the energy in the out flowing air. Special ventilators with an electricity use of only 35 -50 W are used.
- Six local solar heating systems with approximately 100 m² solar collectors each, for hot water and room heating.
- Pulse operation of low-temperature (60/40°C) district heating network.
- Heat supplied from local combined heat and power (CHP) plant.

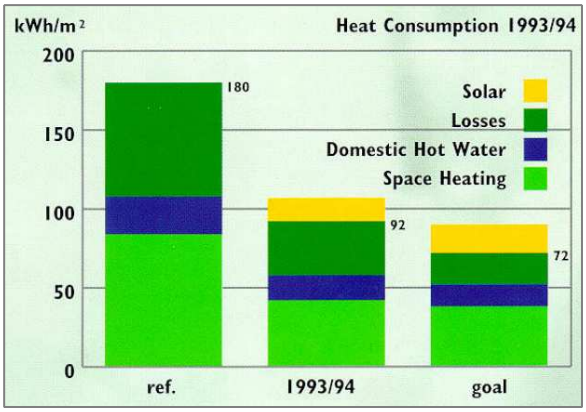
* Local heat meters in each apartment.
* Energy management system (EMS).
* Local water meters.
* Thermostat taps in showers and two-step water saving taps in kitchens and bathrooms.
* Electricity savings.
* Runoff from roofs and streets is via open drains carried to a small lake to help maintaining the ground water.

The most innovative aspects are the six, solar heating systems with approximately 100 m^2 of solar collectors each, both for hot water and space heating. This equals 6 m^2 solar panels per apartment. An energy management system (EMS) is used to control the operation of the district heating network in such a way that it is only in operation when one out of six local solar/buffer storage tanks (5 m^3) calls for heat. After the pulse, the district heating network is filled with cold return water from the tanks (30 - 35 °C). This means that the pipes only are subject to heat losses when a pulse is going on. This saves a lot of energy – especially in summer. The method is known as the ***pulse operation***. Its advantage is less heat loss from the distribution pipes than would occur if hot water were in constant circulation as in conventional district heating systems. In sunny periods the distribution system stops completely, thus preventing considerable heat losses. The gains from the pulse operation system equal more than half of the total energy savings.

SKOTTEPARKEN 2: DETAIL

The results from finished monitoring campaign documents show that a very high reduction of more than 50% of the energy use for heating and DHW has been achieved until now. Besides 60-70% savings of losses from the CHP based district heating network are obtained, because of low temperature pulse operation in combination with local solar heating systems and EMS control.

Because of introduced water savings the mean DHW consumption has been measured to be only 66 litres per day per apartment. And measurements form March 1993 to April 1994 of the solar heating yield from the 6 local block solar heating systems for heating and DHW with approx. 600 m² solar collector area in all shows an annual solar heating yield in a normal year of 274 kWh per m² solar collector. If the annual saving by pulse operation of the district heating network is considered to be a result of the investments in the solar heating systems then, the annual savings because of solar heating and pulse operation together are as high as 382 kWh per m² solar collector.



SKOTTEPARKEN 3: HEAT CONSUMPTION

Based on the monitored data it is possible to conclude that the Skotteparken project has demonstrated an ideal combination of a CHP system and use of local solar heating systems which cover the low demands for DHW heating in an efficient way without large district heating network losses.

Main results

- The normal amount of energy used for heating and hot water has been reduced from 180 kWh/m^2 (normal housing) to 92 kWh/m^2 in 1993, to 82 kWh/m^2 in 1994, reaching 77 kWh/m^2 in 1995.
- 65 % savings on district heating network losses was obtained from the low temperature pulse operation.
- Solar system yields 274 kWh/m^2 (which corresponds to 382 kWh/m^2 when including saved network losses).
- Heating bills of only 4.42 Euro/m^2 which equals approximately 40 % of a "normal" heating bill.
- A good economic savings for the tenants based on an extra investment of approximately 8% compared to normal housing and grants from external sources.

SOLSIKKEHAVEN

Denmark

General information

Name: Solsikkehaven	**Location:** Vonsild, Denmark	**Year:** 1996
Architect: Boye Lundgaard & Lene Tranberg		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; heat recovery; solar thermal power; energy management system (EMS).		
Prizes: _		
Sources: http://cordis.europa.eu/opet/fiches/buw22.htm www.ecobuilding.dk (EHEN Kolding)		

Report

The complex is formed by 33 houses and a common house in Volsind, South of Kolding in Jutland, and there are four different types and sizes of housing units, placed in 6 terraces.

SOLSIKKEHAVEN 1: GENERAL VIEW

The aim of the project is to demonstrate energy saving technologies in the housing sector. The energy consumption for space heating and heating of DHW in the dwellings is reduced considerably by introducing a number of different energy saving measures that go beyond the requirements in the present and future building regulations. Thus it is the aim to reduce the energy consumption for heating from 180 kWh per m² in living space to just 60 kWh/m². It is equal to a reduction of 65%. Besides, different measures will be introduced which will reduce the consumption of water and electricity. The estimated savings are 30% on water and 20% on electricity. The row houses have been optimised for solar energy and daylight utilization - one towards the south and one with the façades towards the east and west. In both types of dwellings a two storey high "sun-room" has been integrated in the design, and detailed calculations of this have been made with the Danish computer programme TSBI-3 by the IBE institute of the Danish Technical University as part of this project.

The solar low-energy demonstration project in Vonsild is also part of the Danish participation in international cooperation related to the International Energy Agency, IEA, on "Advanced low-energy houses".

Technology references and integration concepts

A strong effort has been put in the integration and optimization of different energy saving solutions acting both on the building envelope and on the technological equipment:

SOLSIKKEHAVEN 2: PASSIVE SOLAR DESIGN

- Passive solar design: all the houses, both the south-facing and the east west facing have been optimised for passive solar energy gains. Especially for the east west oriented buildings, the project has been designed to allow considerable gains through a quarter circular roof construction, allowing direct sunlight into the main rooms.
- Solar system: solar heating system for DHW has been installed with 3-4 m^2 solar collectors per flat, giving a total of 100-130 m^2. The collector design has been realized on the basis of experiences developed concerning small low cost solar DHW systems.

SOLSIKKEHAVEN 3: GOOD THERMAL INSULATION

- Improved insulation and windows: they are extremely well insulated: the U-values in the walls range from 0.11 to 0.14 $W/m^2/K$ compared to the building national requirement of 0.3. Roofs and floors have lower U values than the standard (roof 0.11-0.13 $W/m^2/K$ - floors 0.1-0.12 $W/m^2/K$); both window glazing and frame have an U value near to 1$W/m^2/K$.
- Heat recovery of ventilation air: the houses are extremely air tight and a mechanical ventilation system has been designed with heat recovery, user control possibility, low electricity use and a counter flow heat exchanger with high efficiency.
- Low temperature heating: a local district heating system for space heating and domestic hot water has been used; low temperature heating will be used as well as a DHW tank or DHW heat exchanger with low return temperatures. The entire district heating system piping has optimal insulation thickness in order to reduce heat loss.
- Combined heat and power CHP generation plant: the central heating plant has a cogeneration unit working together with a high efficient condensing gas furnace for a total of 5000 running hours per year, to cover the demand of heat and electricity for the 33 dwellings; the internal electricity network is connected with the regional grid.
- Load management: an intelligent energy management system controls the production of electricity, according to the variable electricity demand of the dwellings; a buffer storage has been installed in the boiler room in order to level out the heat production to the heat demand, which is not immediately covered by the heat production.
- Energy management system (EMS) and local heat metering: it has been installed to control the operation of the CHP plant and at the same time to survey local heat meters and electricity meters in order to obtain the plant's optimal operation conditions, to be used for the load management and to produce automatic individual heating bills.

- Water and electricity savings: optimised use of electricity for lighting by means of low electricity light bulbs for the bathrooms and outside lighting, frequency converter for a high efficient ventilator; water savings are achieved by the use of individual water meters, use of two-step low flow taps, thermostatic mixing batteries for the showers and water saving toilets.

Results and achievements

The monitoring period started in summer 1996. The total yearly heat consumption for space heating and domestic hot water was reduced from 180 (standard house built according to the present Danish Building Regulation BR82) to 70-96kWh/m² depending on the building type.

The energy system performances, comparing the monitored data and the simulations obtained, have shown the following results in comparison with the current Danish Regulation:

- Energy saving for heating: 65%.
- Energy saving for electricity: 20%.
- Energy saving for water usage: 30%.

Bioclimatic buildings

HEDEBYGADE BUILDING

Denmark

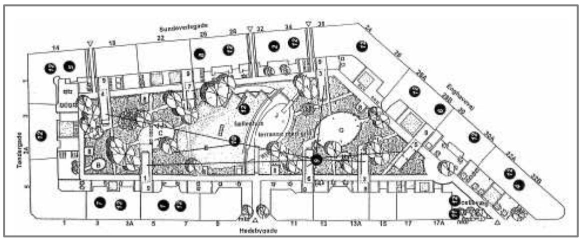
General information

Name: Hedebygade Building	**Location:** Copenhagen, Denmark	**Year:** 1998 -2002
Architect: SBS Byfornyelse		
Type of Project: Bioclimatic Building		**Condition:** Renewed
Energetic characteristics / Keywords: Good thermal insulation; heat recovery; solar thermal power; photovoltaic power; energy management system (EMS); communal composting of waste; air purification with living plants; green kitchen.		
Prizes: _		
Sources: www.europeangreencities.com/demoprojects/denmark_copenhagen/denmark_copenhagen.asp www.cardiff.ac.uk/archi/programmes/cost8/case/holistic/denmark-block.PDF		

Report

The "Hedebygade" building block is comprised of 350 apartments from around 1888. There are different forms of ownership such as housing society tenancies, private tenancies and owner-occupied flats.

The block of flats has gone through a comprehensive restoration and comprises 12 subprojects, which in combination, are intended to demonstrate a catalogue of urban ecology solutions. Those ones have been carried out in close cooperation between residents, owners, consultants and the urban renewal company, SBS Byfornyelse.



HEDEBYGADE 1: PLAN

Since the project was launched in 1998, the tenants have emphasised the importance of resource saving solutions. The project seeks to optimise the consumption of heating, hot water, and electricity through the use of new energy saving technology. Secondary aims are lessening water usage and ensuring good indoor climate. It was the aim to reduce the energy use for heating and domestic hot water by 50-60%, and at the same time obtain 20-40% savings on electricity and water use. These figures are compared to the situation before the renovation.

It was the general goal to make an overall, well-integrated architecturally energy efficient solution for multi-storey buildings that takes care of the indoor air climate and comfort level for the tenants, and at the same time, obtains reasonable energy savings together with the use of renewable energy.

The Hedebygade project has incorporated various low energy technologies, and they clearly illustrate the benefits of integrated solutions:

Building integrated solar energy

The project consists of five different complexes, which all have solar energy measures integrated in the building façade, still, the technology and use of the solar systems varies. Complexes 1-3 have additional power supply in the shape of PV-modules, which are integrated with the ventilation system. Moreover, complexes 2-3 have solar collectors for hot water and space heating purposes.

- **Complex 1 - Tøndergade 3-3A**

  PV-modules with a total area of $32m^2$ and a peak power supply of 1.34 kW are placed around the windows as an integrated part of a façade renovation of the south façade of the building. In this project, the use of PV is also combined with the ventilation system as air for ventilation is pre-heated behind the panels. The ventilation system has heat recovery and low energy ventilator fans.

  Highlights:

  - Additional insulation and low-energy windows.
  - Central placing of the radiators.
  - Two central heat recovery units, placed in the attic, covering 10 apartments each. Heat surfaces that give extra heat to the ventilation air.
  - Building integrated amorphous PV-modules from Fortum in the façade.
  - The living rooms facing the courtyard have a 6 m^2 heated glazed patio each. The window parapets are covered with 60 m^2 amorphous PV-modules. The PV-modules are utilised in a hybrid solution where the ventilation air is preheated behind the PV-modules, which also has the effect that the cooled PV-modules get a higher yield.

- **Complex 2 – Tøndergade/Sundevedsgade**

  Here, the use of PV-modules is based on the PV-Vent technique. The objective of the PV-Vent project is to develop low cost, but high efficiency PV-powered ventilation systems for apartment blocks, where PV modules are integrated in an architecturally acceptable way in façades, gables and roofs. The use of ventilation fans with new and reliable DC-motors enables the photovoltaic modules to cover part of the electricity demand directly, so that the electricity demand for the system is only about 25-40 W per dwelling, which equals to an electricity consumption of only 200-300 kWh per year.

  A thermal solar collection system is also installed in this complex. It is a combined system for domestic hot water and space heating. The solar collector is an air collector type in which the heated air from the collector is transferred to an air/water heat exchanger placed in the roof space. A water pipe system transfers the solar heat to a buffer storage in the boiler room located in the basement. The advantage of using air collectors is that there are no problems with freezing or boiling. Finally the integrated solar façade enables the inclusion of glass patios for the dwellings.

  Highlights:

  - PV-modules: $60m^2$ mains connected to crystalline PV-modules from Gaia Solar have been mounted on the two original stair turrets. Preheating of the air in the stair turrets cools the back of the PV-modules and in this way the transmission loss between the stairs and the apartments is reduced.
  - Solar heating system: On the roof there is a solar heating system from Batec Solar Heating that heats the domestic hot water. The total area is 35 m^2.
  - Heat recovery: In the attic there are two high efficient counter flow heat recovery units from EcoVent, which cover 10 apartments each.

- Central placing of radiators provides savings on investment costs.
- Double windows with hard covering.
- Solar energy optimises sunspaces with overheating protection.
- Heat recovery of the ventilation air has, in this way, reduced the heat loss of approx. 20 kW, equal to approx. 20 W per m² heated area.

82 DKK/m² has been saved by use of a solution with centrally placed versus conventionally placed radiators. In a 70-m² apartment this is equal to a total saving of the investments of 5,700 DKK, which primarily comes from the use of centrally placed riser pipes.

- **Complex 3 - Sundevedsgade 26-28**

This complex includes the rehabilitation of 20 apartments and it is equipped with 39m² of PV-modules with a total peak power of 3 kW, which are situated vertically on the staircase façade facing the courtyard with a south/west orientation. The PV-modules are ventilated in the air gap between modules and the wall in a way that transfer the preheated air to the staircase. The airflow through the staircase is forced by natural ventilation.

This complex also has a thermal solar heating system designed for domestic hot water. The solar collectors make up a roof-integrated system with a storage tank of 1.6 m³ in the boiler room on the ground floor. The piping between the collector and storage tank goes through an old chimney, which is not used anymore.

Highlights:

- Air solar collector: A 19m² air solar collector has been mounted on the roof, and heats a central storage tank in the basement, which is also connected to the district heating system.
- A new solar wall design with an integrated heat recovery unit that is also connected to the district heating system is used for 12 apartments. The only 25 cm thick counter flow solar wall has been built with frosted glass and PV-modules as a covering coat. The heat recovery unit has been placed inside the solar wall. This innovative unit from EcoVent contains the counter flow heat recovery unit, sound absorber and ventilation fans. The complete heat recovery system is highly efficient and has very low electricity consumption. These systems form part of the EU/Joule project PV-VENT together with the PV-modules. A built-in damper in the solar wall that secures against temperatures which are too high.
- Ventilation with heat recovery for eight apartments: The corner apartments cannot be connected to a solar wall and individual counter flow heat recovery units with 85% efficiency have therefore been placed here also as individual systems. The ventilation systems in these apartments have been made as real air heating systems by means of heating surfaces that are heated by district heating. There is also a traditional but centrally placed radiator system to cover peak loads.
- PV-modules: The PV-modules form part of the solar wall and the produced electricity is used directly in the heat recovery unit by help of a so-called PV-mixer. There are approx. 1m² PV-modules per apartment.
- Water heat exchangers: The heating is supplied from the central storage tank in the basement, which is partly supplied with district heating and partly with heat from the air solar collector. The heat is in this way supplied to the apartments for both room heating and domestic hot water via only one duct, which reduces heat loss. The heating of the water takes place via individual domestic hot water heat exchangers that also secure against problems with bacteria.

- South oriented sun-protected sunspaces for each apartment and improved daylight function.

District heating

All three complexes are connected to the local district heating system through a boiler room in each building. The heating system uses a low distribution temperature, which means that the water temperature in the piping system and radiators will be lower than in a conventional one. Therefore the radiators and the piping system require an increased surface area compared to a conventional system. Radiators are controlled by thermostatic valves and placed in the centre of the dwellings in order to get lower installation costs.

Ventilation and heat exchange

The heat distribution pipe system is integrated with the ventilation system, which means that the distribution of the hot water to the dwellings passes through a water/air heat exchanger that heats the incoming airflow. The integrated ventilation system moreover includes highly efficient counter flow heat exchangers capable of utilising up to 90% of the energy in the exhaust air.

There are some differences, however, between the complexes. The ventilation in one of the complexes includes low energy heat recovery ventilation systems, supplied with electricity from PV modules integrated in the building façade. The heat exchanger, the ventilation fans and the filters are installed on the outside of the existing wall and a new building envelope was established around the installations. In order to be able to install the ventilation units on the outside wall, it was necessary to reduce the thickness of the heat exchanger and a special unit with built-in filters and fans was developed. The new building envelope is made of transparent glass also acting as a solar wall.

The ventilation system of one of the other complexes installed highly efficient (90%) counter flow heat exchangers in the loft, each with a capacity to cover 10 dwellings.

Finally it should be mentioned that the project included an Energy Management System (EMS) that controls and monitors important energy fluxes. Preliminary results confirm that the solar systems function satisfactorily and indicate heat energy reductions of more than 50% and hot water reductions of up to 65%.

Solar cells on south-facing wall

The gable project illustrates the utilisation of the potential of a south-facing wall for solar cell technology.

The solar cells produce light for the back yard at night. The end wall also demonstrates the use of alternative insulation materials. This, along with trelliswork planting and the other components of urban ecology, combine to offer considerable energy savings and an improved indoor climate for the residents.

Flexible façades with solar energy

This project presents an advanced façade design based on glass extension modules for utilizing solar energy. The components are highly flexible and can be used for a wide range of different building types. The technology itself saves the residents approx. € 160 per year in energy costs.

The project succeeded in satisfying three criteria: for the solution to be aesthetically pleasing, easy to install and financially viable.

Hedebygade 2: Heliostat

Natural lighting

This project demonstrates how sunlight can be trapped as part of an integrated concept to improve natural lighting and the indoor climate in multi-storey housing.

The unique feature of this project is a light shaft which reflects sunlight from the roof down through the middle of the building. This is achieved with the aid of what is known as a heliostat, which is fitted to the roof. The heliostat is computer-controlled and tracks the sun's light, which is projected onto mirrors in the shaft and from these into the flats.

Consumption metering

This general project - metering of water, electricity and heat consumption - demonstrates how individual consumption metering and energy management can be utilised to ensure minimal environmental impact. The aim in combining these two models is to cut down consumption of resources in the properties by at least 25%.

The system permits precise logging of resource-savings achieved and ensures energy management for the benefit of residents, while also enabling subsequent evaluation of the projects as a whole. Meters are placed visibly in each flat, usually in the hall. On the display tenants can read the daily, monthly or annual consumption. Even the instantaneous rate of consumption can be read. The results available on the display come from radiator meters, hot water meters and electric meters located in the flat. Radio receivers bring the data to a central computer and from there back to the display in each flat.

Quarterly accounts

Each flat gets a quarterly account informing the tenants about energy and water consumption. This account is presented in the form of a diagram that shows the consumption of each flat in the specific house, normally with two or three entrance stairways. For privacy each tenant must identify his own consumption by use of a pin code. In this way the tenants may compare their own consumption with that of the neighbours and check if they are above or below average. The quarterly accounts are presented on notice boards in the entrance of each stairway.

Eco-accounts

Eco-accounts distributed to each individual house explain the level of consumption compared with that of the other houses on the block. Diagrams inform the tenants of the annual consumption, the level of consumption compared to the previous years' and a forecast for the current year. Also the CO_2 emissions are shown. Like the quarterly accounts, the eco-accounts are presented in the entrance of each stairway. An additional diagram of the consumption of the individual buildings is presented on the notice board in the community house.

Waste sorting

A system has been developed for handling of basic household waste, comprised of uncomplicated, public utility environmental stations in which the waste is sorted into eight fractions. Furthermore, there is communal composting of waste in the communal grounds. The aim is to reduce the residual waste to approx. 60% of the original volume.

Residents and caretakers receive instructions on the use of the system in order to ensure optimal source sorting of waste by each household.

Air purification with living plants

This project is an example of a holistic, ecological concept applied to an existing building in which the main principle is to clean the air in the flats by allowing it to re-circulate through living plans – a process which reduces airborne toxins and allergens. By using plants for air purification in this way, the energy expended on heating the flats is reduced by 30-40%. Similarly, the "grey water" from the showers is recycled to irrigate the plants.

Community house

The community house in the back yard is shared by all the residents in the block, and comprises a residents' function room and a laundrette. The design of the building was formed from resource-efficiency considerations and the materials were chosen for their simplicity and environmental soundness. The laundrette also permits recycling of rinse water, and is supplemented by rainwater. The south-facing façade utilises solar energy for passive solar heating for the function room and café. Some of the air purification is achieved through a "plant zone". The kitchen is fitted with a naturally chilled larder.

Communal grounds

The project involves the design and landscaping of an urban courtyard on ecological principles. The grounds achieve the integration of a community house and environmental stations and are designed to require minimal upkeep.

Ecological features include rainwater collection, mini-aqueducts all the way around the courtyard and a water spiral serving as both sculpture and water playground. The planting is varied to promote a diversity of bird and insect life in the green spaces.

Green Kitchen

The focus here is on promoting the "green lifestyle" by reducing consumption of resources by means of "green" kitchens in an old block of flats. Kitchen fittings are made of environmentally sound and healthy, natural materials. Distinctive features include the vertical planting frames which provide passive solar heating, and space for the residents to grow their own ecological herbs. In addition, each flat has an air-cooled larder and there is communal composting of waste in the communal grounds.

Table 1.1. Monitoring: energy consumption corresponds to the standard for new constructions (BR95).

Monitoring period	Sundevedgade 26-28, 21 dwellings with a total floor area of 1204 m^2			
Monitoring results	**Parameter**	**Norms**	**Predicted**	**Monitored**
	Heat (kWh/m^2)	150	90	88.3
	Electricity (kWh/m^2)	32		32
	Water (m^3/m^2)	1.1		1.2

The overall result of the renovation with respect to consumption of water and energy is:

- Water: 120 l/person pr year compared to the Copenhagen average of 126-120 l/person.
- Electricity: 1514 kWh/person per year compared to the Copenhagen average of 1550 kWh/person.
- Heat: 11 MWh/100 m^2 per year compared to the Copenhagen average of 13 MWh/100 m^2.

HERNING

Denmark

General information

Name: Herning	**Location:** Herning, Denmark	**Year:** 1999
Architect: Kristian H. Nielsen		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; rainwater use; heat recovery; energy management system (EMS); comparison between 2 blocks.		
Prizes: _		
Sources: www.ecobuilding.dk www.europeangreencities.com/demoprojects/denmark_herning/denmark_herning.asp		

Report

FællesBo (the former Herning Housing Association) had already perceived tenants' growing interest in ecological considerations when the housing association mid 1996 completed 48 new apartments in Herning, where energy and water saving installations resulted in a rent reduction of some 10%.

This project is situated in the southern part of the city of Herning which, over a period of 10-15 years, is to be converted from an old industrial area into a pleasant residential area using general ecological approaches in the construction and operation of buildings.

FællesBo has constructed a youth residential complex, which functions as a demonstration project showing the way for environmentally sound building approaches. The project consists of two similar blocks, one conventional (Block A) and one "green" (Block B), in order to evaluate and compare the cost/benefit of each choice of environmental measure installed in the two blocks. There are a total of 84 apartments, 3300 m^2 floor area and approx. 120 tenants. Furthermore there is a basement area of 370 m^2 with a laundry room, assembly hall, engineering room, and two study-rooms.

Numerous low energy elements are implemented in the "green" block, such as extensive insulation, solar collectors, electricity saving measures, and an all-over energy management system. Monitoring was initiated almost immediately after the completion in September 1999. Still when it comes to innovation, the ventilation with heat recovery and passive solar energy stands out as the most salient part of the construction project.

Ventilation with heat recovery and passive solar energy

The green block is constructed with a 25-m^2 façade facing south, which is set up as a large sun wall completely integrated in the building design. The façade is the backbone of the passive solar system, which aims to accumulate and partly use the solar energy during daylight hours, and to use the remainder at night or in times of less solar activity.

Herning 1: Sun wall

The façade is constructed as a uniform solar collection area, made up of a heavy concrete wall painted dull black on the outward surface in order to adsorb the radiation optimally. The concrete wall is slightly withdrawn compared to the building façade, which consists of glass, and in between there is room for airflow. Erected on the inside of the concrete wall, a light, yet well-insulated, wall hinders direct and uncontrolled heat transmission into the building. Like the outside, an inside gap is constructed between the two walls. The two air gaps are connected at the bottom of the concrete wall.

During daylight hours, the wall will heat the air in the outer gap, and subsequently transfer the heated air to the central ventilation system. The airflow is controlled and regulated by the ventilation system in correspondence with the heating demand of the building.

Inside the building, the ventilation system is designed as a conventional system with exhaust air from the cooking hood and the bathroom exhaust, and supply of fresh heated air in the living rooms.

The central ventilation unit is equipped with cross heat exchangers, which transfer up to 70% of the heat in the exhaust air to the incoming fresh air. In order to ensure a temperature in the incoming airflow that conforms to the heating demand, the influx is transferred to the top of the inside air gap, where it is distributed horizontally so the air can descend slowly in the inside air gap. At the bottom the cool air is drawn into the bottom of the solar wall by the lower pressure. In the outer gap, the air is heated and ascends to the top and back into the ventilation system.

In order to ensure that the air in the outer gap is not heated to an uncomfortably high level, the air ducts are provided with a temperature regulated by-pass mechanism, which leads a part of the airflow round the sun wall. In order to mitigate excessive cooling in winter with ensuing energy losses, the same function is triggered if the sun wall is colder than the outside air coming in.

If there is a heating demand beyond the capacity of the sun wall, the ventilation system can heat the incoming air through surfaces heated by the hot water supply. The heating surfaces are dimensioned to enable low-temperature heat transfer, which ensures high over-all energy efficiency, particularly when it comes to the energy contributions from the solar system in periods with moderate solar activity. Domestic hot water is supplied partly by a solar collection system, and partly by the local district heating grid. The entire system is monitored and controlled by a central energy management system (EMS).

Combined solar collector and low-temperature district heating for floor heating and domestic hot water

On a south-facing roof surface on the environmentally friendly block (Block B) a 70 m² solar collector connected to the heating system is set up. The solar collector primary produces heat for domestic hot water and secondarily to the heating of rooms. If the water from the solar collector is colder than the water heating up the domestic hot water, the water from the solar collector is diverted to the floor heating system. If the water from the solar collector is colder than the water to the floor heating, it will be diverted as well.

The flats in both blocks are heated through a low-temperature floor heating system connected to the city's district heating and in Block B the floor heating is connected to the solar collector. Furthermore, an additional 50 mm of insulation has been placed in the walls and 100 mm on the ceilings in Block B compared to the conventional block (Block A). Block A is built according to the current building regulations.

These initiatives have resulted in heat consumption in Block A of approx. 70% of the consumption of heat in Block A. It is difficult to point out precisely to which level the different initiatives have influenced in the result.

The heating systems in the two blocks are built up quite differently. In Block B the heat comes from both the district heating system, solar collector and the ventilation system. However, the effect of the solar collector can be measured precisely with regards to the domestic hot water. It turns out that the residents in Block B use only half as much heat for domestic hot water compared to the residents in the conventional block. This is due to the effect of the solar collector.

Solar system costs: 218,000 DKK (29,300 €). Estimated pay back time: 12 years. The payback time is calculated based on a kWh price of 0,60 (0,08 €) and a yearly saving of DKK 30,000 (4,037 €).

Reuse of collected rainwater for toilet flushing

From the roof on the green block (Block B) the rainwater is led down into 2 underground tanks. These tanks contain a total of 11 m³. Hereafter the rainwater from the tanks is used for toilet flushing. When there is a lack of rainwater in the tanks, the water will be thinned-down by the ordinary water supply.

3 floaters connected to the buildings' CTS-system are mounted in the tanks. The first floater signals when there is only 1 m³ water left in the tank. The second floater reacts when there is only 1.5 m³ water left in the tank and water will be thinned down. The third floater stops the water supply when there is 2 m³ water left in the tank.

It is very important that the water is stored underground where it is dark and the temperature constantly 8° C. If the water is stored in a light and warm environment it will rot and cannot be used by the residents.

HERNING 2: RAINWATER IS COLLECTED

Measurements show that the flats in Block B use almost as much hot water as the flats in Block A (the conventional block). However, the consumption of cold water is 50% less in the Block B compared to Block A. According to the measurements, half of the consumption of cold water in the environmentally friendly block is covered by rainwater.

The amount of rainwater only covers approx. 25% of the total water consumption in Block B and does not live up to the expectations which was estimated to 67% of the consumption. Still, the report from the University College of Aarhus concludes that the plant is running satisfactory and that the total economy of the plant is very positive if measured over a period of 20 years.

Monitoring

The following parameters have been monitored since taking up residence:

- Heating consumption for apartments.
- Heating consumption for ventilation.
- Hot water.
- Cold water.
- Supply water for tank for flushing toilets (due to lack of rain water).

- Heating supplied by solar collector on roof.
- Power used in dwellings is individual accounted for to the local power plant by tenants, and not included in the monitoring system.

By measuring the green block, as well as the "not green block", it is possible to compare the value of the environmental approaches.

Table 1.1. Monitoring:

<table>
<tr><td>Monitoring period</td><td colspan="4">September 1999 - December 2000</td></tr>
<tr><td rowspan="5">Monitoring results</td><td colspan="4">42 "green" dwellings (Block B) with a total floor area of 1699 m^2.
42 conventional dwellings (Block A) with a total floor area of 1699 m^2.</td></tr>
<tr><td>Parameter</td><td>Norms</td><td>Monitored Conventional block: Block A</td><td>Monitored Green block: Block B</td></tr>
<tr><td>Heat (kWh/m^2)</td><td>132.0</td><td>131.6</td><td>96.2</td></tr>
<tr><td>Electricity (kWh/m^2)</td><td>32.0</td><td>32.0</td><td>32.0</td></tr>
<tr><td>Water (m^3/m^2)</td><td>1.1</td><td>0.84</td><td>0.68</td></tr>
<tr><td>Other Results/ archievements</td><td colspan="4">In 2000, consumption data has been collected for both blocks. This data shows:
• Heat consumption for room heating in the green block is 26% lower compared to the conventional block.
• The consumption of tap water is 26% lower in the green block.
• The heat consumption for domestic hot water per m^3 is 52% lower in the green block.
Additional monitoring during a 7 week period (12.2-3.4.2001) confirms that there is a minor increase in electricity consumption (1.7%) in Block A compared to Block B.</td></tr>
</table>

LILLEVANGSPARK

Denmark

General information

Name: Lillevangspark	**Location:** Farum, Denmark	**Year:** 1994
Architect: Vilhem Lauritzen		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Heat recovery; solar thermal power; photovoltaic power.		
Prizes: _		
Sources: new-learn.info/learn/packages/cdres/projects/p3/en/over/over_1.html www.ebst.dk/file/1978/lillevangspark.pdf		

Report

The project creates a new western border to Farum; an important border, where the town meets the open landscape. This project includes 67 terraced houses in 11 blocks with different house types: 9 houses with two bedrooms, 42 with three bedrooms and 16 with four bedrooms.

Internal distribution of the houses

The living room is located with windows facing south, to benefit from solar gain and daylight. The bathroom, hall and utility room are located on the north side of the houses, together with all the services. The roof level on the south elevation of the terraced houses is raised, to achieve maximum solar gain and daylight.

The estimated annual gas consumption is 93 kWh/m²; heat input to the house is 43kWh/m² for space heating and 17kWh/m² for domestic hot water.

The energy savings are estimated to be 67% for space heating, 30% for electricity consumption and 25% for water use.

LILLEVANGSPARK 1: GENERAL VIEW

Solar DHW

A solar heating system for domestic hot water is installed on the roof of each boiler room. High efficiency flat plate collectors with selective absorbers and a total area of 20.4 m² are installed, to provide 2.1 m² for each housing unit. A solar storage tank of 1000 litres is installed in each boiler room. Condensing gas boilers are used to provide the auxiliary energy supply.

PV Supply

Two solar heating systems have integrated PV modules in the solar collector. The PV modules are connected to the circulation pump and they also take care of the control of the system.

Daylighting

The day lighting system includes use of a large window area on the south elevation and smaller window areas facing north. There is a risk of overheating during hot, sunny periods by using the large window area facing south, but monitoring of the indoor temperature shows acceptable temperatures during July. Green landscaping and various shading systems minimize overheating from solar gain during summer.

Lillevangspark 2: South and north elevations

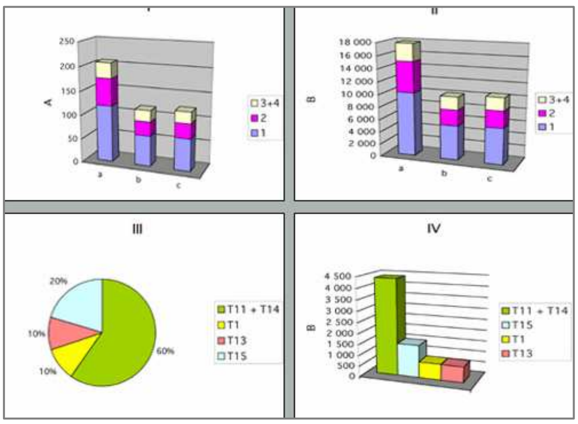
Heat recovery

Individual ventilation systems with heat recovery are installed in the houses. The system is integrated in the construction with easy access for maintenance. The system is developed to have high temperature effectiveness and low electricity consumption together with very low noise level.

Energy Balance

I and II: Energy Balance:

- A: kWh/heated m²/y.
- B: kWh/y/dwelling.
- a: Reference = same project based on thermal building regulations.
- b: Project simulation.
- c: Project measurement.
- 1: Heating.
- 2: Domestic Hot Water.
- 3: Household including lighting.
- 4: Cooking.
- 5: Communal (electricity) not relevant.



Lillevangspark 3: Energy balance

III: Energy saving per technology for the whole project (Monitored).

IV: Energy saving per technology for a typical dwelling (Monitored):

- Passive design including T11+T14.
- T1: Solar collectors (Domestic Hot Water).
- T13: Daylight.
- T15: Water savings.

ØKOHUSE 99

Denmark

General information

Name: Økohuse 99	**Location:** Kolding, Århus and Ikast; Denmark	**Year:** 1998 -2000
Architect: Vandkunsten		
Type of Project: Bioclimatic Building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; Trombe wall; environmental respectful materials; rainwater use; heat recovery; energy efficient devices.		
Prizes: First Prize in an invited competition for low energy social housing, 1996.		
Sources: www.arkitekturbilleder.dk/billedbasen/bygning.php?id=337 www.vandkunsten.com Kristine H. Lorenzen, COWI		

Report

In 1996, the Ministry of Housing arranged a competition to test the possibilities for combining the different environmental technologies and components developed for the building sector in social tenant houses. A demonstration took place in the tree Danish towns of Kolding, Århus and Ikast.

Kolding

Measures implemented in Kolding include:

- Solar walls and building integrated heat storage.
- Heat recovery in ventilation systems.
- Energy efficient devices

ØKOHUSE 99 1: KOLDING

Measurements show that the following results have been obtained in Kolding;

- The consumption of heat has been 60 kWh/m^2 (degree day adjusted).
- The water consumption is around 75 l/day/tenant, which is around 32% lower than in a traditional new building
- The electricity consumption is 1,694 kWh/dwelling, which is around 43% lower than the reference building.

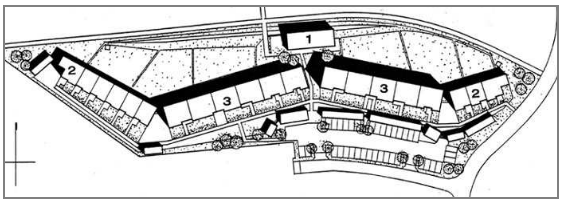
The project is composed by 60 dwellings from 65 to 105m^2 and a community house with a central low energy laundry, common facilities, sorting of waste, etc. Chief energy saving features are:

- The site is located in a young birch forest.
- Minimisation of external surfaces.

- Ecological non-allergic materials are used through-out.
- Extra insulation: roof 300mm, façades 125-225 (+100mm light concrete), floor 300-400, gables 225-350 mm.
- Demand controlled ventilation, partly natural ventilation.
- Preheating of ventilation air in solar wall.
- Low energy glazing U-centre 0.1 W/m^{2}K.
- Passive solar utilisation (south oriented windows and concrete mass for accumulation of heat).
- Solar walls with heat accumulation in stone storage and ducts embedded in concrete walls.
- All electrical appliances are low energy class A.
- All consumption of cold and hot, water, heat, electricity is monitored in a central system.
- Low energy district heating with plastic tubes and common insulation in a 4 pipe system 55/30.
- Central heating station with solar heating, prepared for expansion with RES.
- Remaining heat supply is surplus heat from CHP waste incineration and main industries in the area.
- Rain water is collected for laundry, gardening, flushing etc.
- All waste is sorted in 6 fractions.
- Materials (toys, books, clothes etc) are partly recycled between dwellings.
- No motorised traffic allowed between houses and a public bus line is provided to the town centre.
- Shopping area is available with-in walking distance.

Measured heating energy consumption is 55kWh/m^2 and electricity consumption is 1694 kWh/dwelling which is 43% below Danish average. Besides, the houses are cheaper than normal buildings about 20 Eur/m^2 per year (rent and consumables).

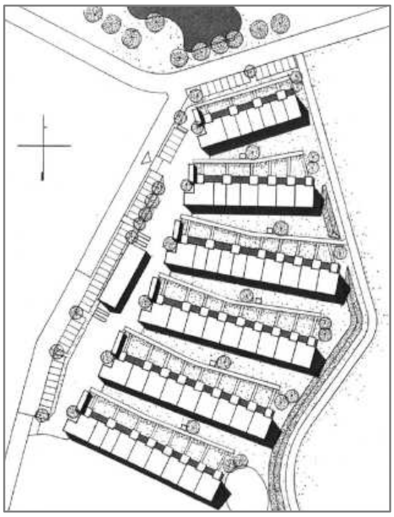
Århus



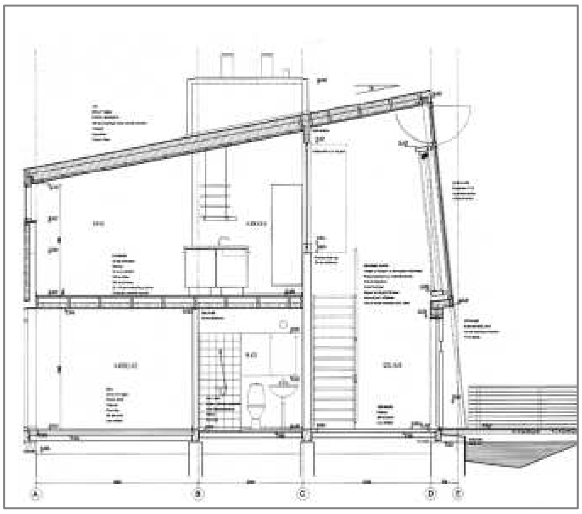
Økohuse 99 2: Århus, plan

Økohuse 99 3: Århus, view

Ikast



Økohuse 99 4: Ikast, plan



Økohuse 99 5: Ikast, cross section

ROCKWOOL'S RESEARCH CENTRE

Denmark

General information

Name: Rockwool's Research Centre	**Location:** Hedehusene, Denmark	**Year:** 2000
Architect: Vandkunsten		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; solar thermal power.		
Prizes: _		
Sources: www1.rockwool.com/environment/building2k/content/pages/trondheim_paper.pdf www1.rockwool.com/environment/building2k/content/pages/Towards%20sustainable%20solutions.pdf		

Report

A new research centre has been built for 130 employees in Rockwool International A/S' R&D department in Hedehusene. The total floor area is approximately 4,000m^2 comprising an open office environment and test rooms.

The goal was to create a low energy office building with a good quality of architectural design and a space heating demand of only 1/3 of the building code requirement – approximately 50 MJ/m^2 per year. The indoor environment should be pleasant with regards to temperature, daylight and air quality obtained by means of controlled natural ventilation.

ROCKWOOL 1: GENERAL VIEW

The low energy consumption for space heating is a part of the main goal of minimizing the environmental impact from the building. Life cycle analyses of materials, constructions and the building process have formed the basis for choice of materials and the building system.

A key issue was also to have the building performance documented by independent organizations. For this reason, the Technical University of Denmark and the Danish Building Research Institute was asked to be responsible for the measurements and evaluation of the results. The energy consumption, indoor climate parameters, architecture and other relevant parameters should be continuously shown to the public on the Internet.

Insulation

The west façade's extremely thick 470 mm insulation consists of 220mm Super A-Batts in wood frames, ProRock roof boards and Rockwool lamella boards placed on the exterior as floating and visible slabs – behind tempered glass. To avoid a clumsy appearance, the insulation is held free of the foundation by a continuous band of windows. Thermal bridging must be taken very seriously in a building as well insulated as Building 2000. Therefore, there is a recess for insulation in the foundation where the façade meets the concrete. In this way it has also been possible to create the sloping foundations which contribute to the lightness that the architects, at the Tegnestuen Vandkunsten office, sought to achieve in the building.

The roof's 490 mm thick insulation consists of 300 mm ProRock roof boards combined with Super A-Batts in the roof coffers, fire-resistant Conlit and Rockfon Sonar acoustic ceilings. The roof's long surface slopes southwards and consists of the ProRock roof system with black painted aluminium panels, laid in whole lengths to minimise the risk of moisture intrusion. Some of these roof boards are 70 metres long, which meant that they could not be transported under normal conditions. Consequently, the roof boards were rolled on site, with a mobile press placed at the lower edge of the roof, and slid directly into place. This reduction in installation time was also a plus factor in preventing potential problems due to adverse weather conditions.

Rockwool 2: West façade and roof

The window area is 35% of the total floor area, which is the highest ratio to date in a low-energy scheme. The windows are triple-glazed with double coated glass, and the cavities are filled with krypton gas. The U-value for the glass alone is 0.45 $W/m^2/^oK$, while the glass and the frames have a total U-value of 0.85 $W/m^2/^oK$.

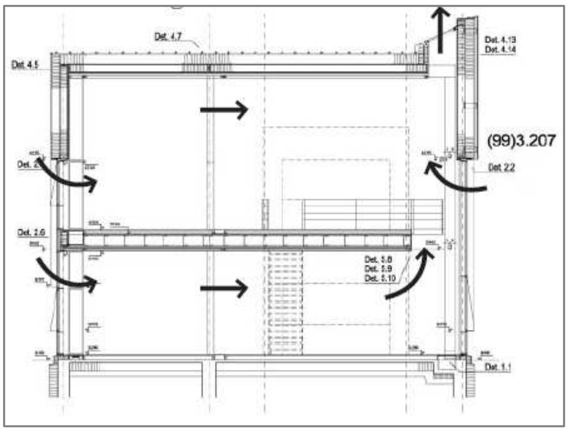
Heating

Building 2000's excellent environmental performance is achieved by reducing heating demands. It is in this area that the building sector's significant potential for energy savings lies.

The building has a heating system based on natural gas, with specially designed radiators recessed in the walls. This system is only active during extremely cold periods or when the building has been closed for vacations and is not receiving supplementary heat from the workforce, computer equipment etc. On the roof, 33m^2 of solar panels produce hot water for the bathrooms. In addition to this, the extremely large windows provide a great amount of natural daylight - a very important "free" source of supplementary heating.

Natural ventilation

Thermal chimney effect and wind pressure differences are some of the natural forces employed in the ventilation of Building 2000. Here, the building's form and location on the site play an important role. The arrows indicate how the air moves through the building when the automatic windows in the roof and façade are activated.



Rockwool 3: Cross section, ventilation

Façades

- The west façade is characterised visually by the Rockwool lamella insulation seen behind a transparent, tempered glass exterior.
- The east façade is covered with mat black Rockpanel boards on top of 250 mm ProRock roof boards and 220 mm Super A-Batts.
- The north façade's sloping glass areas provide a large amount of daylight to the offices, even without direct sunlight, through the triple layer energy glazing.
- Along the south façade, reflections from the pool feature create an exciting effect at the entrance to Building 2000. Here the rainwater from the roof is collected without the use of gutters and downspouts.




ROCKWOOL 4: FAÇADES

SEEST

Denmark

General information

Name: Seest	**Location:** Kolding, Denmark	**Year:** 2006
Architect: Kristian H. Nielsen		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Good thermal insulation; class 1 on Danish building regulations.		
Prizes: _		
Sources: www.rockwool.dk		

Report

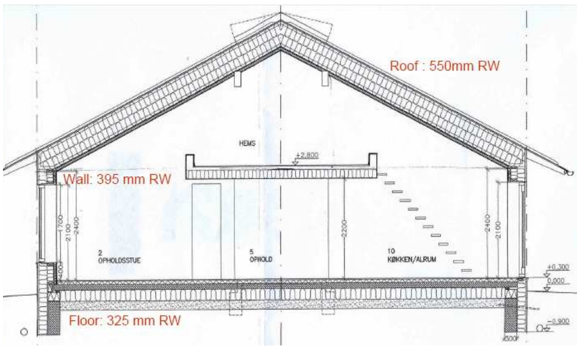
The project consists of a 223m[2] family house. It is the first low-energy house in a new standard house series from Seest Huse, which is developed in co-operation with Rockwool International A/S, Denmark.

SEEST 1: GENERAL VIEW

The new Low-Energy House 2005 is a stunning technical and architectural example of how to improve energy efficiency in single family housing. With a competitive price of DKK 11,000 per m², the goal is to make architecturally sound and 'indoor climate friendly' low-energy housing affordable for ordinary home owners.

The new building regulations that came into force in Denmark in 2007 introduced a new classification scheme on energy consumption for heating. The new Seest House joined the new Class 1 category. To be classified in this top-class, the house must be twice as efficient as a new standard house, and thus must not exceed an annual heating consumption of 2.5 litres of oil per m². The Seest House consumes only 1 litre of oil per m² calculated according to the building regulations.

This figure takes into account higher room temperature and lower use of free heat from electrical appliances. Extra insulation minimizes the cost for heating. Realized energy consumption is 27 kWh/m² per year.



SEEST 2: CROSS SECTION

THE ROYAL PLAYHOUSE

Denmark

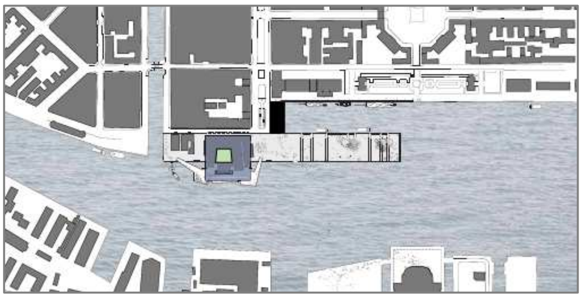
General information

Name: The Royal Playhouse	**Location:** Copenhagen, Denmark	**Year:** 2008
Architect: Boye Lundgaard & Lene Tranberg		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Heat recovery; energy management system (EMS); sea water heat pump; thermo active concrete.		
Prizes: Danish Sustainable Concrete Award, 2009		
Sources: www.ltarkitekter.dk/projects/7/lt-skuespilhuset-miljo-09.pdf www.cowi.com/menu/project/IndustryandEnergy/Energy/Pages/EnergyConceptforTheRoyalDanishTheatre.aspx www.cowi.com/menu/NewsandMedia/News/EconomicsManagementandPlanning/Documents/Sustainability2009_COWI_FINAL.pdf		

Report

Situated on the harbour front in central Copenhagen the Royal Danish Playhouse is a central attraction in the development of the Copenhagen waterfront into a recreational area on a par with cities like London and Amsterdam.

An innovative energy concept has been developed for the Royal Danish Playhouse. The energy concept contains; thermal active structures with energy storage, sea water cooling with heat pump and demand-driven ventilation. The expected energy savings for heating, cooling and electricity consumption are; heating 30%, cooling 75% and electricity 15%.



ROYAL PLAYHOUSE 1: PLAN

Integrated "climate belt" energy storage using thermoactive slabs

The thermoactive slab is used as energy storage - as a so-called 'climate belt', where surplus heat from the Theatre Hall during performance at night is stored for basic heating needs at the façades during the day. In summer, the system is used for surface cooling.

The use of the systems have a very positive effect on the utility systems as peak demands are levelled out over the day. The system is used with interruptible heat pumps.

The thermoactive slabs are linked to the overall Energy Concept because of the temperature set. This fluid temperature can be reached using free cooling and the seawater utilised by a heat pump. Surplus heating from the audience hall will be heat exchanged and moved to the thermoactive slabs for storage (in the winter). This use of renewable energy sources and surplus energy will be controlled by the intelligent BEMS system.

Optimised seawater heat pump and seawater cooling

A heat pump with seawater cooling is used. This project will optimise the systems by utilisation of surplus heat and interaction with building integrated energy storage as described above, and further optimise the overall efficiency of the systems by implementing reversible and interruptible heat pumps. This means that the systems can be used for low-temperature heating and "high-temperature" cooling, depending on the demand in the building. In addition, the use of a heat pump prolongs the use of seawater and ground water because the heat pump can provide the required temperature in the distribution systems.

The accumulation capacity of the thermal active slabs means that heating and cooling can be stored in the slabs at night, when the cost of electricity for pumps is low. This peak saving is an important issue of the national electricity production.

Optimised and intelligent controlled ventilation system, including BEMS

The ventilation systems of cultural buildings are complex because of the buildings' different use patterns. In the theatre, six different ventilation systems are used with very strict demands on acoustics and comfort level.

The project will improve the state-of-the-art by increasing the demand controlled part of the ventilation, with a highly efficient heat recovery rate using regenerative heat recovery systems and with heat pumps with storage of surplus heat/cooling in the thermo active slabs. The building will be ventilated with different ventilation systems, using combinations of natural ventilation, pulse ventilation, hybrid ventilation and mechanical ventilation with different control strategies, depending on load and season of the year.

In Denmark, special attention will be given to the stage and theatre hall and auditoriums. As the theatres are not always fully occupied, the ventilation will be controlled by the use of the audience seats. When the seats are used, only the necessary air volume will be distributed.

As cultural buildings are complex by nature, not least with the systems described above, an intelligent BeMS system is needed. The project will increase the on-line use of the BeMS system by constantly benchmarking the use of the building with references. In Denmark, the BeMS system will be connected to four other theatres for direct relative comparison under the same weather conditions. The energy savings by an optimised BeMS system will normally result in about 10% reduction in energy consumption.


Royal Playhouse 2: View

Environmental friendly building materials - "green concrete"

ECO buildings should always be built of environmental friendly materials. Denmark is the European leader concerning the development of environmental friendly concrete, also known as "green concrete". Environmental friendly concrete will be used for the "climate belt" and will underline the energy savings of the climate belt/seawater solution. The environmental concrete has not been used in buildings before, but has been tested - in a slightly different format - at a highway bridge in Denmark. The environmental friendly concrete will reduce the embodied energy for the concrete as well as reduce the CO_2 emission from the production of the concrete.

NORWAY

Eco-neighbourhoods / Eco-cities

BJØLSEN STUDENT HOUSING

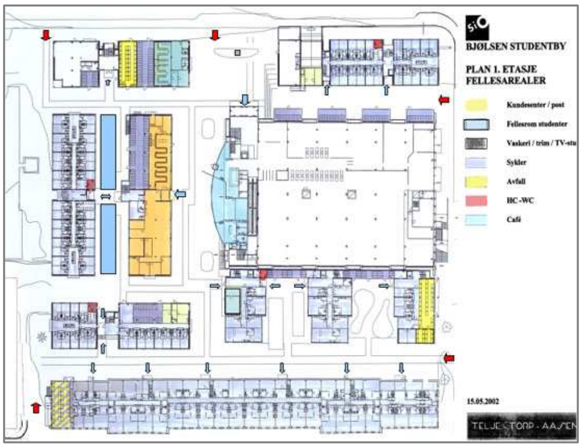
Norway

General information

Name: Bjølsen Student Housing	**Location:** Oslo, Norway	**Year:** 2003
Architect: Telje-Torp-Aasen Arkitektkontor AS		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New + Renewed
Energetic characteristics / Keywords: Good thermal insulation; environmental respectful materials; heat recovery; geothermal power.		
Prizes: Building of the Year Award, 2003		
Sources: www2.arkitektur.no/page/preview/preview/10056/57487.html		

Report

Bjølsen student housing with its 1,064 apartments has been built on a site formerly occupied by the Oslo Railway company's bus garages and workshops. 77 of the student units have been built in an attractive old workshop hall dating from 1929. The rest are in new buildings arranged around alleys, small squares and gardens. The area is very dense, and the landscaping design has been important to soften the overall impression. The Bjølsen project received the "Building of the Year" award in 2003 from the Federation of Building Industries.



BJØLSEN 1: PLAN

Reduction of construction waste

The workshop hall is one of three buildings that were decreed as protected areas. It has been remodelled as accommodation for students. Such re-use implies large energy and resource savings, compared to the alternative of demolition and new construction, with the ensuing wastes and use of new resources. Energy calculations were made to ensure that the building conforms to today's standards, whilst retaining the original character of the building. It was therefore insulated internally as well as in the floor. A new, insulated roof was constructed. New glass has been installed in the old steel windows, with new wooden windows added inside to achieve a U-value of 1,4 W/m^2.K.

The two other buildings zoned for preservation are the large bus hall, which has been converted into a sports hall and the roof over the pumping station which is now the main entrance to the area.

Reduction of energy consumption

- The geothermal system: A flexible energy system is provided by a heat pump based on energy exchange with the ground (boreholes in the bedrock). This accounts for nearly half the energy supply to the student complex. The energy is distributed by sub floor water heating, and the area is also connected to the district heating system.
- Energy efficiency: The ventilation system includes heat recovery from the exhaust air. Kitchen fans have automatic shutoff installed, and energy control (SD) systems are installed throughout.
- Energy consumption: Total 164.1 kWh/m^2/year, of which bought energy is 86.2 kWh/m^2.

Sustainable use of materials

The timber in the façades is treated with the "Royal" system, which is a combination of salt impregnated timber, using copper salts, and a subsequent coat of oil which can has pigment colour added. The oil provides a water resistant surface and provides stability, and the timber does not develop a grey colour.

Bjølsen 2: Landscape design

GEORGERNES VERFT

Norway

General information

Name: Georgernes Veft	**Location:** Bergen, Norway	**Year:** 1999 - 2002
Architect: Rambøll AS; Kalve og Smedsvig AS		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Good thermal insulation; environmental respectful materials; heat recovery; sea water heat pump; composting system.		
Prizes: Housing Planning Award, 2002 Award of the Federation of Norwegian Housing Association (NBBL), 2003		
Sources: www2.arkitektur.no/page/preview/preview/10056/57481.html		

Report

The housing complex is centrally located in Bergen on the site of a former shipyard by the sea. There are 10 blocks of 4-6 storeys, with a parking garage running under the buildings. The average size of the 151 apartments is 90m^2. They are of varying sizes and ensure a wide variety of residents. The site is an excavated quayside shelf set against a steep rock face. The site and building concept resulted in a wide variety of building layouts. This is in addition intended to provide the best possible views between the buildings towards the sea and the park.

The outdoor spaces include squares, courtyards, a quayside promenade and pedestrian pathways linking the project to the Nordnes Park. These outdoor areas are designed to have a public character, whilst creating a clear difference between public and private zones.

Georgernes Verft received the Housing and Planning award in 2002 as a successful transformation of a former marine site into housing with high quality architecture and outdoor space. The focus on energy saving and resource use was also commended in the award. In 2003 the project also received the award of the Federation of Norwegian Housing Associations (NBBL).

GEORGERNES VERFT 1: GENERAL VIEW

Reduction of energy consumption

The sea-based heat pump of 311 kW has a heat factor of 3. The backup is a flexible system of electric / oil boilers. The heat is used for space heating, hot water and preheating of ventilation air. Space heating is by water borne floor and radiator elements. All bathrooms as well as living rooms on the ground floor have water borne sub floor heating. The other rooms have radiators, which are calculated and dimensioned individually for each apartment.

Heat distribution is preset to 21 degrees in the daytime and 18 degrees at night. Residents can override this manually, and rooms can be heated to different levels. The energy being used for heat, hot water and electricity can be read in each apartment, and is metered individually.

The energy windows (argon gas, U = 1.1) have a selective coating that reduces radiation by 65%. Solar protective glass was chosen on the basis of considerations related to maintenance and day lighting; some modern coatings reduce daylight very little and are visually not very different from clear glass. The solution chosen is considered to be the best overall although it will result in a slightly higher heating need than could have been achieved.

Waste and drainage systems

Residents can sort waste at source, with special bins installed in all kitchens and easy access to the waste collection points. These measures result in lower municipal rates.

There is a vacuum system for paper and residual household waste, with deposit points in the garages and in the internal street. Wastes are collected by the municipal trucks in a closed system at a collection point outside the housing area. This reduces both traffic in the residential zone, and the area usually needed for waste handling.

There is a composting system for organic wastes. The reactor (Jorakompost 5100) is located near the entrance to the garages. The compost can be used by the residents. There is also a recycling collection point for glass, plastic, metal and drink cartons.

Indoor climate

The building site was managed according to the “Clean Construction” method, contributing to better worker environment as well as reducing humidity and dust in the construction. All apartments have balanced ventilation with heat recovery from the exhaust air. Wall cupboards are fitted up to ceiling height to reduce dust accumulation, and there is a central vacuum cleaning system. Good construction materials are used with low emission of indoor pollutants.

Green spaces

The outdoor areas are open to the public with easy access to the waterfront. Private spaces are well separated from the public zones, with vehicle traffic in the residential zone strictly limited to emergency vehicles and waste removal services. Both residents’ and visitor parking are restricted to the underground garage. The open spaces have well designed playing and meeting areas, with pathways leading to schools and the park.

Georgernes Verft 2: Waterfront

The outdoor areas comprise 6,500 square metres, of which nearly half is on top of the garage. Parts of this are sunken beds four metres wide allowing large trees to be planted. Total amount of area: 33 square metres floor area per person, inclusive of common spaces.

Energy consumption

The total energy consumption is 205 kWh/m^2/year (temperature corrected), of which 155 kWh is bought energy and the rest is provided by the heat pump system.

KRISTIANSAND

Norway

General information

Name: Kristiansand	**Location:** Kristiansand, Norway	**Year:** 1995 - 2006
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** Renewed
Energetic characteristics / Keywords: Bio-fuel; improved public transport; cycle network; attractive urban spaces; accessibility for all.		
Prizes: Urban Environment Prize, 2002		
Sources: www2.arkitektur.no/page/preview/preview/10056/44678.html www.kristiansand.kommune.no www.bussmetro.no		

Report

Kristiansand is a regional centre with an important harbour. As a commercial centre, the old part of the city had to compete with a large new shopping mall located 12 kilometres east of the centre. Most of the residents of Kristiansand moved out of the centre to new residential areas. However, the majority of the jobs remained in the city centre. The expansion of the city generated a great need for transport. Large industrial companies polluted the inner part of Kristiansand fjord.

KRISTIANSAND 1: GENERAL VIEW

In 1994, the city of Kristiansand elaborated an environmental action plan which main goals were:

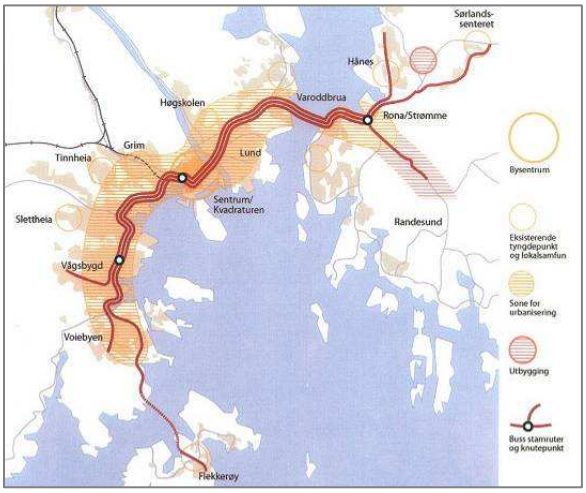
- Reduction of use of land resources for urban purposes.
- Reduction of energy use for transportation and heating.
- Reduction of air pollution.
- Strengthening of the city centre as a commercial and cultural meeting place.
- Providing local communities with services and meeting places.
- Ensuring a green structure.
- Cleaning the river and fjord.
- Reduction of quantities of waste and increased recycling.
- Ensuring cultural heritage and aesthetic values.

The objectives and strategies of the Environmental City project were integrated into the municipal master plan of Kristiansand for the 1995-2006 period.

For a number of years the Municipality has played a leading role in developing partnerships with the state, the county, the private sector and the public. The city's work with environment is broad-based, encompassing themes ranging from cultural preservation and aesthetic urban space to waste recycling and energy. A good example of awareness-building is the Miljøfyrtårn (environmental lighthouse) project where businesses are given an environmental certification.

Overall urban structure

The municipal plan for the 2000-2011 period has imposed limits on space use and steers urban growth towards a sustainable pattern based on a main bus axis stretching from Vågsbygd to Randesundet. Both development of the city centre as well as all new housing and commercial developments are planned in accordance with this main spatial strategy, which also ensures the protection of recreational areas and agriculture. A district heating system using energy from industry, bio fuels and heat pumps has been developed following the same urban structure. It will reduce the climate gas emissions of the city by up to 10%.



KRISTIANSAND 2: OVERALL URBAN STRUCTURE

Improved public transport and cycle networks

During the 1990's the county of Vest Agder and the city of Kristiansand implemented a package of measures which achieved an increase of 30% in the number of commuters using the bus network. This work is now being followed up in the "Bussmetro" project, which also includes the county roads authority. The main idea is that the public transport system shall be attractive and competitive. Bussmetro shall have:

- The same qualities as a metro system, but be operated by bus and not on rails.
- Good access which ensures punctual departures.
- Frequent departures with less waiting time and better connections.
- Services that cover a minimum 50% of the homes, places of work and schools in town.
- Access to stops and buses for everybody.
- High standard and maintenance of stops.
- A modern design that is easily visible in the urban landscape.
- A good information system based on real time.

Bussmetro is equipped with a real-time info system based on GPS, which at all times records where the bus is located, and can provide information to the passengers. Each metro stop between Rona and Trekanten has an information column with a display showing either the number of minutes until the bus will arrive or the schedule if the bus has not yet left its point of departure. The blind or visually impaired may receive this information over a loudspeaker by means of a remote control unit.

As of autumn 2003, the main urban axis has buses every five minutes. Cyclists have a continuous cycle network. The city has also contributed to establishing a cycle network through the Setesdal valley and along the southern coast.

Attractive urban space and green structure

The main squares of Øvre and Nedre Torv have been transformed from the "asphalt deserts" of parking areas into attractive urban spaces. The Markensgate pedestrian street has been extended. Several streets have been transformed into environmental priority zones, with widened sidewalks and lower accident frequency. A green structure plan has provided the basis for securing the limits of urban expansion. The urban districts have better recreational qualities due to new rest areas, walking paths and links to the forests, the river and the coastline.

Cleaner water environment

Most of the pollution in the Otra River and the fjord was removed during the 1990's and a continuous pedestrian path was created along the river and eastern harbour. The polluted sediments in the Kristiansand fjord are also now being decontaminated. The lower reaches of the Otra River are once again a very good area for salmon. Cleaner water from the Otra as well as sewage treatment made it possible to develop the waterfront urban beach (Bystranda), now enjoyed by crowds of users only a stone's throw from the heart of the city.

Accessibility for all

For a number of years the city has worked systematically together with the organisations for handicapped people and built up its capacity to deliver universal design. Political and technical goals regarding accessibility are built into the city's planning system. Many concrete results can be seen, achieved not least through redesign of urban spaces, the beachfront and the city's recreational areas. The Bussmetro is also being developed with a high level of universal design.

Kristiansand 3: Accesibility for all

Evaluation

During the 1990's there was no further growth in car traffic, whilst bus traffic grew by 30%. This was due to a combination of an economic downturn and the strong policies for public transport. However during the latter part of the 1990's car traffic again began to increase rapidly and use of public transport decreased slightly. This in turn was caused by new economic growth combined with less focus on public transport and less restrictive policies towards private cars.

Seen over a long time scale, a densification strategy can lead to reduced traffic growth, but this will also depend on which measures are implemented to steer development.

NYDALEN POWER PLANT

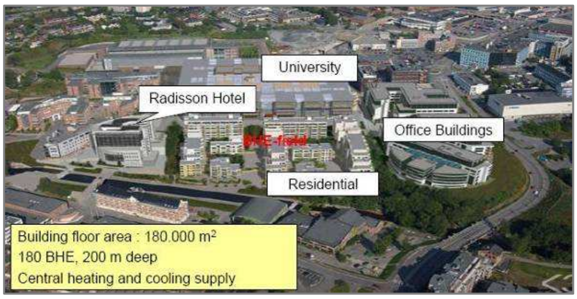
Norway

General information

Name: Nydalen Power Plant	**Location:** Oslo, Norway	**Year:** 2007 - 2010
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New + Renewed
Energetic characteristics / Keywords: geothermal power; good public transport; bioclimatic buildings.		
Prizes: _		
Sources: www2.arkitektur.no/page/preview/preview/10056/57483.html www.nordicenergy.net		

Report

Nydalen is a fairly new development area. It is situated along the main river – "Akerselva" (Akers river) - that runs through the central parts of Oslo. The total building floor area in Nydalen – all building types included - covers some 200 acres. It is one of the largest urban development projects in Norway. It is estimated that about 18000 either will live there or be employees and students connected to various industries, offices and an educational institution



NYDALEN 1: GENERAL VIEW

A key factor in creating an attractive area for commercial activity has been to develop the area as an urban transport node. A balanced and varied composition of buildings, infrastructures and functions has been vital.

Coordinated transport planning

A high degree of accessibility is ensured by coordinated planning of the transport infrastructures. Good access to public transport includes a new centrally situated metro station, taxi ranks, bus and train connections. In addition the ring road (Ring 3) is very close by. A pilot project for car sharing has also been set up to reduce car use.

Urban spaces

The creation of attractive public spaces fosters social contact and activities. The heart of Nydalen is at Gullhaug square, where a range of key functions have been located to ensure a vital urban centre.

Industrial synergies

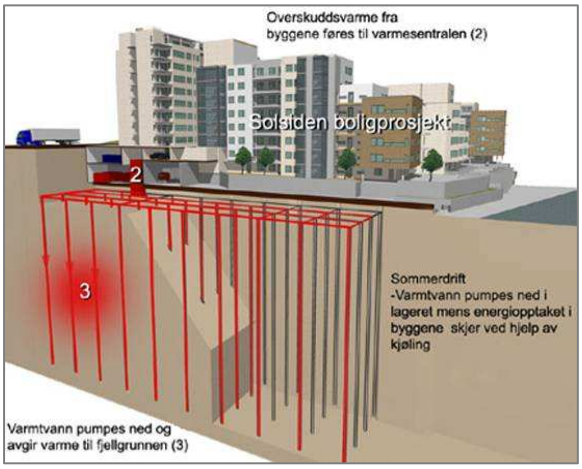
The co-localisation of about 200 companies to the area creates a strong commercial environment with many possibilities for cooperation and synergy effects. Companies can find both customers and suppliers nearby. At the same time it means that a comprehensive range of services is on offer both to the companies themselves, and to the local population.

Re-use

Over the past few years the formerly polluted and industrialised Aker river has been redeveloped into a continuous urban green corridor, with parks and paths leading all the way from Maridal lake down to the waterfront at Bjørvika. At the same time, valuable historical industrial buildings along the river have been preserved and converted to new uses. The green spaces and the mix of new and old buildings create a lively, dynamic urban typology.

The Nydalen energy plant

Energy systems for Nydalen were considered in detail together with Oslo city's energy conservation consultants. The developer came to the conclusion that it would be feasible and profitable to build a central energy supply plant. The investment will be paid back within 2-3 years, taking into consideration some subsidies from the state and the city. The development, covering a total of 200,000 m^2 of floor space, will receive 80% of its energy needs from the Nydalen energy plant. Backup supply will be with electric or oil boilers, depending on the cheapest alternative at any time.



NYDALEN 2: GEOTHERMAL POWER PLANT

Energy storage

The source of heating is the energy used for cooling purposes. The cooling plants in the area will be used as heat pumps for large parts of the year. These heat pumps will supply heat for ventilation, space heating and hot water as well as being used to melt snow outdoors. However, since the production of cooling does not coincide in time with the main needs for heating, there is therefore a need for energy storage, both on a diurnal and annual basis.

This storage is achieved by pumping excess heat from the cooling units down into the rock strata below Nydalen, in the form of hot water at 40 degrees. There are 180 energy boreholes to a depth of 200 metres. This gives a storage capacity of 1.2 million cubic metres of rock.

Antifreeze fluid circulates in a closed system in the boreholes, which are connected to four large heat pumps. In summer, the system is used to cool indoor air by sending used warm air down into the boreholes. In this way the rock is gradually heated to around 25 degrees in the course of the summer, and thus constitutes a huge heat source for the following winter.

The heat stored underground is then used to heat the buildings in winter. Raising the underground temperature by 10 degrees corresponds to 6 million kWh of stored energy. A further 7 million kWh is supplied directly from the waste heat given off by the cooling units, and only an additional 2 million kWh is needed from conventional backup sources.

Energy efficient buildings

All buildings – new and old – have high energy efficiency requirements. Some of the older industrial buildings have average heat energy figures of 160-180 kWh/m^2. The new buildings use water based systems for heating and cooling. In future, the older buildings may also be connected to the same central energy plant.

Cost effectiveness

Under normal operation, the Nydalen energy district heating plant will result in 60-70% lower energy use than normal. The peak effect is 9.5 megawatts of heat plus 7.5 megawatts of electricity. The large scale, efficient cooling units will deliver 6 kWh of cooling per kWh input. The developer can thus deliver both cooling and heating at extremely competitive prices. The project will deliver energy to The Norwegian School of Management, the Radisson SAS hotel, the Solsiden housing area as well as the office buildings on Nydalshøyden. It is the largest project of its kind in Europe.

Pilestredet Park

Norway

General information

Name: Pilestredet Park	**Location:** Oslo, Norway	**Year:** 1999 - 2006
Architect: Lund og Slaatto Arkitekter AS (architects), GASA AS Arkitektkontoret (architects), Bjørbekk og Lindheim AS (landscape architects), Asplan Viak (landscape architects).		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New + Renewed
Energetic characteristics / Keywords: Environmental respectful materials; MOP environmental Program; recycle of demolition materials; composting system; bioclimatic buildings; improved public transport; cycle networks.		
Prizes: _		
Sources: www2.arkitektur.no/page/preview/preview/10056/57482.html		

Report

This is currently one of the largest urban ecology projects in Scandinavia. It includes more than 600 new apartments. The two main actors, the Directorate of Public Construction and Oslo city, have had high ambitions for the area. An environmental program (MOP) has been developed which obliges developers to follow urban ecological principles and to achieve set targets.

Pilestredet Park 1: General view

Environmental Issues

In contrast to many other projects, the environmental program or MOP poses quantified environmental performance requirements. The three main environmental themes are:

- Resource use: concerns consumption of resources and energy generally.
- External environment: emissions to air, water and ground.
- Health, environment and safety: HES concerns working environment, indoor climate, transport and external works.

Specific requirements are set for materials, energy use, waste management, water consumption and treatment, indoor climate, transport, outdoor areas, HES and maintenance.

Many studies were carried out during project preparation, for example environmental comparisons of renovation contra demolition and new building, and CO_2 calculations to compare different building scenarios. Another pioneer feature was that the detailed climate studies that had been carried out were stipulated to be a binding basis for the design work.

The development is in progress, and requirements for documentation of results achieved are being elaborated. In some cases, developers have applied for exemption from requirements. The major issues from the MOP are presented below:

Reduction of construction waste

The plans for Pilestredet Park included a large amount of demolition. A separate subproject was executed together with the developer; the MOP setting predetermined high standards with regards to recycling, waste handling, noise, dust and other issues.

The MOP required that 90% by weight of all demolition material should be recycled and that all recycling should be on site or as close by as possible. This recycling should be at the highest possible level (direct re-use being highest, thereafter recycling, and combustion as lowest level). A minimum of 0.25% must be re-used directly and minimum 25% as recycled material. All hazardous substances must be sorted and delivered to treatment facilities.

Feasibility studies assessed the possibility for a new building made from re-used materials, and for using old materials in the outdoor works. Catalogues were compiled of the materials in all buildings that were to be demolished, also describing which materials or components were suitable for re-use in new buildings or outdoor works. A modified version of these was then used as an order form in contracts with the demolition firms and the materials were collected.

A permit was obtained for handling the heavy materials on the site, in particular crushing and sorting of brick and concrete elements. This greatly reduced transport and much of the material could then be re-used directly on site too. The crushing plant in Pilestredet, which is very centrally located in the city, caused less noise and dust than anticipated. Thanks partly to careful sitting, it was only a minor nuisance to local residents.

The requirements of the MOP were largely fulfilled. No less than 98% of all materials have been recycled. Nearly 3% was re-used directly (mainly as aggregate in new concrete) and other materials were sent for materials recycling. Large quantities were used in Pilestredet for road building, infill, etc. All contaminating materials have been removed.

The MOP stipulates that waste in connection with new construction shall be minimised. The first housing area to be built, in zone H, produced 18kg per square metre of built floor area. Only 25% of this was delivered to waste dumps, the rest being sorted and returned.

During construction, maximum permissible levels were set for noise, vibration and dust. A specially designed rig was installed which washed the tyres and undercarriages of the trucks which they had to pass before they entered public roads.

Sustainable use of materials / Indoor environment

The MOP requires that at least 25% of materials in the buildings shall be re-used or recycled materials. In addition, the five most used materials (by weight) shall have environmental declarations, in compliance with GRIP Foundation's "Environmental declaration for building materials". A Dutch handbook was used as the basis for material selection. No materials are permitted which contain over 1% by weight of the substances on the "red list" of the Pollution Control Authority (SFT). PVC is not to be used where good alternatives exist. New buildings are also to be constructed with a view to eventual selective demolition.

Pilestredet Park is using a prefabricated concrete element which uses waste materials, both concrete and water, from their own production cycle.

Indoor climate

Requirements regarding indoor climate included low emission materials, reduction of humidity damage, avoiding allergens, and careful localisation of electric and magnetic fields. A daylight factor of minimum 2% was set for housing and 3% for workplaces. Subsequent analyses have shown that the indoor climate is good.

Water

The MOP requires that housing areas be designed for a maximum water consumption of 150 litres per person/day, with individual water metres in each apartment. It was also specified that drinking water should be high quality and that piping should not emit any hazardous substances in the event of fire.

Reduction of energy consumption

For housing, the annual designed energy use is to be 100 kWh/m^2, for offices it is to be 90kWh/m^2 and for educational buildings 80kWh/m^2. Flexible heating systems are to be used and there is a district heating supply. All apartments have water borne heating.

Waste and drainage system

Residual waste requiring to be dumped is less than 30% of total wastes. Wet organic waste is composted.

Green spaces

Whereas the private outdoor spaces are developed by the builder, Statsbygg has the overall responsibility for parks and common areas, following a separate ecological landscape plan. Asplan Viak has designed the areas near the apartments as well as the "Re-use park" which was opened in 2004, where materials like granite from the former buildings are used. The landscaping uses open drainage solutions and swales. Parts of the pathways are built with recycled crushed brick and concrete.

Pilestredet Park 2: Re-used materials

Area and transport

It is a requirement that a minimum of 80% of transports to and from the area can be by public transport, foot or cycle. A high level of cycle parking is required, with 2,5 places per apartment, partly indoors, and with good accessibility. The area is nearly car free with only small side roads where it is possible to enter the area for special purposes. Access to the underground parking garages is from neighbouring streets.

Evaluation

The project has contributed to the development of new working methods and forms of public-private cooperation, both with regards to environmental quality control and subsequent management. The fact that major actors such as Statsbygg and Oslo city prioritise environmental targets has also sent an important signal to the whole building industry.

Preliminary objective results are available with regards to the demolition and re-use projects. They are very favourable: only 3% of demolition materials have gone to waste, while 97% have been re-used on site or in other construction works.

Bioclimatic buildings

Borgen Community Centre

Norway

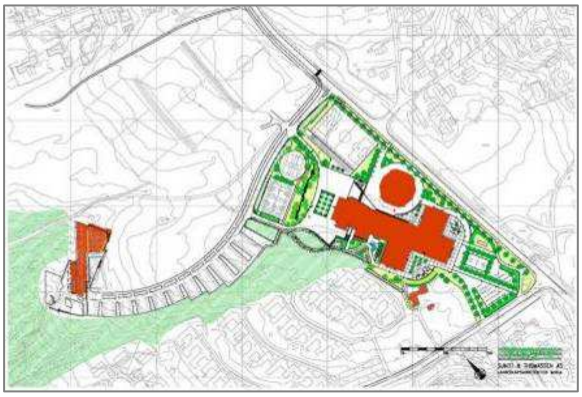
General information

Name: Borgen Community Centre	**Location:** Asker, Norway	**Year:** 2005
Architect: HUS Arkitekter Trondheim AS (Architect); Sundt & Thomassen Landskaparkitekter AS (Landscape architect).		
Type of Project: Bioclimatic Building		**Condition:** Renewed
Energetic characteristics / Keywords: Good thermal insulation; heat recovery; geothermal power; re-used materials.		
Prizes: _		
Sources: http://edit.brita-in-pubs.eu www.skoleanlegg.utdanningsdirektoratet.no/asset/938/1/938_1.pdf		

Report

The main objective was to turn the building into a modern local community centre with emphasis on environment, resources and indoor climate. The existing building was poorly ventilated, had minimum day lighting, and was not suited for modern working methods and cultural and social activities. The goal of the renovation was to reduce energy consumption by 50% or better, using a number of innovative low-energy building technologies.

Borgen Community Centre is located in an open suburban area approximately 2 kms from the centre of Asker, which is situated 20 kms southwest of Oslo. Local Community Centre contained secondary school, kindergarten, youth activity centre, health care, dental services and rooms dedicated to private organisations. Original school building was built in 1971.



Borgen 1: Plan

Building construction

The retrofit concept was to reuse all construction elements that could satisfy Norwegian building requirements: foundations, prefab concrete pillars and beams, concrete floor slabs, drainage and sewage pipes. Roof elements and all walls needed to be replaced.

To provide enough floor space to meet the revised school and community centre needs, an extension of approximately 2000 m² had to be added.

Roof construction was strengthened due to new regulations on snow loads and insulation was increased to an average thickness of 300 mm, which resulted in a U-value of 0.13 W/m^{2}K. Walls were completely rebuilt with 200 mm insulation. This gives a U-value of 0.2 W/m^{2}K that is within Norwegian requirements.

New windows have wooden frames with outside aluminium cladding. Glass is high quality double-glazing with low emissive coating. Theoretical U-value is 1,1 W/m^{2}K, which is well below the national requirements of 1.6.

Existing floor slabs were given a new 100 mm insulation layer underneath a new 100 mm concrete floor slab. Some areas were covered with oak floorboards, but the greater part was grated and waxed to give a robust surface with high thermal capacity. The insulation layer was also used to lay new water pipes and electric cables.

BORGEN 2: GENERAL VIEW

Heating

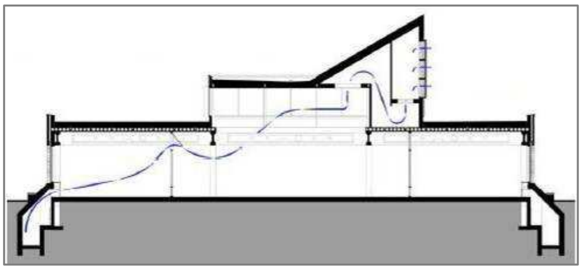
To optimize the use of renewable energy, a geothermal heat pump was chosen. Heat is pumped from the ground from 44 energy wells, at an average depth of 150 m. During the summer it could provide cooling by pumping excess heat back into the ground and thus "recharging" the wells. The heat pump produces low temperature hot water, 45 to 50° C. Heat is distributed by water to radiators under the windows. It is also used to preheat DHW to about 40°C and the temperature is then lifted to 75°C by electric heating.

Two oil boilers are installed as a backup system, and they have sufficient capacity to heat the building and supply hot water if the heat pump is out of order. The heat pump is dimensioned for 60% of total needs. Under normal conditions this is enough and the oil burners will kick in only a few days during the winter. The energy plant also supplies hot water for heating to the nearby Vardåsen church.

Ventilation

The main ventilation is based on a natural hybrid system with inlet towers and underground culverts for fresh air supply. Since it was an existing building, culverts had to be built outside along the foundations. From the culvert air is let into the room through specially designed grids that allow people to stay close without feeling a draught. Air flow through each room is regulated by electrically operated windows in the wall towards the central area. The opening (and the air flow) is regulated by temperature and CO_2 sensors in each room and thereby adjusted to the actual needs.

Exhaust towers located over the central area in each base, are equipped with fans that are activated when natural driving forces are insufficient. Heat recovery systems supply heat to the preheating units in the culverts. To benefit from wind forces a special shutter system was developed to ensure that wind always helps evacuate the air and never build up a counter pressure that could reduce or stop the natural airflow.



BORGEN 3: VENTILATION

Lighting

The shape of the building made it necessary to improve daylight conditions. The large skylight is facing north at an angle that does not let direct sunlight and heat into the long central section of the building, but greatly increases the level of daylight. The narrow window facing south also contributes without letting in too much heat. The raised windows in the central section of the base areas do the same, but shutters had to be used to prevent unwanted heat.

To optimize the effect of daylight, all artificial lights are adjustable and regulated by light sensors. In addition, light is also regulated by motion sensors that will turn the light on when someone enters the room, if conditions require so. When a room is left empty, the light will automatically be turned off after a preset time lapse. The IR-sensors also serve as detectors for the burglar alarm during the night.

Energy saving

The goal was to reduce energy consumption by 50% or better. The old building had a total energy consumption of 280kWh/m^2/y and the energy consumption estimate after the renovation is 111 kWh/m^2/y.

Table 1.1. Energy consumption:

	Energy estimated (kWh/m^2/y)
Space heating	29
Heating ventilation air	20
Water heating	13
Funs and pumps	15
Lighting	23
Equipment	11
Cooling	0
Total	111

Solar thermal collectors

The development of a new type of solar collector, based on a glass construction and liquid heat medium, has moved from the initial face to constructive planning. A project group is planning to install a prototype at Borgen. The idea is that collectors can become building integrated elements in roof or wall constructions.

Preliminary studies of potential energy gain under different solar conditions and different locations indicate temperatures from approximately 22 to 43°C for the southern Norway region. Naturally, results improve as one moves south, but the low sun in the winter also gives good results for vertical collectors. Production of domestic hot water will require a heat pump to raise the temperature to a level where legionella problems are avoided. This may not be a problem with closed circuits for room heating only.

ACC windows

The same group is also engaged in the development of a wooden window with a sash that may be turned 180 degrees in the frame. The sealed glass unit has one solar absorbing glass and one glass with low emissive coating. This will give increased solar gains during the heating season with the solar absorbing glass facing inwards, and reduction of unwanted heat during the summer when the absorbing glass is facing outwards.

GLØSHAUGEN

Norway

General information

Name: Gløshaugen	**Location:** Trondheim, Norway	**Year:** 2000
Architect: _		
Type of Project: Bioclimatic Building		**Condition:** Renewed
Energetic characteristics / Keywords: Photovoltaic power; double façade.		
Prizes: _		
Sources: www2.arkitektur.no/files/file19618_bp_solar_skin_final_endelig_rapp.pdf		

Report

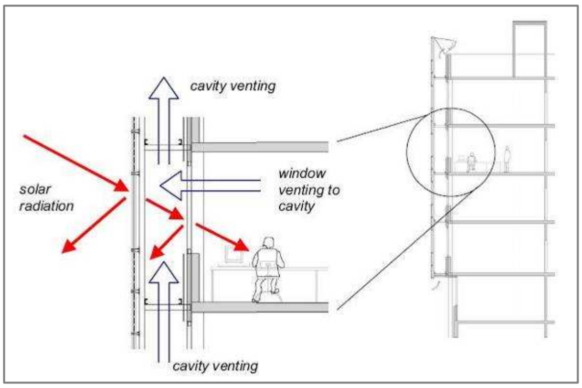
BP Norge and BP Solar commissioned Norwegian research units at NTNU and SINTEF developed a building system for façades, based on photovoltaic solar cells. An appropriate existing building to mount the double skin façade on was chosen at the University Campus in Trondheim, O.S. Bragstads plass 2. A wing of this office complex for the Electrical Engineering faculty has a slightly protruding four-storey façade, oriented 25º east of due south. The main part of this wing was built around 1970, with fairly poor insulation and a large amount of air leakage.

Double façades

A double façade, or double skin façade, consists of a glass skin mounted outside the normal insulated external wall of a building. The cavity formed between the outer skin and the main wall will provide extra thermal insulation and improved air tightness for the building. The cavity also offers a protected location for solar shading systems and other façade equipment, and platforms for maintenance, cleaning and a fire escape can be introduced.

GLØSHAUGEN 1: FAÇADE BEFORE AND AFTER

With southerly exposure, the glazed cavity will trap solar radiation the same way as a greenhouse or an atrium. The energy captured can be used for preheating supply ventilation air; the raised cavity temperature will in any case reduce the heat loss from the building. In the cooling season, the cavity will have to be vented.



GLØSHAUGEN 2: AIR AND HEAT DIAGRAM

Adding a double façade to an existing building will in many cases be a viable alternative to installing new windows and improving the thermal insulation, especially for historically important buildings where façade upgrading maybe not feasible.

Building Integrated Photovoltaic Cells

Applying PV cells to the building envelope is often termed Building Integrated PV, BIPV. Better economy than for a standalone system is often realized with this concept, as the PV modules also have other functions. At higher latitudes, the solar radiation on a vertical south-facing wall is not much less than on a sloped surface oriented optimally for maximum radiation. It is therefore feasible to integrate PV cells in the cladding of façades. The PV output is dependent on temperature, the cells should be kept cool, and therefore in a BIPV application, the PV modules should be vented.

The proposed building system is based on a combination of a double skin façade and building integrated PV façade cladding, where the PV cells are integrated in the outer glass skin. The cells are laminated in glass, and placed in façade sections that are not in front of the ordinary windows. The performance characteristics of the two combined façade concepts are complementary – the systems help each other if controlled properly.

Some important features of the BP Solar Skin concepts are:


GLØSHAUGEN 3: FAÇADE INTEGRATED PV CELLS

- Both electricity and thermal energy are provided.
- The PV cells convert about 15% of the solar radiation into electricity.
- The thermal energy can be used to reduce the heating load of the building.
- The PV cells provide solar shading for the windows for high summer sun.
- The cavity can be implemented in a scheme for natural ventilation.
- The cavity can be vented to keep the PV cell temperature down for better performance.
- The cavity provides a protected location for solar shading systems.
- The skin and the cavity will provide improved noise protection.
- The cavity enables operable windows in high-rise buildings.
- The cavity can be supplied with platforms for maintenance and evacuation.
- The concept is well suited for thermal upgrading and climate protection of existing buildings, but can also be applied in new buildings.

The BP Solar Skin concept of course also implies some problem areas: important items are fire safety related to smoke propagation in the cavity, sound propagation likewise, reduced daylight levels, impairment of view in some configurations.

In order to assess the performance more closely and evaluate alternative designs, a comprehensive R&D project was carried out after the first conception stage. The energy performance of the façade and the thermal comfort in the building were assessed, using computer simulations, for a generic office building in various Norwegian climates.

The architectural and visual aspects of the concept were studied using scale models, full-scale mock-ups, photomontages and computer visualizations. An important consideration was the effect of PV cell spacing in the outer skin and the apparent transparency of the whole skin from both sides. The impacts on daylight levels and glare problems were also important aspects of the research.

The double façade prototype

The double façade prototype was constructed with glass panels mounted in a standard aluminium framing system. The outer skin is carried by vertical steel frames, which are bolted to the concrete floors of the building. Open-grate steel platforms are installed at each floor level for monitoring, maintenance and cleaning purposes. The cavity can be vented by motor-operated vents at the top and bottom, controlled by temperature sensors.

The PV cells and the conduits are embedded in a resin layer in laminated glass modules. These modules are located outside the façade sections without windows. The total façade area is 455 m^2, of which the PV module area is 192 m^2 (PV cell net area 102 m^2 – 16 kWp).

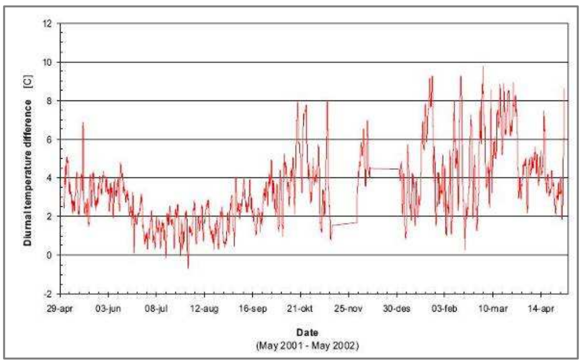
GLOSHAUGEN 4: FAÇADE DETAIL

The prototype is instrumented with automated monitoring equipment that registers both the electricity delivered to the building's grid, and how the solar energy façade affects the heating demand and indoor climate of the rooms that face the new façade.

Monitoring results

- Thermal winter gains:

  The increased cavity temperature over the external temperature in the heating season gives an indication of the heating demand reduction achieved by the Solar Skin buffering and solar gains. The total heating energy saved was calculated to be 7-8 %, using a computer simulation program that takes into consideration the overall thermal balance of the whole building.



GLOSHAUGEN 5: TEMPERATURE DIFFERENCE

This figure shows the mean diurnal temperature difference between the cavity and the ambient air for the whole monitoring period. Especially during the heating season, which in Trondheim typically runs from mid September through April, there is a positive contribution from the cavity heat.

- Summer conditions:

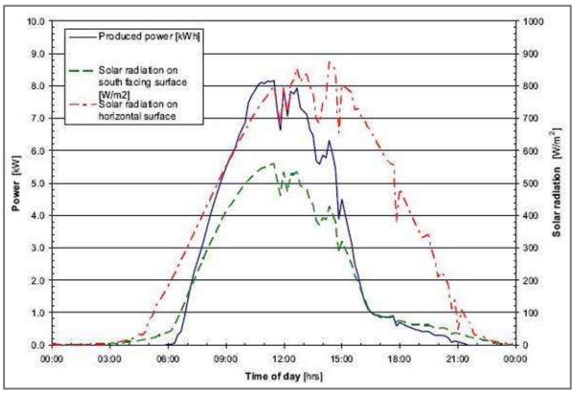
A pre-construction study of the cavity performance showed that the best cooling strategy for summer conditions is to keep office doors open to the north side corridor and draw cold air from the corridor windows, using the solar façade cavity as an exhaust stack.

The occupant survey shows, however, that some of the occupants at the top (4th) floor do experience periods of overheating in the summer. A closer investigation has revealed that under unfavourable combinations of high solar radiation, high outdoor temperature, and certain wind directions, the air flow in the cavity is reversed, resulting in the top floor offices receiving hot cavity air through the windows. A revised venting control strategy will be implemented to improve the summer conditions.

- Electricity generation:

For a full year, May 2001 to May 2002, the PV system delivered about 7200 kWh to the building, this result is corrected for lost energy during a short period of system malfunction.

The theoretically maximum generation should have been about 9400 kWh with the solar radiation registered for the monitoring period. The system overall efficiency, or performance ratio, was therefore about 75%. The losses are due to the shading at the site, the inverter configuration which is sensitive to shading, and lower efficiency at low solar intensity, which at this latitude is more pronounced.



Gløshaugen 6: Data on June 23rd 2001

GRONG SCHOOL

Norway

General information

Name: Grong School	**Location:** Grong, Norway	**Year:** 1998
Architect: Letnes Arkitektkontor A/S		
Type of Project: Bioclimatic Building		**Condition:** Renewed
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; environmental respectful materials; heat recovery; hydro-electric power; bio-mass.		
Prizes: _		
Sources: www.skoleanlegg.utdanningsdirektoratet.no www2.arkitektur.no/page/preview/preview/10056/48757.html www.ecobuilding.dk		

Report

The Grong school is part of an EU-project, MEDUCA, which covers co-ordinated design, construction, monitoring and evaluation of educational building projects in seven countries (DK, N, S, DE, ES, IT, GR). The MEDUCA projects offer possibilities for teaching energy conservation, using the demonstration buildings as "living examples".

One of the design challenges was to find suitable solutions for co-ordinated use of the school and the community centre. Many rooms are planned both for social and cultural activities, and for teaching and learning.

The new wing is a one-storey school building. Classrooms are situated on the northern side of a central circulation spine. Common rooms, rooms for group activities, storage rooms, and locker rooms are located on the south side.

North facing classrooms have no need for glare reduction devices or shading systems, but have low heat gains and thus increased need for heating during winter. To increase solar gains, the exhaust air chamber (top of the building) is designed as a solar collector (sun space), which gives heat to the fresh air via the heat recovery in the exhaust tower, and also gives some sunlight into the classrooms.

GRONG SCHOOL 1: VIEW

Passive solar heating

A sunspace runs along the entire ridge of the building. The tilted south facing glazing was designed to optimise the use of incident solar energy over the year. The sunspace also functions as a roof monitor that transmits daylight into the classrooms; and it serves as a ventilation air exhaust chamber as well.

GRONG SCHOOL 2: SUNSPACE

The sunspace (solar air collector) is expected to allow for a high fraction of usable solar heat contribution. Heat loss to ventilation air represents a large portion of the heating energy requirement in cold climates. A system of indirect ventilation air pre-heating is employed. Solar radiation incident on the south facing glass of the sunspace will cause the temperature of the exhaust air to rise. The heat is recovered at the exhaust tower and exchanged to the fresh air at the underground air intake tunnel.

Daylighting

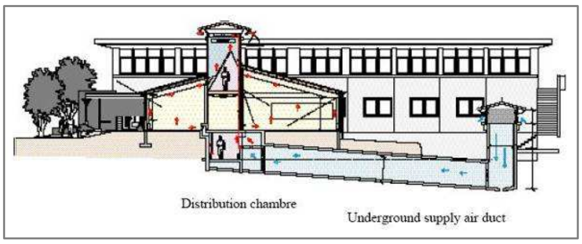
The internal walls of the sunspace are glazed in order to allow daylight to reach the back of the classrooms. Three different methods were used to simulate the daylight levels in the classrooms. The selected roof monitor (sunspace) design optimises passive solar heating and even distribution of daylight on the workplaces.

Separately operating zones of artificial lighting is implemented in order to reduce uneven lighting levels and contribute to energy savings. Timers and daylight sensors are used to control the artificial lighting.

Ventilation

An air inlet tower is located outside the building. The air is brought into the building through an underground tunnel that connects the air intake tower to a distribution chamber below the central circulation spine. Exhaust air is extracted through the exhaust chamber (sunspace) above the circulation spine. A centrally located exhaust tower at the top of the building provides the necessary stack effect.

The underground supply air duct provides for pre-heating of ventilation air in the winter season through ground coupling; and pre-cooling of the air during the summer. Increased night time ventilation during overheated periods provides a significant amount of cooling energy to the building with an estimated 12 hour time lag.



GRONG SCHOOL 3: AIR DIAGRAM

The supply air, which is distributed in the classrooms by displacement ventilation, is introduced at floor level through low-velocity diffusers.

Warm and contaminated air rises and leaves the room at ceiling level, through controllable dampers, into the exhaust chamber. Wardrobes and toilets are provided with overflow air, and the exhaust air is being mechanically extracted from the toilets. In order to reduce air contamination by source, low-emitting materials has been used predominantly. Lower emissions from materials allows for a substantial reduction of the air change rate, which in turn promises a decrease in the heat loss to ventilation air during the eating season.

The sunspace/exhaust air chamber was designed to assist the movement of air. The driving force represented by the hot air in the exhaust chamber reduces the need for fan assistance. This is particularly important in summer season when increased ventilation air volume is used to cool the building.

Fan Assisted Supply and Extraction

Fans are installed both at the supply side and the exhaust side. The supply fan is supposed to ensure a steady air flow into the building, while the exhaust fan is used to achieve forced ventilation for cooling during summer when buoyancy forces are insufficient.

A preliminary study indicated that wind-driven natural ventilation could not provide satisfactory ventilation at all times. Calm periods of 5-7 days have been reported at the site. Buoyancy-driven ventilation is considered reliable for the coldest part of the heating season, but it may not work sufficiently for summer conditions and for some periods during spring and fall. Additionally, the installed filters and heat exchangers cause an airflow pressure drop. Hence, fan-assisted buoyancy driven ventilation strategy was employed in the final design.

GRONG SCHOOL 4: AIR INLET TOWER

Heating and Cooling

Today the school has electric and oil fuelled hot water heating. Connection to a planned biomass fuelled district heating system is intended.

Pre-heating of supply air during the winter occurs in three steps: First by the thermal mass in the underground supply air duct, then by a heat exchanger providing heat from the heat recovery system, and finally by a hydronic coil heat exchanger.

The building itself is considered as light, but brick walls between the classrooms and the circulation space, and the concrete floors, provide some thermal mass.

The solar gains from the sunspace will also add heat to the heat recovery system during spring and fall. On cold days, a net heat loss from the exhaust airflow through the glazed areas will contribute to an expected decrease in the stack effect by less than 10 %.

Since the temperature of the basement distribution chamber is set at 19°C, it can be claimed that the central corridor of the building has a kind of passive radiant floor heating system.

The underground supply air duct will also provide a considerable pre-cooling of the air during the summer. However, with a design summer temperature of 23°C, the cooling demand is relatively low. Pre-cooled ventilation air may still be called for, particularly in early fall when low sun angles and predominantly clear skies could occasionally contribute to indoor temperatures above the comfort zone.

Heat Recovery

Heat is recovered from the exhaust air in the exhaust tower by the use of a heat exchanger. The recovered energy is then used to heat the air supply via another heat exchanger placed between the underground supply air duct and the distribution chamber. A water-glycol loop conveys the heat between the heat exchangers. The expected heat recovery rate is some 55-60 %. Expected pressure losses are 25 Pa for the inlet air exchanger and 28 Pa for the exhaust air exchanger.

A considerable pre-heating of the air will also occur in the underground supply air duct, before the heat recovered from the exhaust air is added. During periods when heat recovery is not needed, the exhaust air bypasses the heat exchanger in order to avoid creating a pressure drop.

Filters and Fans

A mosquito net is installed in the air intake tower. Fine filter is installed at the end of the underground air inlet duct, just before the inlet heat exchanger unit. The pressure loss through it is substantial, about 20 Pa for a new filter. It is assumed that large particles will be deposited in the underground supply air duct, before reaching the fine filter.

Fans are of the propeller type, having a diameter close to the inner diameter of the duct. The supply fan, which is placed in the air inlet tower, has the ability to enhance the pressure by some 70 Pa. The exhaust fan, which is placed at the lower end of the exhaust tower, will add a pressure of about 35 Pa to the system.

The building's performance

- Reduced use of electricity app. 20 kWh/m^2 per year:
  - Reduced use of electricity due to control of artificial lighting: 10.2 kWh/m^2 per year.
  - Reduced use of electricity for ventilation fans: 9.2 kWh/m^2 per year.
- Reduced demand for heating app. 16 kWh/m^2 per year:
  - Reduced demand for heating due to passive solar heating: 6.9 kWh/m^2 per year.
  - Reduced demand for heating due to low energy windows, low emitting materials, and demand controlled, hybrid ventilation: 8.7 kWh/m^2 per year.
- Avoided CO2 emissions:
  - The electrical energy is provided by hydro power, which has no CO2 emissions.
  - The thermal energy is today provided by oil, but the oil will in the future be replaced by biomass, which is CO_2 neutral.

GRÜNERLØKKA STUDENT HOUSING

Norway

General information

Name: Grünerløkka Student Housing	**Location:** Oslo, Norway	**Year:** 2001
Architect: HRTB AS Arkitekter (Architect), Multiconsult AS, Seksjon 13.3 landskapsarkitekter (Landscape architect).		
Type of Project: Bioclimatic Building		**Condition:** Renewed
Energetic characteristics / Keywords: Good thermal insulation; saving both energy and waste in the building renovation.		
Prizes: _		
Sources: www2.arkitektur.no/page/preview/preview/10056/57798.html		

Report

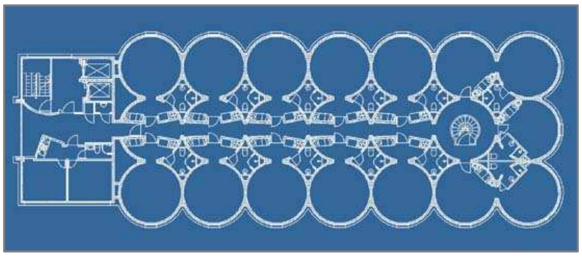
The original building was a grain silo from 1953, the first building in Norway to be erected using sliding formwork. The conversion into student housing is a result of a competition during the 1980`s where HRTB Architects suggested forming it into a hotel.

The building is situated at the bank of Aker River, a former industrial area dating back from the 17th and 18th century. The government turned the area into a national park in the 1990`s. not only as a recreation area; a number of old and typical industrial buildings have been transformed with new functions such as The Oslo School of Architecture and Design, The national college of Arts, and parts of the national TV and radio network. This part of the river is surrounded by working class housing from the 18th century - now one of the most popular residential areas of central Oslo especially among young people. The city of Oslo therefore sponsored projects in the area in order to get more families into old flats which were being renovated.

GRÜNERLØKKA 1: VIEW FROM THE PARK

The silo now comprises 226 residential units on 16 floors. All living spaces are circular, hallways and kitchen are circle segments, and bathrooms occupy the star-shaped parts of the original plan form.

The aim of the architect was to keep as much as possible of the structure both in form and material. The corridor is therefore shaped as a walk from "cell to cell". The rough texture of the original concrete has been retained and is contrasted by the strong colours of the new elements. Groups of floors have got their own colour scheme which "leaks" out of the



GRÜNERLØKKA 2: FLOOR PLAN

building through the coloured glass of the "balconies".

The façades have been insulated externally and rendered. Internally the surfaces have been treated with environmentally friendly silicate paint. The internal concrete walls also functions as thermal mass. The most important environmental issue is the saving of both energy and waste when this building was transformed and renovated.


GRÜNERLØKKA 3: FAÇADE

The source of energy is electricity, oil and district heating system. The energy consumption in 2003 was 156 kWh/m²/y.

The water based floor heating system is flexible for other energy sources and a heat exchanger is mounted on the roof.

The roof is transformed into a common terrace with adjacent rooms for common social activities. Arrangements for extensive use of bicycles have been focused with an indoor and outdoor lockable bicycle shed.

KLOSTERENGA ECOLOGICAL HOUSING

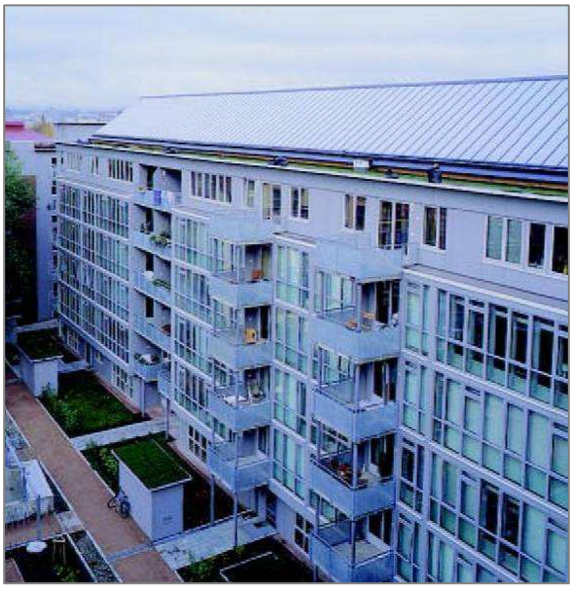
Norway

General information

Name: Klosterenga Ecological Housing	**Location:** Bergen, Norway	**Year:** 1999
Architect: Arkitektskap AS (architects), GASA AS Arkitektkontoret (architects)		
Type of Project: Bioclimatic Building		**Condition:** Renewed
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; environmental respectful materials; rainwater use; heat recovery; solar thermal power; holistic ecological approach.		
Prizes: NBO Nordic Building Award, 2000		
Sources: www2.arkitektur.no/page/preview/preview/10056/57484.html "Does use of technical systems create sustainable architecture in Nordic countries?", Birgit Kollandsrud Friis		

Report

Klosterenga lies in an area with typical city blocks from the end of the 1800's. It replaces former industrial and storage buildings. The project consists of 92 apartments, of which one block comprising 35 apartments was designed with comprehensive ecological measures.



KLOSTERENGA 1: GENERAL VIEW

Central goals of the program were as follows:

- The building construction should have the lowest possible resource use seen in a life cycle perspective.
- It should have the lowest possible environmental impact under construction and operation.
- The extent and quality of nature on the site should be increased.

Klosterenga received support from the EU Fifth Framework Plan within the SUN/SHINE program which had as its main themes active and passive solar energy. The project is recorded as a Best Practice building in Caddet Technical Brochure no.170 (IEA/OECD), as an example of Ecodesign by the State Pollution Authority, and it received the NBO Nordic building award in 2000.

Environmental issues

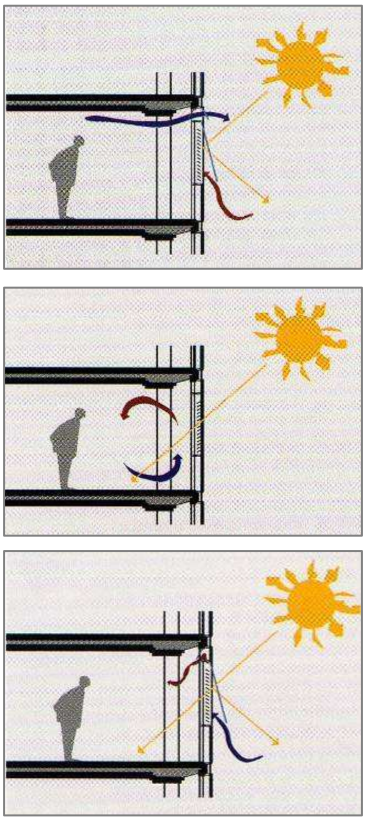
Klosterenga is designed with a holistic ecological approach. It connects well to its context with regards the urban water and green structure as well as the pedestrian and cycle networks. The building volume is shaped and situated so as to protect the outdoor spaces against cold air movement and sources of air pollution, as well as to provide optimal solar radiation. The natural qualities are actively enhanced through the design of water and vegetation features.

Renewable energy

The building envelope is designed as a solar collector, in order to maximise solar energy with both passive and active systems. The floor plans have a clear temperature zoning; rooms needing stable heating are in the centre, whilst rooms needing less heat are on the north side. Rooms that can tolerate temperature variations are to the south. This systematic temperature zoning lowers the heating needs. The average temperature is lowered, since only 6.3% of the space needs a high temperature such as 25 degrees, whereas about 30% of the space only requires 17 degrees.

The floor plan provides apartments lighted and ventilated from both sides, and the zoning principle results in the bedrooms being on the north, bathrooms in the middle and living rooms to the south.

The north façade is given a solid and closed character, with brick masonry and small windows. The south façade is a solar collector, designed as a double glass façade. The double façade is 30cm in depth, and provides insulation as well as preheating of ventilation air. The heavy mass of the internal construction containing the warmest room functions provides heat capacity and acts as a thermal buffer. The building is favourably sited for solar gain, also thus reducing heating needs, with an orientation 19 degrees east of south.



Klosterenga 2: Double glazed façade in summer, spring-autumn and winter.

The roof construction incorporates 245m^2 of solar collectors at an angle of 30 degrees. The solar collectors are used to heat water in storage tanks under the roof on the seventh floor. The hot water is used in a low temperature subfloor heating system. Measurements show that the collectors provide 75,000kWh of heat per year.

Sustainable use of materials / indoor climate

A good indoor climate is achieved through the use of natural and simple materials. The north wall is a load-bearing double skin construction in brick, with 200mm of glass wool insulation, providing a breathing wall which regulates temperature and humidity variations. Design using simple details and few materials simplifies all maintenance operations. The walls in rooms to the north, east and west are of unrendered brick. Interior partitions are plasterboard on steel framing with environmentally friendly finishes. Floor finishes are linoleum, ceramic tiles and wooden parquet. There is a central vacuum cleaning system. Apartments have individual balanced ventilation systems with heat recovery.

Water

Apartments have individual controls and meters for water use. Normal water saving installations such as low use shower heads and two-tier toilet flushing systems are used.

Rainwater is collected for use in the gardens. The apartments have a double waste pipe system; toilet waste is taken directly to the municipal sewage system, whilst grey water is taken to a biological cleansing system in the courtyard. This root zone cleansing system, which uses no chemicals, consists of a sludge trap, pre-filter and root zone beds, from which the water continues through water ladders, a small dam and then open channels to a nearby park.

Green spaces

The courtyard is designed as a luxuriant small park. The wide variety of plants attracts many different insects and birds, providing high biodiversity. To maximise biological activity, the storage rooms and waste collection shed have green roofs with sedum plants. The choice of all other materials used outdoors prioritises healthy, recyclable and long lasting components. This includes granite, gravel, slate, concrete and galvanised steel, and untreated larch for all timber elements. There is a composting system in the courtyard, with a composting reactor in the recycling shed of the housing cooperative. In order to reduce the use of private cars there is extensive cycle parking as well as covered cycle sheds.

Evaluation

The results have been extensively documented. Energy use for this type of building is normally about 150-180 kWh per m^2 year.

Table 1.1. Estimated and measured electric energy use in the apartments:

	Estimated (kWh/m²)	**Monitored (kWh/m²)**
Space heating	20	43
Ventilation	9	0
Hot water	11	24
Fans and pumps	19	unspecified
Lighting	17	unspecified
Equipment	28	unspecified
Cooling	0	0
Total Electric energy consumption	104*	127**

*Excluding common spaces / ** including common spaces.

Calculations done following the Norwegian Standard NS 3032.

The divergence between estimated and measured energy use has several causes. About 10 kWh/m^2 is due to poor technical performance of the solar collectors during the first year of operation. About 15 kWh is due to three “extreme” consumers who use 18,000 kWh per year more than the others. The average electricity use in the other apartments is 4,000 kWh whereas these four each use 22,000 kWh. In addition, actual indoor temperatures are higher than 20 degrees which was the baseline taken for the estimate. This adds another 10 kWh to the actual consumption. When one corrects for these “deviations” the consumption is 102 kWh/m^2, which is about as estimated.

SPAIN

Eco-neighbourhoods / Eco-cities

EL TOYO

Spain

General information

Name: El Toyo	**Location:** Almería, Spain	**Year:** 2003
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Good thermal insulation; solar thermal power; energy management system (EMS).		
Prizes: _		
Sources: www.eltoyo.info Margarita de Luxan, architect.		

Report

El Toyo is a tourist and leisure complex located in Almería in an area very close to the Cabo de Gata Nature Reserve. This location guarantees an average temperature of 26º C during the entire year and an average of 320 days of sun. Built on a 260 hectare plot and constructed for 5,000 dwellings, it is promoted by the Town Hall of Almería and managed by the Autonomous Government of Andalusia's Empresa Pública del Suelo de la Junta de Andalucía. This residential complex accommodated the Villa Mediterránea which was the residence of over 7,000 judges and athletes who took part in the 15th Mediterranean Games.


EL TOYO 1: MODEL

The urbanisation which corresponds to plot VM-2 has 351 bioclimatic dwellings of one, two and three bedrooms all with garage, junk room and lift. Distributed in blocks of three heights, those on the ground floor have a garden (between 50 and 75 m²), those located on the first floor have a balcony (between 11 and 14 m^2) and those on the top floor have a solarium (between 44 and 50 m²). The urbanization has ample gardens, sports areas and two swimming pools for use by the residents.

The piece of land corresponding to plot VM-2 has a surface of 55,521m² distributed in the shape of a rectangle. The Detailed Study assigns a development potential of 33.782 m² for this piece of land, all for residential use. As a consequence, the average constructed surface per dwelling will be approximately 96 m². The density is 68.6 dwellings/ Ha and the development potential of 0.6 m^2/m^2. The floor occupation is over 50%.

Various climactic parameters where considered for the design of this complex which can be recognized with precision since they were also used in the Almería Airport, some 2 kilometres away from the area and in a similar situation. The following stand out:

- The daytime temperatures and the moderate average temperatures despite the fact that in the last ten years it has increased more than a degree with respect to the previous fifty years.
- The relatively high humidity, although a drop can be seen, especially in summer over the last ten years of 4% with respect to the previous fifty.
- The low precipitations and the strong seasonality, meaning that the availability of large bodies of water, vegetation with a great demand for water and high evaporation because of irrigation systems which are inefficient are inadequate, especially if we consider the high evapotranspiration of the area; making it necessary to continuously supply water, and the increased humidity the irrigation would aggravate the sense of discomfort because of saturation in the hot climate.
- The prevailing winds come from different directions during hot periods and winter months, which is why it is possible to have spaces in function of the effective collection of winds during hot periods, avoiding them the rest of the year.
- Radiation is very high which can compensate the low temperatures with direct solar collection and it is necessary to have protection during hot periods by hiding the spaces, and the shading of the façades and in the vicinity of the building.

In these conditions, volumes and sections were considered which allowed for sun exposure during the winter, protection during the summer and maintain the circulation of breezes and forced air movement. The type of dwelling must clearly respond to the Mediterranean type dwelling. A dwelling which extends to the south, with courtyards, spaces and balconies, which create shade on windows and façades and acclimate the interior spaces in winter and summer. The wet rooms, kitchens, air dryers and bathrooms, all exterior, with direct exterior ventilation and light are located to the north. The terraces and courtyards are deep because the south orientation has been chosen for the all the living and sleeping areas, although the floor, only slightly compartmentalised, allows for crossed ventilation of all the rooms through wet room spaces.

El Toyo 2: Mediterranean typical houses

The design proposed to increase the interior inertia, maintaining the insulation as close as possible to the façade and increase the insulation capacity in relation with the regulations which must be fulfilled. To achieve it, the behaviour of different types of walls and framings were studied, their type, thickness, price and weight, to see if they had sufficient capacity to accumulate heat or cold, phase and insulation.

Natural ventilation chimneys were built to take advantage of the stairwell design which have openings to all the dwellings, creating secondary ventilation at the hours in which the exterior heat contradicts opening main windows.

Earth was moved due to construction and was relocated on the plot of land without taking material to the dump; the few existing trees were taken advantage of, integrating them in the landscaping.

The active solar installations proposed were placed in a communal thermal solar capture installation to produce domestic hot water.

The dwellings were equipped with a modern automated system and alarm, detectors via radio and control of the dwelling through landlines and mobiles.

The road network was limited to the edge of the site, not extending any vehicular traffic between the blocks. Only paths for pedestrians and bicycles (5m) cross the neighbourhood. These pedestrian and bicycle paths are less than 10 metres from the buildings and the maximum distance to the vehicular accesses are less than 30 metres. Public transportation is accessible on foot.

The free spaces are partly paved to avoid lawns and plants which demand continuous irrigation. The treatment of open spaces with permeable areas avoids the formation of concentrated water flow.

Given that the average annual precipitation is some 200mm and the potential average annual evapotranspiration is between 950 and 1,000mm both bodies of water and vegetation will require more water than only rain can provide. The urbanization has not planned any water masses, ponds or fountains with containers of water, both to avoid unnecessary consumption and to avoid excessive saturation of relative humidity over and above that provided by the vegetation. The green spaces are varied. Some are made up of tall trees with deciduous or perennial leaves, others of bushes with and without flowers and succulent plants are also proposed. All these species consume little water and adapt to the local climate.

MUNICIPIO ECOLÓGICO AMAYUELAS DE ABAJO

Spain

General information

Name: Municipio ecológico Amayuelas de Abajo	**Location:** Palencia, Spain	**Year:** 2001
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; environmental respectful materials; solar thermal power; photovoltaic power; bio-mass; "Gloria" heating system.		
Prizes: _		
Sources: http://habitat.aq.upm.es/bpes/onu02/bp226.html www.elmundo.es/albumes/2009/03/23/casa_barro/index.html María Jesús González, architect.		

Report

Amayuelas de Abajo was a semi-uninhabited rural centre, located in the heart of the Tierra de Campos nature region, only 30 km from Palencia. The migratory processes from the countryside to the city affected this community directly, intensifying in the last 20 years after the use of new technologies in agriculture. The municipality had a great cultural and architectonic heritage in continuous deterioration and ruin like the entire region.

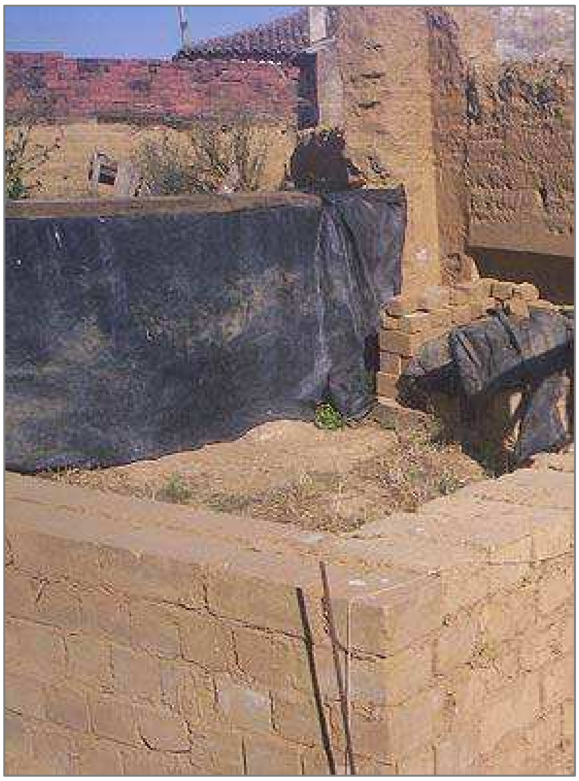
The initiative to revitalize the town came from private collectives linked with ecological and agrarian organizations. These collectives, by analyzing the resources available in Amayuelas and the infrastructure it had, considered a C.I.F.A.E.S. project (Centre of Research and Training in Sustainable Economic Activities) with the idea of creating the Ecological Municipality of Amayuelas and work on ecological agriculture, promotion of small companies, boost self-employment, etc.

AMAYUELAS 1: GENERAL VIEW

The pilot counted on the economic aid of European programmes (LEADER Programme), the collaboration of the "Architects Without Borders of Castilla y León" NGO, and the ecological municipality of Amayuelas. The University of Valladolid's Department of Construction conducted technical checks of the materials used and the architects were María Jesús González, Jorge Silva and Francisco Valbuena. Construction began in 1999.

The complete pilot was presented at the United Nations' "4th Spanish Catalogue of Good Practices for the Improvement of Human Settlements" (*IV Catálogo Español de Buenas Prácticas para la Mejora de Asentamientos Humanos*), in 2002, obtaining a classification of "Good".

The greatest contribution of this project was the use of raw earth as a construction element since the construction tradition of rammed earth (raw earth), adobe and traditional construction with wood were totally lost. It consisted in a private construction of ten bioclimatic dwellings with traditional methods, rammed earth and adobe walls, passive and active solar design, low environmental impact materials and the addition of new technologies like photovoltaic and thermal solar energy.



Amayuelas 2: Adobe construction

Recovering raw earth as a construction element was a challenge because it was not considered a construction material but its use was decided because of the many possibilities it offered, since the material has excellent thermal qualities and it is endorsed by thousands of years of tradition. In addition, an attempt was made to modernize the traditional construction systems, adopting them to today's situations.

Other elements which make the project a sustainable construction are the following:

- The use of passive heating systems.
- The use of photovoltaic and thermal solar energies.
- The recovery of the gloria heating system as an alternative to the conventional.
- Perfect bioclimatic design adapted to the characteristics of the microclimate.
- The use of low environmental impact materials.
- Minimum contaminant cost, both in the building and the subsequent maintenance of the buildings.
- The use of recyclable and recycled materials.
- The total elimination of toxic construction material, which is customary today in conventional construction.
- The recovery of wood as an economic construction element.

The construction consists of 10 houses, very simple, with a quadrangle base, in a single volume, with two plan formats, with dimensions 4.50 x 6.00 m and 4.50 y 7.00 m and with a ground floor and attic, in the traditional manner. The total area of the houses vary around 55 m^2. There are two types of interior layouts: one with a sitting room, open kitchen and bathroom on the lower floor and a bedroom on the upper floor. The other type has a sitting area and kitchen on the lower floor and the bedroom and bathroom on the upper floor. In both cases they have a gabled roof with a North-South orientation.

The extreme continental climate of the region demands a precise orientation for each part of the programme, giving the South the glass areas, the East and West other rooms such as bathrooms and stairs; and completely close the building to the North, where only the "pantry" is placed. The large surface openings are located on the South and the medium ones are oriented to the East and West, to improve direct solar collection.

A glazed gallery greenhouse was placed at the access, facing South. The great thermal inertia of the South rammed earth wall is ideal to store the overheating obtained with the greenhouse effect. It will be opened during the hot months to favour air circulation, an effect which increases with the presence of deciduous leaf vegetation. The placement of climbing plants with deciduous leaves on the façade protects it during the hottest months from overheating, and in the coldest months it allows the sun to pass.

Heating comes from two sources. The first is the greenhouse, the second is from the gloria. It is made up by a series of parallel conduits under the floor, made up by brick walls which support vaults of the same material. They are connected in such a manner that the smoke travels from the space of greater size in which the fuel (normally bales of hay) is burnt and the chimney located on the opposite extreme. The gloria, built this way since the roman era, serves as support for a rammed earth dwelling finished off with clay tiles. This system aids in the circulation of air under the building, it could serve in the warm months to cool and guarantees against capillary humidity.

Domestic hot water is produced through a thermal solar energy system, in thermosyphon type equipment made up by two 2 m^2 thermal solar collectors with a 150 l tank in each house. A support system for the days in which sufficient solar energy cannot be captured (some 30 annually) a butane heater was installed.

5.3 kWp photovoltaic solar energy equipment was also installed connected to the grid. The installation was placed on the exterior of the plot of land, in a position where maximum sun capture was guaranteed, oriented south at a 40º angle.

With regard to the consumptions, lacking the final results of the monitoring, we can consider

- Electricity consumption in a house: 15 kWh/m^2/year.
- Fuel consumption in a house: 82.5 kWh/m^2/year.
- Type of fuel: biomass
- Water consumption in a house (two people): 45 m^3/year.

This experience demonstrates a new participatory construction model with the following results:

- Revival of a deprived area.
- The implication of diverse classes, strengthening participation and new collective cooperation systems.
- Gathering of old and new technologies and the recovery of traditional construction systems, making them compatible with normal comfort levels.
- It was shown that construction with mud is possible today without assuming costs.

RESIDENCIAL PARQUE GOYA

Spain

General information

Name: Residencial Parque Goya	**Location:** Zaragoza, Spain	**Year:** 1995 - 2007
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; solar thermal power.		
Prizes: _		
Sources: www.viviendaragon.org José Antonio Turégano, architect.		

Report

In 1995, Aragón Government's Department of Public Works and Urbanism and the Institute of Land and Housing of Aragón (ISVA) started up the preparation of the Partial Plan for a 53.7 Ha area in the area north of the city of Zaragoza.

The objective was to promote 3,500 subsidized housing units and the reduction of CO_2 emissions as a specific action, taking into account European directive 93/76/CEE. The design of the urbanization and the buildings according to the Bioclimatic Architecture criteria included in the Partial Plan meant a potential reduction of the buildings' energy demand by 60% (heating, refrigeration, ACS and lighting) in relation with the basic values to comply with the regulation and a somewhat lower savings with respect to the normal typology of the area.

RESIDENCIAL PARQUE GOYA 1: PLAN

An innovation with respect to any previous urbanisation, the Partial Plan for the Parque Goya Residence had some specific bylaws to regulate the bioclimatic conditions of the buildings.

This project had the support of the European Commission through a Thermie project (no. BU 178/95) for three buildings in the first phase: lot P-4 (178 dwellings), P-11 (50 dwellings) and PU-9 (26 houses).

Location

The Parque Goya residential neighbourhood is located in the city of Zaragoza, capital of the Autonomous Region of Aragón, which is located in the centre of the Ebro Valley at 41.39º latitude North.

It is a Mediterranean climate, although it has strong continental influences, a fact which can be appreciated in the extreme temperatures: high temperatures in summer and lows in winter, with NW-NWW winds which increase discomfort.

Table 1.1. Most significant climactic variables in the area:

Month	Average Daily Temperature (ºC)	Horizontal Solar Radiation (MJ/m^2 day)	South Vertical Solar Radiation (MJ/m^2 day)
January	6.1	6.96	10.36
February	7.6	9.13	11.31
March	9.2	12.50	11.48
April	14.3	18.46	11.62
May	16.3	20.38	9.49
June	20.5	22.39	10.14
July	24.3	22.48	10.01
August	23.5	20.00	11.03
September	19.4	16.26	13.75
October	14.8	11.51	14.00
November	9.4	7.61	11.53
December	6.0	5.60	7.82

Data obtained from the Solar Radiation Atlas of Aragón and Climate Data from Aragón.

Key Characteristics

Some of the concepts incorporated in the urban design of the Partial Plan or the obligatory Document of Obligations for all the Parque Goya Residential buildings are:

- Orientation of the streets, distribution and height of the buildings which favour the capture of solar radiation on south facing façades.
- Insulation above that demanded by the regulation (<25%).
- 50% glazing or greater on the south façade, with the option of glazed galleries, and keep it to a minimum on the north face.
- Carpentry which is of greater quality than that demanded by the regulation.
- An abundance of green areas, water masses and materials with appropriate colouration.

The main elements used in the three buildings selected in the Thermie project are:

- The incorporation of greenhouse galleries with thermal load walls.
- Superior insulation in general, maximum quality of double glazed windows and carpentry in the face of infiltrations.
- Collective auxiliary systems with low temperature boilers (high efficiency) or thermal solar collectors and condensers.

Individualized control of the ACS and heating consumption.

Description

The buildings selected for the specific project represent the different typologies present in the urbanization (semi-detached homes PU-9, collective buildings with double spaces P-4 or quadruple spaces P-11).

- Thermal inertia and insulation

  After the initial studies, the urban project established as a specific norm that the insulation had to be 25% greater than that defined by the regulations in force.

Table 1.2. Values for U (W/m^2K) correspond to the exterior enclosures of each building with respect to the values demanded by Spanish regulations:

U (W/m^2K)	National Regulations (NBE-CT-79)	Building P-4 (178 flats)	Building P-11 (50 flats)	Building PU-9 (26 houses)
Exterior wall	1.6	0.44	0.64	0.39
Mass walls	1.8	0.88	1.47	1.47
Roof	1.2	0.22	0.33	0.28
Interior framing	1.4	0.26	0.42	0.86
South and East Windows	5.8	3.3	3.3	3.3
North and West Windows	5.8	2.6	2.6	3.3

In order to reduce energy losses, the thermal bridges in the pillars and main beams have been eliminated with exterior insulation. Double carpentry has also been introduced on the N and W façades to reduce losses by transmission and infiltration, affected by the dominant wind, North wind, which reaches high velocities.

The buildings which have elevated reinforced thermal inertia are those which have a more compact form (building P-11), less in building P-4 and clearly inferior in the semidetached houses. The inertia has increased by placing the insulation on the exterior side of the enclosures, roof and the framing on the lower floor. In addition, materials with great inertia have been used, such as Airblock (19 cm in P-11) and Thermoclay (19cm in P-4 and PU-9).

With these characteristics, the buildings undergo slight temperature fluctuations in the interior during the night when the auxiliary heating is off. Also, with night ventilation, the inertia allows for the reduction of the daily maximum temperature so that the majority of the time it falls within the comfort condition range.

- Solar gain

The buildings are oriented with their main façade towards the south and without shades during the winter. This treatment has been applied to the entire urbanization. On the South façades the glazed area has been increased by incorporating greenhouses without air heating. To increase the capture effect and take advantage of the delay in the capture of greenhouses mass walls have been incorporated (29 cm blocks filled with sand and cement or 19 cm blocks of thermoclay). On the East, West and North façades the window areas have been kept to a minimum given that solar capture is very low (N) or can provoke overheating in summer (E,W). The interior distribution of the dwellings place the living quarters to the south while the kitchen, bathrooms and stairs are located to the north.

Overheating because of the summer capture is reduced through the use of eaves and mobile elements (blinds). Also, the distribution of the dwellings allows for natural ventilation, beneficial during summer nights. It also improves comfort during the summer by reducing the overheating effect in the streets, using clear coloured road surfaces, trees and green areas.

- Heating and solar collectors

The heating system used (low temperature boilers) in each of the three buildings is collective, being more efficient than individual heating systems. The total collectors installed in the urbanization in the first phase of the project was 600 m^2.

- Technical Results

The three buildings selected were monitored for two years. The interior temperatures of the north and south rooms, greenhouses and the interior temperature of the specially constructed walls were measured. The humidity of the south areas and the heating consumption of the dwellings were also measured. All these parameters were recorded each 10 minutes. In total, the number of monitored dwellings were 9 from the P-4 block, 12 from the P-11 block and 6 from PU-9.

Table 1.3. Heating unit consumptions for an interior temperature of 20ºC:

Average consumption in kwh/m^2 year	2000-2001	2001-2002
P-4 (178 dwellings, the majority south orientation)	20	21
P-11 (50 dwellings, 16 of them to the north)	35	32.5
PU-9 (26 houses, south orientation)	48	41

URBANIZACIÓN LLIRI BLAU

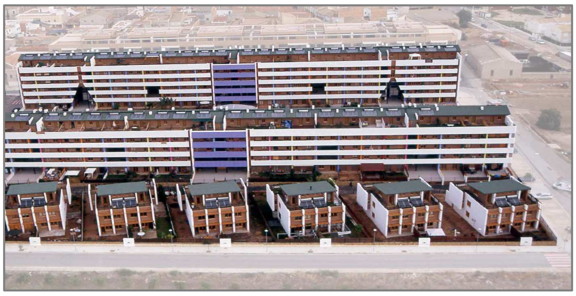
Spain

General information

Name: Urbanización Lliri Blau	**Location:** Massalfassar, Spain	**Year:** 2003
Architect: Luis de Garrido		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; environmental respectful materials; green roof; solar thermal power; energy management system (EMS).		
Prizes: _		
Sources: www.ecoconstruccion.net		

Report

Located in the city of Massalfassar in Valencia, the Lliri Blau residential complex, designed by architect Luis de Garrido, is a 100% sustainable and bioclimatic project which incorporates automated technology. The urbanization is made up by 130 dwellings equipped with all types of services and features. The area includes business areas, offices, leisure centres, a senior's residence and daycares.



LLIRI BLAU 1: GENERAL VIEW

The design process employed was based on a series of parameters (materials and resources, energy, waste management, quality of life and the use of the building) and in 40 sustainable indicators devised by the architect, which serve to determine the level of sustainability of a certain construction.

Among the indicators used the following are worth highlighting:

- The use of natural materials such as wood.
- The use of recyclable and recycled materials.
- The use of materials which have required the least amount of energy possible to obtain.
- The use of materials which have generated the least amount possible of waste during their manufacturing.
- Local labour.
- The building's thermal inertia.
- The building's energy losses.

Another key point in the urbanization is Bioclimatism. Exhaustive care was taken to find a perfect south orientation, special structure, architectonic design, the placement of windows and natural ventilation canals, the design of intermediate spaces, in such a manner that, only because of its architectonic design, the buildings tend to heat up in winter and cool down in summer without any type of mechanical system. To reinforce the bioclimatic behaviour of the buildings, load bearing walls have been used (high insulation and thermal inertia), roof gardens, greenhouses, carpentry with gates to allow for air circulation, and with that, the ventilation and natural thermal conditioning of the building.

LLIRI BLAU 2: BIOCLIMATIC BUILDING

The residential complex, which stands out because of its architectonic design, has foreseen new coexistence spaces and habitat typologies which include patios at different heights and different depths which generate microclimates. These microclimates allow for natural thermal conditioning as well as human coexistence. The building occupants can choose between complete intimacy and the possibility to visually connect with a reduced number of neighbours.

High energy efficiency has been reached in these dwellings. It is estimated that because of the insulation level, thermal inertia and bioclimatic design, the buildings consume around 30 – 40 % of what conventional buildings with the same surface and characteristics consume. The use of alternative energies have also been applied. A clear example is domestic hot water, it is generated through thermal collectors with the aid of accumulators with a nocturnal rate.

All dwellings in the complex come equipped with automated systems classified in 4 areas:

- security and alarm devices.
- the control of energy consumption through hourly programming and control of the desired temperature.
- the control of automatisms like blinds, irrigation, curtains, lighting, gas detectors and flood detectors.
- telecommunication systems.

In relation with the automated systems aimed at achieving control over energy consumption, its use is relative since the building is bioclimatic, it has high thermal inertia and is well insulated, this already implies strong energy savings, much superior to that any possible automated system could provide, and cheaper. The control over energy consumption has focused on the control of heating and lighting.

With respect to the control of automatisms, the intent was that the dwellings work with as few as possible. In fact, and after a long study, only five were identified:

- Heating control (electric radiators with power 10 times less than that necessary for any dwelling. The total power installed of the radiators with a nocturnal rate is only 1,500 W per dwelling).
- Lighting control of the low consumption illumination.
- Control over the flood detectors.
- Control over the lighting close to windows (when the afternoon comes there is less light and the different lighting circuits are turned on gradually but only the lighting closest to windows)
- Roof garden irrigation control (with the aim of cooling during the summer).

With respect to communications, a telephone controller for the previously mentioned mechanism was included, giving the possibility to communicate directly with the house control centre to re-programme it, know the incidents occurred or activate any appliance or automation.

VALDESPARTERA

Spain

General information

Name: Valdespartera	**Location:** Zaragoza, Spain	**Year:** 2001 - 2008
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; environmental respectful materials; rainwater use; solar thermal power.		
Prizes: _		
Sources: www.valdespartera.es		

Report

Over the last few years Zaragoza has undergone a drastic urban transformation because various actions have affected it urban centre: the arrival of the high speed train (AVE) Madrid-Barcelona, the creation of the 1,050 ha. Logistics Platform of Zaragoza (PLAZA) and the EXPO 2008, with an area of approximately 100 ha.

These events have elevated the housing demand and the Zaragoza City Hall has promoted the Valdespartera eco-city. The eco-city has an area of 243.2 ha, of which 60.5 ha are destined to city amenities (mini-stadium, ice palace, aqua park, etc) and 182.7 ha to the construction of 9,687 dwellings with their corresponding free spaces and social, school and sporting amenities.


VALDESPARTERA 1: GENERAL VIEW

The design of the new Valdespartera neighbourhood clearly answers the sustainable development criteria.

- Affordable housing: It is a large promotion project of subsidized housing. 9,687 dwellings were constructed on land obtained through an urban development agreement, 97% of which will be affordable housing.
- Integrated town planning: The project is aimed at people in different social sectors, providing a varied offer in the generation of an urban environment characterized by social integration.
- Equipment: The urbanization contemplates a wide range of educational, sport and cultural features which not only benefit the sector but the city as a whole.
- Bioclimatic architecture: reduces the dependence on non-renewable resources and places an emphasis on alternative energies. The design of ecological corridors to improve the new Eco-city's environmental integration.

When tackling the urban design of the affected Sector, it began from the firm belief that the exploitation of bioclimatic criteria could not only remain in a series of prescriptions relating to the methods of constructing the dwellings, but rather that the Project should have an adequate relation between dwelling and the environment, with optimum typologies and morphologies offered, combining to formulate a perfect energy saving and environmental quality equation.

The objectives set by the Partial Plan were formulated through three different and complimentary avenues:

- Urban development distribution, for the best passive solar collection and to fight dominant winds.
- Architectonic design, in line with that stated above.
- Imperative regulations with respect to the construction materials and elements established by a sustainable construction system.

Urban Development

The development proposed is a transition from an urbanized area to the north, essentially residential, to an area in the south, treated as a large extensive park where important sports installations will be located. The intent has been to structure the urbanization around a large primary axis which is treated as a green-route, integrated into open spaces throughout its length, with a winding layout, avoiding long views dominated by asphalt and a strong woodland presence. The construction is organized in elongated rectangular blocks in an east-west direction. The central spaces of the blocks are treated like green areas for collective use by the dwellings.

- The orientation of the buildings to favour solar collection: Placing sufficient space between the buildings with relation to their height.
- The placement of screens for dominant winds: On the built-up side, the construction has been raised a couple of floors above the general contour with the aim to avoid excessive monotony and place an efficient barrier for the penetration of north winds in the bordering neighbourhoods to the east.
- Microclimates: The placement of surfaces with vegetation mixed with streets and spread out between the dwellings, obtaining microclimates in private spaces and avoiding long views dominated by the hard asphalt and a strong woodland presence.
- Vegetation with indigenous species: and deciduous leaves to favour shades during the summer and sunlight during the winter.
- Water savings in the entire sector: On one hand and with respect to the buildings, the bathroom fittings must have devices to reduce water flow; on the other, and with respect to public areas, the plan is for ponds and water masses which collect rain water through an independent circuit to irrigate the gardens.

Architectonic Design

- Flat roofs to effectively place solar panels: these solar collection panels must comply with regulation UNE-9410. The exterior surface of the roofs will be finished in light colours.
- Each façade will be treated in accordance with its orientation: all the dwellings will have a double façade with opposing orientation which will allow for crossed ventilation. An attempt will be made to place the stairwells on the north side and sitting rooms will be prohibited from facing only north
- Glazed galleries on the south façade: on the south façades there will be larger windows and glazed surfaces which favour maximum caloric adsorption.

Construction system

- Materials with elevated insulation levels: windows which open directly to the exterior will have double glazing with an air chamber, the seals of the carpentry must be accredited, the shutters must be filled with thermal insulation, the finishes and construction of the rolling shutter boxes must avoid infiltrations to the interior of the dwelling and the construction must specifically consider the insulation of all the thermal bridges.
- Surfaces with sufficient collection capacity: the separation wall of the dwellings' interior space with the glazed gallery will be designed so as to optimize its caloric absorption.
- Centralized heating system for complete blocks.

The use of the following construction material will be demanded:

- The paint and varnish employed will comply with regulation UNE 48-300-94.
- The use of insulations which use HCFC in the manufacturing process are prohibited.
- The use of tropical woods or those coming from non-sustainable cultivation are prohibited.
- A recommendation to use wood produced by the Spanish market, in a sustainable manner and without artificial treatment.
- The lumber used must have a certificate of origin so as to certify its sustainable exploitation.
- PVC will be used as least as possible and, in any case, it will never be used if it is not recycled.
- The use of fibre cement with asbestos is prohibited.
- The recommended use, whenever possible, both the interior and interior envelopes, of water based paints of an environmentally friendly type (breathable).
- It is recommended to use insulation manufactured from natural fibres.
- It is recommended to use electric mechanisms manufactured from materials which are completely recyclable.

The building projects must be submitted to the energy performance certificate in force in the Autonomous Community of Aragón, in accordance with that set out by European directive 93/76/CEE of 13 September.

Road Network

The urbanization will have 60 streets, a total of 32 kilometres, distributed over 4 km of Avenues, 20 km of roads with medians and 8 km of two way roads. It will also have 10 pedestrian squares, a number of roundabouts, 5 linear parks and 2 large parks, with an emphasis on the Los Lagos Park with 22 hectares and two 40,000 m^2 ponds.

- Avenues: 50 metres wide, 2 carriageways with 3 lanes per direction, a wide median and spacious 10 m wide pavements which have bicycle lanes on both sides.
- Interior streets: 2 unidirectional lanes, a line of parking, pavements of 3 metres or more, lateral pedestrian lines, reaching a width of over 20 metres.
- Shared traffic streets: conceived as a space with restricted traffic where the pedestrian, automobile and cyclist coexist with areas where individuals live and play.

Bioclimatic buildings

Casa Fujy

Spain

General information

Name: Casa Fujy	**Location:** Madrid, Spain	**Year:** 2005
Architect: Luca Lancini		
Type of Project: Bioclimatic Building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; environmental respectful materials; rainwater use; solar thermal power; energy management system (EMS); energy efficient devices.		
Prizes: _		
Sources: http://casaoriginal.com/arquitectura/casas-ecologicas-proyecto-fujy/ http://habitat.mundoejecutivo.com.mx/articulos.php?id_sec=4&id_art=76		

Report

This dwelling is a 340 m^2 avant-garde home located in the Madrid municipality of El Escorial, less than 40 km away from Madrid. The dwelling has areas for social activities on the lower floor while the upper floor contains the bedrooms, a common bathroom, the greenhouses and the main bathroom with a balcony.

Fujy house 1: north and south elevations

To guarantee low environmental impact during its useful life cycle, the construction uses different systems. The main ones are:

- Urban integration with the landscape thanks to the bioclimatic design of the construction which has a different treatment on each orientation of the façade and the ventilation and illumination spaces.
- The use of secure and renewable interior furniture, finishes and materials thanks to the use of certified wood.
- The integration of different passive systems in the project (insulation by inertia, carpentry with breaks in the thermal bridge, solar control slats, electric grills for the pre-heating large areas, thermal glass, solar control rolled shutters, greenhouses and solar dryers).

- Thermal energy production through solar panels, high performance modulated electronic boiler and an inverted radiant floor refrigeration system by propane gas chillers.
- Access without architectonic barriers and a bathroom adapted to the disabled.
- An integrated energy efficiency control system for the installations.
- Integrated automatic system in the installations to guarantee the security of the spaces and energy savings.
- Non-renewable energy and water savings thanks to the use of:
  - Highly insulated materials.
  - High performance lighting systems.
  - Rain water accumulation.
  - Recycling of grey water to irrigate green spaces.
  - The use of electronically and mechanically timed taps.
  - The use of highly efficient appliances.
  - The introduction of domestic urinals.
  - Low temperature radiant floor heating system (in winter) and a refrigerated floor to cool (in summer).

The architectonic plan is developed from a rectangular plan with an east-west orientation, so that over 65% of the façades are oriented to the south and north.

The south façade has large windows protected under a balcony and greenhouses with aluminium slats which regulate the entrance of solar radiation depending on the time of year. The greenhouse system is regulated by electric slats and automatic windows which allow the rooms to be cooled in summer.

In the north area, small vertical openings allow for the enjoyment of the views without reducing the efficiency of the natural heating system. The automatic windows on the roof illuminate the service passageways of the lower floor in addition to strengthening the natural convection during warmer times.

This façade has various openings which offer panoramic views of the surroundings while the west façade is the most protected of all, given that it does not have windows. This fact is justified by the relief of the terrain which has large rocks.

FUJY HOUSE 2: SOUTH FAÇADE DETAIL

The house has been constructed with thermo acoustic brick and the structure is certified multilayered wood. The brick walls have a natural water-resistant layer to avoid humidity and the roof insulation is reused wood fibre. All the carpentry is aluminium with a break in the thermal bridge, thermal glass with solar control selective filters and insulated security shutters. All the floors are anti-slip and the bathrooms and the entrance of the dwelling are accessible to the disabled.

The dwelling has a security system, fire and smoke detectors which automatically cut the electricity, gas and anti-flooding system.

As for the lighting efficiency, the dwelling has a detection system which turns the lights on and off in the service and circulation areas. It also has a lighting sensor system, in accordance with the times of the day.

To save water all rainwater is collected, it is pumped and is employed for all non-drinking uses such as irrigation, dishwashing or filling cisterns. Also, grey water and sewage are also reused thanks to a treatment plant.

EDIFICIO ACCIONA SOLAR

Spain

General information

Name: ACCIONA Solar Building	**Location:** Pamplona, Spain	**Year:** 2007
Architect: _		
Type of Project: Bioclimatic Building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; environmental respectful materials; solar thermal power; photovoltaic power; geothermal power; bio-fuel; energy management system (EMS).		
Prizes: _		
Sources: http://www.pvdatabase.org/pdf/Acciona-Solar_Building_es.pdf		

Report

The new headquarters of ACCIONA Solar, which the group has built in the City of Innovation of Navarra, a technological park beside Pamplona, will become a point of reference in bioclimatic architecture. With a built surface of 2,591 m^2, it is the first non-experimental building in Spain for tertiary use (offices), conceived and certified as "zero emissions", which is to say, it covers all its energetic needs without emitting greenhouse gases.

It is possible thanks to a design which integrates efficient energy solutions both passively –through architectonic and construction techniques oriented at reducing energy demand- and active, incorporating renewable source installations from four different technologies: photovoltaic solar, thermal solar, geothermal and biodiesel. The building's distribution is a sub-level for a garage, a double height ground floor for storage and two elevated floors. In total it has a capacity for some 90 people although the current number of employees which use it is approximately fifty.

ACCIONA 1: SOUTH FAÇADE

Bioclimatic Architecture

The option was to have a building designed to minimize energy losses and maximize energy collection from the exterior. The most significant measures in this field are:

- A building in the shape of a compact cube which reduces energy losses.
- A large south facing façade, with a curtain wall equipped with large windows and photovoltaic modules as parasols, designed to allow the sun to enter in winter and avoid it during the summer months.
- Greenhouse on the south façade, between the curtain wall and the wall, equipped with a ventilation system which takes advantage of the heat absorbed through an automated door and conduit system when it is necessary.

* The north face with individual windows for each office, more reduced, to allow natural light to enter and avoid heat loss during the winter.
* The interior of the N, W and E façades are constructed of concrete with high thermal inertia and finished on the exterior with high quality insulation which has a naturally ventilated air chamber with zinc panel finish.

ACCIONA 2: ENCLOSED YARD

* Natural wood glazed enclosures – because of its good loss and thermal bridge coefficient- with double glazing.
* Deciduous trees beside the W façade which avoids heat gains during the summer.
* Construction elements which favour the entry of natural light and avoids overheating: closed and glazed interior garden which avoids direct solar radiation or vertical skylights which allow for natural light to pass.

Efficiency and Savings in Installations

The installations at the ACCIONA Solar headquarters have been designed and calculated with dynamic simulation methods which have allowed for an analysis of the real behaviour of the building and avoid its oversizing to impede the waste of energy. This is of great significance if it is considered that the service and residential sector represents more than 26% of the final energy consumption in Spain, a percentage which continues growing. In lighting, a minimum level has been anticipated in common areas, complemented locally in function of the concrete needs of other spaces. Intensity regulators have been installed –which vary the level of artificial light in function of the natural illumination available at every moment-, and presence sensors which turn off artificial light in the absence of people. All regulated through an intelligent automata. As for the heating and cooling systems, the installations have been concentrated on the roof of the building to save on losses during transport, radiant floors and ceilings are used to distribute heat and cold, with moderate temperatures in both cases, intelligent regulation is carried out which controls and modifies the temperature in function of the solar energy available.

Renewable Energies

One of the most relevant aspects of the building's energy infrastructure is the incorporation of several renewable technologies to cover its demand without contributing to global warming or the depletion of natural resources. The technologies used are the following:

* Photovoltaic solar (electricity): The installation of 153 modules integrated harmoniously to the South façade, plus another 119 modules on the roof, which represent a total nominal photovoltaic power of 50 kW. The installation is connected to the grid.
* Thermal solar (heating and cooling): The installation of 156 square metres of solar collectors located on the roof, with a total power of 110 kilowatts. It directly covers the demand for heat, and transforms it into cold through two 70 and 10 kW absorption machines, respectively.
* Biodiesel (heating): To guarantee the energy need at every moment, an auxiliary boiler has been installed, fed by 100% biodiesel (without a diesel mix), an environmentally friendly fuel of vegetable origin which ACCIONA manufactures in its plant located in Caparroso, 60 kilometres to the south of its Navarra headquarters.

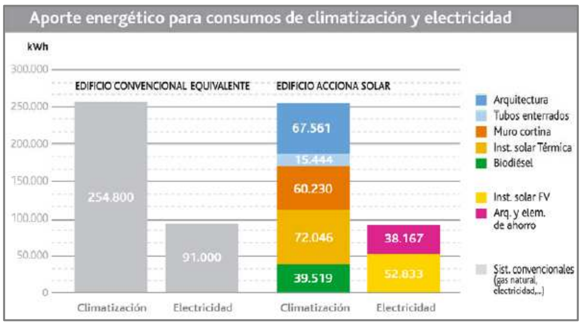
- Geothermal (heating and cooling): Automatic system of 8 subterranean concrete pipes, 30 metres long and 50 cm. in diameter, buried at a depth of 2 metres under the vegetable layer in the area northeast of the plot of land. The geothermal system takes advantage of the difference in temperature between the subsoil and the exterior to provide hot or cold air for heating and cooling when necessary, given that the temperature at this depth is constant (18 degrees), independently of the temperature on the surface.

Bioconstructive Criteria

In addition to the characteristics mentioned, other bioconstruction criteria like the use of materials which are more appropriate with health and the environment –natural woods, polyethylenes, polypropylenes, rubbers and granite – avoiding others which are less environmentally sustainable like asbestos, polyurethane, PVC, fibreglass or led. The façades allow for the absorption, retention and evaporation of environmental humidity, achieving a more natural, agreeable and healthy environment in the interior. Along the same line as the creation of a sustainable environment, the construction or paving does not exceed 20% of the total surface of the plot, while 80% is a green area.

Emissions Avoided

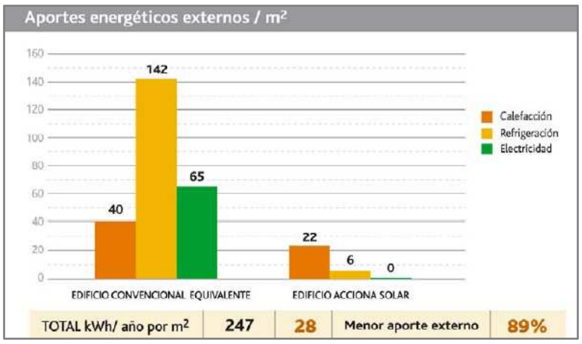
The engineers have evaluated the energy needs of a building of the same dimensions and similar climatological determinants as ACCIONA Solar as a total of 345,000 kilowatts hour annually, approximately 74% to heat and cool and the rest for electrical consumption. A conventional building would obtain that energy from the exterior, costing the corresponding amount and in addition would emit 116,343 kilograms of CO2 into the atmosphere each year. On the other hand, the ACCIONA Solar building saves 52% of that energy with the systems mentioned and the remaining 48% is covered by renewables which do not emit greenhouse gases. The property has been certified as "zero emissions" in compliance with the criteria established in Royal Decree 47/2007 of 19 January which regulates the certification of the energy efficiency of newly constructed buildings, according to an analysis carried out by an independent consultant. The graphic describes the contribution made by each technology or construction system in the building, in comparison with the conventional building, without saving and efficiency systems and which needs an external supply to answer its energy consumption needs.



ACCIONA 3: ENERGY DIAGRAM

External Energy Contribution: 89% lower than the conventional

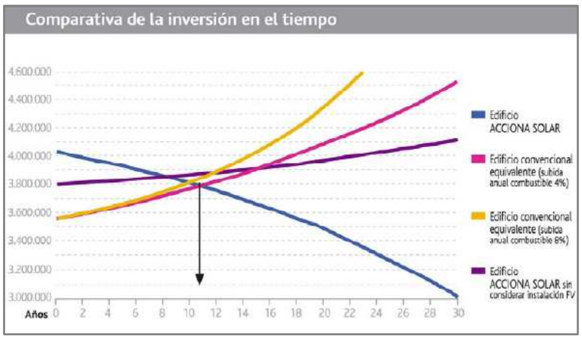
A conventional office building located in similar environmental conditions to those of the ACCIONA headquarters would consume 247 kWh annually per square metre of useful surface that this energy would have to be purchase from the exterior. On the other hand, the ACCIONA Solar building saves and produces 89% of that energy itself. The remaining 11%, which requires it to be brought from the exterior, is covered by biodiesel, which does not emit greenhouse gases either.



ACCIONA 4: Energy diagram

An Initial Cost Overrun which is Compensated Over Time.

The Acciona Solar building has been an investment of 4 million Euros. That represents approximately 13% more than a conventional building. Nevertheless, that cost overrun is compensated over time with savings in fuel and the greater income derived from photovoltaic production which is injected into the grid. That way, the engineers at Acciona Solar have estimated that, hypothesising that the average cost of fuel required by a conventional building would grow at a rate of 4% annually, the cost overrun on the initial investment would be amortised in ten years as can be seen in the graphic below, and in 16 years if the photovoltaic installation is not taken into account.



ACCIONA 5: Investment

EDIFICIO CALL CENTER DE TELEFÓNICA MÓVILES

Spain

General information

Name: Telefónica Mobile Call Center Building	**Location:** Toledo, Spain	**Year:** 2005
Architect: Pich-Aguilera Arquitectos.		
Type of Project: Bioclimatic Building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; rainwater use; heat recovery; solar thermal power.		
Prizes: Sustainable Architecture Award from Foro Civitas Nova, 2006		
Sources: www.construible.es http://en.urbarama.com/project/edificio-call-center-telefonica-moviles		

Report

The building is designed from a detailed study and analysis of good bioclimatic behaviour; the energy and environmental load is not treated as an extra but rather they, in essence, determine the architecture and the use of materials and construction systems.

The building is designed as a large container where the different elements manufactured by the industry are put together. The intent is to avoid the finishing touches on the ensemble, showing the industrial systems and materials used in a strong visual manner.

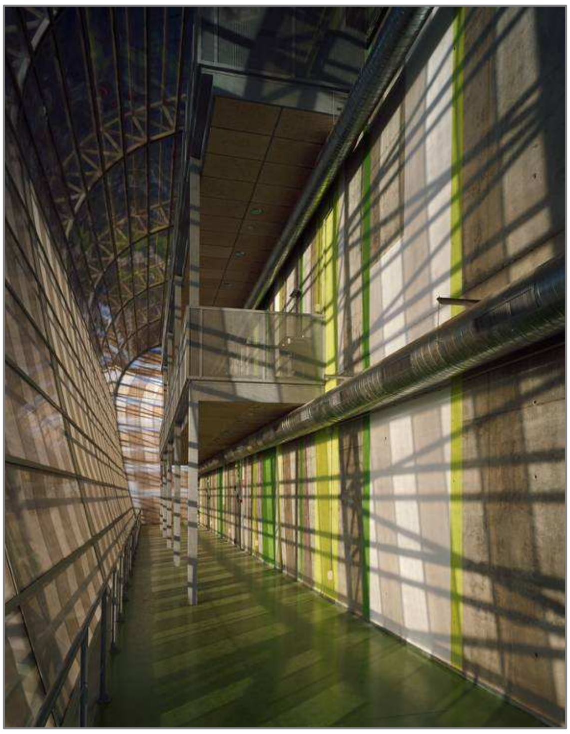
CALL CENTER 1: EXTERIOR VIEW

In function, the building is clearly different in three areas:

- The first, where the operator service is placed, it works like a large heating and cooling atrium with a translucent roof which covers the entire space with its different angles and allows for optimum energy collection and air distribution (hot and cold) to all the spaces. All the natural light in this area is through two ceramic latticework façades, studied in conjunction with the Industry to control sunlight and give sufficient natural light to the work spaces on the one hand, and on the other, optimize its manufacturing and placement.
- The second area, located to the south, houses the operators' rest area. It works like a large greenhouse which provides comfort to the other space in winter. This area is structured around a triple space, with direct access to each of the work platforms.
- The third area, where the offices, training rooms and parallel services are located, is a grouping of closed volumes and semi-covered patios. In this area the bridge infrastructure is enclosed within

itself, creating compartmentalized work areas which look onto covered patios at all heights with a basic climatic function. This space oriented to the north works as a thermal regulator and provides coolness to all the spaces. The vegetation in this third area plays a role of utmost importance in the patios, providing a natural refrigeration effect and absorbing noise. This vegetation is possible thanks to the roofs' terrace tanks which collect and store rainwater by means of the projections which extend farther than the structural portico and the enclosure, and which serve as a hydroponic substratum for the vegetation.

Along with the bioclimatic architecture, the project proposes construction systems which also take into account its efficiency, the design of industrialised enclosures and structure systems which allow for quality in manufacturing and ease and speed in its assembly (lightweight construction materials) and the possibility to recycle all the elements.



CALL CENTER 2: INTERIOR VIEW

The building installations were designed to supply the needs that are not covered by the building's bioclimatic contribution. On the one hand, the active heating and cooling systems have the support of thermal solar collectors to produce hot water and for the heating and cooling systems (heating and refrigeration through a heat pump and absorption machine), and on the other hand, the enthalpic recovery of exterior air or renewal (free-cooling). Controls permit allow the passive systems to work before the traditional heating and cooling systems.

It is estimated that the annual savings is 18,000 Euros and the amortization of the doubled installations necessary to satisfy the current comfort demanded by society is six years.

EDIFICIO CENER

Spain

General information

Name: Edificio CENER	**Location:** Sarriguren (Navarra), Spain	**Year:** 2002
Architect: César Ruiz-Larrea Cangas, Luis Miquel Suárez-Inclán and Antonio Gómez Gutiérrez.		
Type of Project: Bioclimatic Building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; environmental respectful materials; rainwater use; green roof; solar thermal power.		
Prizes: Awarded in the Sustainable Building International Congress, 2005 Architectural Innovation Award in Construmat, 2005		
Sources: www.cener.com/es/que_es/sede.asp		

Report

The close to 5,000 m^2 headquarters of the Spanish National Renewable Energy Centre (CENER) was built in 2004 in accordance with the bioclimatic and environmental criteria focused on energy savings and respect for the environment. The aspect related to its design, orientation and both material and systems used, collaborate so that it is considered to be one of the buildings which most represents bioclimatic architecture in Spain.

CENER 1: GENERAL VIEW

The work of architects César Ruiz-Larrea, Luis Miquel and Antonio Gutiérrez fulfils three main objectives: it is a building with a minimal energy demand, it satisfies at least 50% of the demand with energy from renewable sources and was constructed with criteria and materials with scarce environmental impact.

Reduction in Energy Demand

Strategies and construction and architectonic solutions were used for passive heating and cooling systems, typical in bioclimatic architecture. The most important elements in the building's passive heating and cooling are:

- A glazed gallery, double height and oriented to the south in each of the four modules. It has canopies which can protect it from direct solar radiation and thermal curtains which avoid undesired energy losses.
- A singular piece of prefabricated concrete covers this gallery, elevated above the roof like a periscope, capturing and redirecting the North wind. On the other hand and working like a large chimney, it serves to evacuate the hot air from the top part of the gallery when necessary.
- The burying of the lower-ground floor to take advantage of the thermal inertia provided by the terrain.
- An inertia wall on the lower-ground floor which runs along the entire gallery.

- Workable carpentry on opposing façades and the top part of the interior partitions to allow for the cross ventilation of the building.
- Roof vegetation and access to the modules from the garden spaces

Operation of the Building in Accordance with the Seasons

- Winter:

The objective during winter consists in maximizing solar gains and reducing energy loss, trying to conserve the energy captured insofar as it is possible.

  - Solar gains: During the sunlight hours the protection on the glazed galleries are removed, allowing solar radiation in.
  - Thermal inertia: The inertia wall and the floor accumulate heat which they will then radiate at the end of the day.
  - Greenhouse effect: Thanks to the greenhouse effect, the heat of the sun is trapped in the interior of the gallery and because it has less density it moves to the top of the space. From there it is collected and pushed mechanically to the general hallways of the building and the offices on the upper floor.

- Summer:

During summer months the objectives are: avoid solar gain from the exterior, lower the generation of internal loads, expel the excess heat and refrigerate by means of ventilation when the exterior air temperature allows it.

  - Shade: To avoid overheating there are adjustable motorized canopies located on the exterior of the galleries to minimize the flow of direct radiation, although they allow for natural lighting. The vegetation on the roof and the patios collaborate in the shading of the building, as well as slightly lowering the air temperature of the ventilation.

CENER 2: SUMMER

- Natural ventilation:
  - The ventilation of the modules is done in a crossed fashion and on the upper part of the rooms, this way it removes the warmest air, avoiding drafts which can be bothersome to the user if they are excessively fast.
  - Warm air is expelled through the top part of the gallery, working like a natural chimney.
  - The days when a north wind blows the grills located on the north side of the top of the gallery are opened. The north wind, after passing over the roof garden which it cools down, is introduced into the gallery and helps evacuate the warmer air, which will be displaced by the air entering, exiting through the upper grilles on the south side of the gallery.
- Conclusion: Thanks to the application of the strategies above, the energy consumption of the CENER building for heating and cooling is lower than 30 kWh/m^2 year.

Integration of Renewable Energies in the Building

The heating and cooling of the building, once its energy demand has been minimized, is carried out by a connected system using Thermal Solar Energy (TSE) and natural gas, TSE providing over 50%.

The 250 m^2 high efficiency thermal solar collector installation on the building's roof satisfies the majority of the heating and domestic hot water needs in addition to the refrigeration when necessary with the help of the 350 kW absorption machine.

CENER 3: Solar thermal power

The distribution of heat and cold is done through a radiant floor, cold in summer and warm in winter. The radiant flooring system achieves the optimum heating degrees, given that it allows for a uniform thermal distribution and converts the floor into an energy collector, this provides two advantages: large thermal inertias and self regulation of the heating.

The system elevates the temperature by transferring heat from the gallery (free natural contribution), having the option to use the radiant floor when necessary. During summer months the air from the false ceiling in the offices is returned, except when the bioclimatic gallery is ventilated by the north wind registers more favourable conditions in the interior.

On the other hand, 150 m^2 of photovoltaic panels located on the façade of the building, providing 15 kW and offer solar protection for the south facing façade.

Environmentally Respectful Construction

The construction of the building has been undertaken with the premise of "healthy construction"; which is to say, construction that is respectful of the environment, an intent to minimize impacts provoked by the manufacturing and use of different construction materials.

Construction techniques which consume little energy were used. Being a totally prefabricated building with recyclable materials, the use of material with great energetic or environmental loads were avoided, such as PVC, the fire sprinkler system does not use Halon, CFC or HCFC, and the wood in the carpentry has an environmental stamp which guarantees its sustainable exploitation.

On the other hand, it is worth mentioning that there is a network to collect, treat, and reuse rainwater to irrigate the building's green areas.

EDIFICIO CENIFER

Spain

General information

Name: Edificio CENIFER	**Location:** Imárcoain (Navarra), Spain	**Year:** 2002
Architect: _		
Type of Project: Bioclimatic Building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; Trombe wall; solar thermal power; photovoltaic power.		
Prizes: Eurosolar Award, 2005		
Sources: www.cenifer.com/ktmllite/files/uploads/folleto%20institucional%20.pdf		

Report

A 400 m^2 building located in Imarcoain (Navarra), belonging to the National Integrated Centre of Training in Renewable Energies CENIFER, which is used as a demonstrative building, a reception area for the Centre, to provide training, a conference room, as a lab for students, in addition to conduct research developments for professors at the centre.

It incorporates all type of active and passive installations to obtain an almost zero energy balance: thermal solar installation, water tank to accumulate inter-seasonal energy, heating and cooling through a radiant wall and floor, photovoltaic solar installation connected to the grid, a greenhouse with direct collection and ventilation, Trombe wall, exterior insulation of enclosures with ventilated façade, cooling by well water and forced ventilation with thermosolar shunt.

CENIFER 1: EXTERIOR VIEW

Architectonic Elements

The general enclosure of the building consists in a ventilated façade with a high internal thermal inertia which is made up of five elements:

- Exterior covering made of ceramic plates.
- 3 cm ventilated chamber.
- 8 cm rockwool thermal insulation
- High thermal insulation interior wall.
- Radiant baseboard.

The façade enclosure is completed with an inertia interior flooring, which incorporates a radiant floor and a passable flat roof which acts as a base for the pergola which supports the photovoltaic and thermal solar panels.

Within the passive solar energy systems which the building has, the greenhouse stands out. In summer, the collector is protected by a system of motorized lattice shutters, located inside the carpentry of the exterior glazing. The upper and lower compartments. motorized and automated, are opened to achieve forced ventilation to refresh the element, preventing heat from reaching the interior. In winter, the radiation which penetrates the greenhouse is absorbed inside it, becoming heat, accumulating in the floor and walls and they transmit it by radiation to the interior of the building. In parallel the air in the interior is heated then introduced into the building by forced convection through fans placed on the upper part. The floor and wall of the greenhouse, with great thermal inertia, absorb the radiation, accumulating the thermal energy and transfers it to the environment with a delay and cushioned, by long wave radiation and convection, which minimizes losses through the glass.

It is estimated that its thermal production is 10,800 Kwh in winter and 14,245 Kwh in both spring and autumn.

The trombe wall is another passive system employed. It is composed of a glazing connected to a wall made up of two solid walls which have a small internal ventilated chamber. The solar radiation which reaches the wall, passing through the glass, heats the exterior wall, painted in a dark matte colour. This wall heats the interior wall by radiation and the air that circulates in the air chamber located between them. This chamber is equipped with automatic doors and ventilators.

In summer the doors open the chamber to the exterior, achieving forced ventilation which prevents heat from entering. In winter the doors open the chamber between the walls to the interior of the building allowing hot air to enter. Its thermal production is 4,970 Kwh in winter and 6,500 Kwh in both spring and autumn. Emission savings obtained during the year is 33 kg de SO_2, 10 kg of NOx and 2.640 kg of CO_2.

The thermosolar shunt is exclusively used in summer. It cools the interior of the building by means of forced ventilation from a garden area and a shaded area on the north face. Forced air is introduced from there through four ceramic conduits by means of fans. Said conduits are buried at a depth of 1.8 m and travel to the south façade where they emerge at the interior raising the air which is heated to the shunt of the roof. Its cooling production provides 2,838,000 B.T.U.'s in summer. Emission savings obtained during the year is 6 kg of SO_2, 2 kg of NOx and 5 kg of CO_2.

Installations

The building's photovoltaic solar system is 5Kw and is connected to the grid. It has 68 80Wp monocrystalline photovoltaic panels located on the roof of the building and oriented to the south with an inclination of 30º and 2, 2.5 Kw inverters.


CENIFER 2: Solar and PV panels

The estimated annual production is 7,440 Kwh (an average of 20.38 Kwh of production daily). This production intends to cover the electrical energy consumption of the building. Emission savings obtained during the year is 15 kg of SO_2, 4.8 kg of NOx and 1,228 kg of CO_2.

The thermal solar installation has 24 panels with a useful collection surface of 2.5m^2 placed on the roof of the building and oriented to the south at an inclination of 50º. This way they take advantage of the solar radiation to heat the heat transfer fluid circulating in them. They cover 100% of the domestic hot water needs and 44% of the heating. Emission savings obtained during the year is 102 kg of SO_2, 32 kg of NOx and 8,251 kg of CO_2.

The large accumulator tank, built under the greenhouse, works to accumulate the energy from the thermal solar panels so that it can be used in the heating circuit on the days with low solar radiation. Its capacity is 40,000 l, and is constructed of stainless steel and its perimeter is covered with 30cm of granulated cork which acts as insulation. The energy savings from this additional insulation is considered to be 18%.

The radiant floor and baseboard are made up of a series of cross linked polyethylene conduits where water circulates, integrated into the floor and wall baseboards. In summer they absorb heat through the fresh well water which circulates through the conduits, and in winter they provide heat by means of the circulation of water from the accumulation tank which has been heated by the solar panels. These emitters can provide 35,000 kcal/h. The energy savings of this low temperature radiation system compared to the conventional radiator convection heating is 23%.

To cool the building in summer an underground cooling system has been used which uses underground water and the radiant floor and baseboard. The system works by means of a submersible pump which is placed at a depth of 8mm in a well on the north face of the building, it pushes the water into the radiator elements, travelling through them and then returning to the water table.

The absorption capacity of this element is 15,000 B.T.U.'s/h. The yearly emission savings obtained with this system is 3kg of SO_2, 1 kg of NOx and 248 kg of CO_2.

EDIFICIO PAU CLARÍS

Spain

General information

Name: Pau Clarís Building	**Location:** Barcelona, Spain	**Year:** 2004
Architect: Pich-Aguilera Arquitectos.		
Type of Project: Bioclimatic Building		**Condition:** Renewed
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; environmental respectful materials; rainwater use; green roof; solar thermal power.		
Prizes: _		
Sources: Pich-Aguilera Arquitectos.		

Report

This is a building which houses flats, offices, garage and recovers the interior of a block in Barcelona's suburb. The dwelling programme develops into two compact blocks, one looking onto the street and the other onto the block's patio. The ensemble is broken down as if they were two buildings separated by a central space where the accesses are located. The two part of the resulting building, narrower, adjust more to the reduced dimensions dwelling programme, allowing for the recovery and strengthening of the benefits of induced transversal ventilation.

The main objectives of the project are:

- Incorporate the best technology possible and the most adequate bioclimatic design to maximize comfort levels and minimize energy consumption. The initial objective of the project was to save between 50 and 85% of the energy. This was analyzed through simulations and various phases in the project's development.
- The application of passive and active technologies.
- The use of renewable energies.
- The reduction of the environmental impact in the construction processes and later use of the building.
- Duplicability of the solutions taken so that the resulting building can be a building of reference for other private and public developers.

PAU CLARÍS 1: BLOCK COURTYARD

The project was financed by the European Commission's "Altener Programme" for an adaptable study in the incorporation of active and passive energy saving systems in urban areas.

Various aspects where taken into account in the design of the building which were studied from a technical perspective but also costs in comparison with a conventional building:

Building envelope

The façades have a low conductivity (0.4-0.5 W/m^{2o}C), with a ventilated chamber and thermal and lighting controls during the day.

The street façade (NE), when establishing the size of the openings, integration with the immediate surroundings was taken into account, which is why the opening proportions and their rhythm were respected in keeping with the Barcelona Suburb construction tradition. In addition, industrialized solutions allowed for the achievement of textures which are traditional in the Suburb and are currently unfeasible to use old artisan systems. Lastly, the openings incorporate aluminium mobile solar controls which allow for the light and heat entering to be controlled.

For the façade which looks onto the block's large central patio, which is oriented SW and is very sunny in the summer, the traditional galleries of the Barcelona Suburb were recovered, which act as a thermal buffer and create a cantilever which avoids direct solar radiation in the summer. The gallery has coloured textile protection which allows views to the exterior without depriving individual control over the direct solar radiation which enters the interior of the dwelling. This façade breaks its uniformity by providing different colours to the textile solar protectors.


PAU CLARÍS 2: SW FAÇADE'S GALERIES

The large central atrium can also be considered a covered exterior space. The proposed façade has a light exterior panel made of recycled wood, with continuous insulation and an interior wall.

On the roof, an ecological cistern has been proposed which stores rainwater and allows for the maintenance of vegetation without using domestic water. The solution creates a space of coexistence, avoids the heat of the floors under the roof, as well as allowing for the regeneration of the air quality in the exterior.

Crossed Natural Ventilation

The large central atrium is topped off by a skylight which allows for the solar radiation to heat the air until it is sucked vertically, creating a natural draft. On the lower floor an open walk area allows for the channelling of the dominant winds (SW-NE) from the block patio to the large building atrium, introducing a fresh air flow in the central atrium and allowing the dwellings to be considered open-ended with crossed ventilation.

The air flows in the atrium improve with vegetation and irrigation. The vegetation reduces the temperature some degrees, provided humidity and air quality.

Inside the dwellings, the open distribution allows for correct ventilation. The windows, placed on opposing façades (exterior-atrium), allow for crossed ventilation. They preserve the intimacy of the users, the windows have moveable horizontal slats which optimize the necessary crossed ventilations while protecting intimacy.

Constructive and Structural Systems

Industrialized construction elements and processes of construction efficiency were studied for this project. Initially it was proposed to streamline the structure so that it could be made with prefabricated elements, but the location of the dwelling on busy urban street made transportation and the placement of structural elements very difficult, which is why the idea was rejected.

There was collaboration with the industry when making the building façade and roof. The façade which faced the street was constructed with architectonic concrete panels, its dimensions were appropriate for its manufacturing and installation and with a texture suitable to the Suburb, obtaining the traditional sgraffitos at a very reasonable price.

The terrace is made from an inverted roof which consists of a cistern, on which porous cement has been placed, waterproof material and earth and plants which are very resistant to extreme temperatures and do not have to be watered. The thickness of the ecological substratum is 7 to 10 cm. Because the thermal insulation is placed above the water from the cistern, evaporation and freezing is avoided.

Pau Clarís 3: Communal terrace

The interior of the dwellings were constructed with quick systems and lightweight construction materials.

Eco-materials

During the development of the project, an analysis of the use of materials which are more respectful of the environment and do not mean a cost greater than traditional materials. The materials where classified into three groups: Ecological and low environmental impact, with a green label or certified and recycled materials. Materials used:

- Ecological and low environmental impact: exterior mortars with natural components, lime mortars, OBS panels, plastic insulation without HCFC, linoleum, woods with FSC eco-labels, polypropylene conduits, water consumption control mechanisms, green roof. electric mechanisms without CI components.
- Products with Eco-labels: Wood with the FSC eco-label; natural acrylic paints, mortars; water consumption control mechanisms.
- Recycled Materials: Architectonic concrete panels with recycled aggregates, finished elements, paving from recycled car tyres, wood recycled from pressed shavings.

Renewable Energy Possibilities

To optimize and minimize the building's thermal needs, including renewable energies, the installations project was worked in conjunction with the architectonic project.

Solar energy is used in two manners, as passive solar energy included in the design of the building and as active solar energy for Hot Domestic Water and support for the heating and cooling systems.

42 m^2 of thermal solar collectors were installed (21 units) with an accumulation volume of 3,500 litres distributed into three deposits which guarantee 63% of the domestic hot water. The collectors face south and are integrated into the roof.

Because the radiation level is elevated and the consumption of Hot Domestic Water descends during summer, undesired peak temperatures are reached which can deteriorate the installation. To avoid this there is a circuit that dissipates the energy into the pool. That way the communal pool can be used for a longer period.

Energy Efficient Systems

The building's heating and cooling installations are centralized although they have individual management and meters. Each dwelling has an energy meter for the cooling and heating system and a volumetric meter for the hot domestic water, as well as a thermostat to establish comfort conditions.

The management of hot domestic water consumption was an added complication in the project since the consumption was managed collectively but was calculated individually, each dwelling has its own hot water heater and the cost of its consumption is attributed. The management of this consumption is through an energy intermediary. This figure was very complex for these companies which made the start-up of the system difficult.

The production of heat and cold is through an electric heat pump. 63% of the domestic hot water produced is obtained through solar collectors. The rest of the needs are covered by the residual heat from the heat pump and in the case where there is insufficient a low temperature boiler is used.

The heating and cooling distribution system of the dwellings are done by means of fan-coils located in a false ceiling and a system to distribute water (hot and cold) throughout the building by means of two pipes. The heating and cooling system of the dwellings is zoned through two fan coils (except in dwellings with two bedrooms) which distinguish day and night use zones.

All the building's installations are registered from collective areas located in each stairwell landing. The building has a company which maintains and controls all the installations.

The heating needs were studied by MEDEA software. The studies concluded that the design achieved a reduction in the energy demand of 40% with respect to a current standard building.

Domestic Consumption Management

The project has done a use analysis at both an individual and communal level. The flats are provided with selective collection systems for garbage (organic, plastic, paper and glass). In the communal spaces on the ground floor there is selective collection of batteries, fluorescent tubes, furniture and wood.

The project includes three reduction levels in the consumption of water in each flat: control of the water consumption and pressure of individual taps, thermostats in showers and aeration in taps.

Results

The overall annual energy consumption of the building is 217,636 kWh, which is a 55% reduction in comparison with the total consumption of a conventional building. On the other hand, the building's daily water savings is 2587 litres in comparison with the consumption in a conventional building.

EDIFICIO DE VIVIENDAS

Spain

General information

Name: Apartment building	**Location:** San Cristóbal de los Ángeles (Madrid), Spain	**Year:** 2004
Architect: Margarita de Luxán and Gloria Gómez Muñoz.		
Type of Project: Bioclimatic Building	**Condition:** New + Renewed	
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; solar thermal power; energy management system (EMS).		
Prizes: Awarded in the Sustainable Building International Congress, 2005		
Sources: Margarita de Luxán, architect. http://termoarcilla.com/notBoletin.asp?id_rep=1230		

Report

The Project is the result of the "European Restricted Contest on Architectonic Ideas for the Energetic Renovation of two Residential Buildings in the San Cristóbal de los Angeles neighbourhood in Madrid" EMVS, Residential Innovation, the City Hall of Madrid, in the "Regen Link" Project, (R&D), sponsored by the DG T.R.E.N. of the European Commission. It later represented Spain in the "Sustainable Building 2005" International Conference in Tokya, chosen by the Spanish Executive Committee at the "Green Building Challenge".

The two blocks planned for the project, 30 and 28 dwellings in each, were constructed in the 60's, a result of the property development of that era, with low quality construction materials, they lacked thermal insulation and were affected by structural pathologies and serious foundation faults. This situation obligated one of the buildings to be demolished and another will be constructed on the plot following bioclimatic criteria, while the other was the renewed to improve its environmental friendliness and accessibility without vacating the residents.

SAN CRISTÓBAL 1: NEW BUILDING

The technical solutions planned, like the natural heating and cooling gallery and windows, solar refrigeration chimneys, etc., are elements that are applicable to all building in the urbanization and have been done with accessible and simple materials, not unknown in national construction, which also ensures the possibility to replicate it in the rest of the neighbourhood.

Measures Carried Out in Both Blocks

The bad orientation of the existing blocks, (with façades to the East and West), has been corrected, folding the envelope of the building to capture solar radiation in the interior in winter and its protection in summer, creating a series of "heating and cooling galleries", with capture windows oriented to the southeast in the dwellings' living areas. These galleries are protected by shade elements over the windows which eliminate the greenhouse effect in summer and are protected by exterior shutters which also provide shade and create chambers which avoid cooling by convection of the exterior cold air in winter.

The exterior carpentry is made of cross sections which break the thermal bridge and are glazed with low emission double glazing.

Two types of façade enclosure were built, one made up by walls with great thermal inertia with plastered exterior insulation and another also with insulation on the exterior layer but with a ventilated chamber finished with prefabricated panels with resins applied on cellulose fibres.

For all the dwellings, both new and existing, accessibility has been achieved and they have been equipped with power-efficient lifts.

Measures Carried Out in the New Block

A floor plan was proposed which allowed each neighbour to choose several layouts: living-dining-kitchen in a single space, different dimensions for large rooms and kitchens or choose between 1, 2 or 3 bedrooms and with different sizes and shapes; this is achieved by taking the bathroom, shower and the joint installations of kitchen, clothes drying area and bathroom to the façades which, in addition to acting as insulating "stopper spaces", they are all exterior and have natural lighting, and leave the living area dedicated to rooms free of structural elements or installation conduits which impede the free and appropriate organization for each type of grouping or family which inhabits the dwelling.

*0% of the heating and cooling of the dwellings, both in winter and summer, is achieved by passive means, meaning: the shape, distribution, window position, materials and insulation are prepared in a manner so that the entire building acts like an solar radiation accumulator which collects heat in cold times, and is protected from overheating in hot months. The materials were also chosen to take advantage of the day/night temperature changes and achieve improved constant temperatures in the interior.

The dwellings have a heating system which compliments the passive solar gain, with radiant flooring with low temperature water and a thermostat in each flat. This system also accumulates solar radiation during sunlight hours in winter.

The dwellings do not need any conventional refrigeration system to achieve comfort during the summer but to have even better conditions they are equipped with "solar refrigeration chimneys" which are self regulated to remove hot air accumulated in the high part of the dwellings and substitute it with naturally cooled air from the underground chamber located underneath the building.

All the rooms, both living and services, have natural ventilation and lighting.

70% of the domestic hot water is obtained from solar collectors, with a centralized solar hot water system, with closed circuit collectors, 2 tanks with a 2,000 litre capacity and an exchanger with 4 electric pumps. The taps are low consumption.

The heating and complimentary heating is carried out by high performance communal installations which are monitored to consume the least natural gas, which as a common fuel, is the one which produces the least environmental contaminants. It has a Telemanagement System to control the heating and Solar Hot Water in the boiler room with a calorie meter for heating and another for hot water flow to each dwelling, with individual meters on each access floor.

The proposal was to use recycled materials: wood fibres in the waterproofing and exterior panels which take advantage of the rubber from used tyres.

The specific installations are made with materials which care for environmental conditions during their useful life. Polypropylene plumbing network and the plumbing inside the dwellings is made of polybutylene.

The ensemble of the buildings achieves a level of insulation and adaptation above 200% that demanded by the regulations.

SWEDEN

Eco-neighbourhoods / Eco-cities

AUGUSTENBORG

Sweden

General information

Name: Augustenborg	**Location:** Malmö, Sweden	**Year:** 1998 - 2001
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** Renewed
Energetic characteristics / Keywords: Good thermal insulation; rainwater use; green roof; heat recovery; solar thermal power; photovoltaic power; sustainable public transport; biodiversity and ecocycle technique.		
Prizes: _		
Sources: www.ukswedensustainability.org/projects/augustenborg.jsp www.greenroof.se www.malmo.se		

Report

The Ekostaden Augustenborg initiative has been one of the most far reaching sustainable urban renewal initiatives in Sweden. The Augustenborg neighbourhood in Malmö was built between 1948 & 1952 when it was a pioneer of Sweden's new social housing. The area has suffered a long period of social decline until the mid 1990s when a new partnership between housing company MKB and various departments in the City of Malmö, launched the Ekostaden renewal programme. Augustenborg has 1800 homes, almost exclusively rented accommodation owned by MKB.

The Ekostaden programme started in 1998 and has addressed a wide range of issues relating to the whole built environment, as well as working with social issues in the neighbourhood. Augustenborg is now considered in positive terms by most residents in Malmö; 30% more residents are in work and empty apartments are a thing of the past.

AUGUSTENBORG 1: VIEW

Sustainable construction and renovation

Former steel shuttering with mineral wool insulation, installed on the old façades in the 1970s, has been removed on a number of housing blocks and replaced with modern external cellular plastic insulation with a render finish, restoring some of the original appearance of the buildings. The former system had a number of disadvantages such as thermal bridges in the fittings to the façades, inefficient insulation system, negative impact on internal environment & ventilation leading to dampness problems, aesthetic problems. The new insulation system is attached directly to the façade overcoming many of the above problems and has a render finish which restores the 1950s character of the building.

There has been some new-buildings in the neighbourhood in addition to the waste management system. 32 new apartments for senior residents have been built as a lightweight structure on the concrete roof of an old underground car-park. Cost-efficient modular construction and the fact that the housing company already owned the vacant land helped ensure a good financial viability for the building with no public finance, despite an advanced aesthetic design and certain environmental measures including green roof for stormwater management.

In the school grounds a new modular building now provides the most attractive classrooms in the school. The dismountable building is designed to be able to be moved to another school in the future if demand in Augustenborg decreases. The factory made timber building was designed specifically for Augustenborg but the potential of adapting it for serial production is underway. The building features a high level of natural lighting, heat recovery system, ground water heat pump for space heating, direct radiation initial heating system, solar collectors for hot water, natural materials and composting toilets. The building is designed to maintain a background temperature of around 17°C to be complimented by the heat generated by appliances, computers and not least children, when the building is in use. The direct radiation system installed in the ceiling helps maintain thermal comfort when the children first come into the building in the morning.

AUGUSTENBORG 2: SCHOOL

Green Roofs

Augustenborg's Botanical Roof Gardens started their life as an initiative to get to grips with the uncontrolled flooding problem that hit the neighbourhood on a regular basis due to pressure on the under-dimensioned combined sewage and drainage system. 10,000m^2 of green roofs became Scandinavia's largest single green roof project. The EU LIFE funded initiative has included a vast range of research into green roofs, investigating not only their stormwater retention capacity, but also other properties such as extending the life expectancy of the roof seal, decreasing energy demand in the buildings, promoting biodiversity, aesthetic improvements etc. All new developments in the neighbourhood have green roofs and they have also been installed on a number of existing buildings.

© Scandinavian Green Roof Institute

AUGUSTENBORG 3: BOTANICAL ROOF GARDENS

Stormwater Management

Previous major flooding problems from the under-dimensioned combined sewage and drainage system have now been solved thanks to the open stormwater system which now retains 70% of all rainwater falling in the 32 ha neighbourhood. The system includes a number of different designs from the concrete urban to more naturalistic forms, but the whole system of channels and ponds is sealed as infiltration attempts could be counterproductive on the heavy clay soil. Part of the system has been designed by one of the local residents who has started his own business based on the natural movement of water.

AUGUSTENBORG 4: STORMWATER SYSTEM

Renewable Energy

Local residents in Augustenborg first started raising the issue of renewable energy when they heard about the development planned for the Western Harbour in Malmö. The resulting process has involved local people, energy supplier Sydkraft, the MKB housing company and the City of Malmö. The result is a number of solar energy installations in the neighbourhood that are supplying hot water and electricity for local use and also providing other benefits. 400m^2 solar collectors are producing hot water on the roofs of the industrial estate with excess production being fed into the district heating system. 100m^2 of photovoltaics functions not only as an electricity production unit, but also shade south facing office windows from excessive solar gain during the summer months. An innovative moveable sun-screen that also functions as a solar collector and photovoltaic system, is about to be installed in another building on the industrial estate. One of the most innovative and cost efficient solar applications is also the most popular. Under the gravel football pitch in the park is now a series of pipes which extract heat from the ground and pump it into the district heating system, essentially functioning as a large solar collector. In the summer, Augustenborg has the coolest football pitch in Malmö, and in the winter, when temperatures fall below +5°C it is possible to create an ice rink which provides a social facility for about four months of the year.

Energy Efficiency

A number of measures have been undertaken to increase energy efficiency in the neighbourhood. Façade renovation as described above has contributed to 10% energy savings, measures to optimise the energy system throughout the neighbourhood has also reduced energy use by about 15%. A new initiative to introduce a pilot pay-as-you-use system for domestic heating (which is normally included in the rent) combined with an innovative "CO2 slim club" initiative is expected to decrease energy use by a further 15% in the target buildings.

Green spaces for nature and people

The outdoor environment has been enhanced in close consultation with local residents and school children to create a more pleasant environment for both people and biodiversity. The most dramatic changes have been as a result of the stormwater system which has created a large number of ponds and wetland areas which are attractive and a haven for wildlife. Other changes have included more trees, shrubs and flowers, as well as improved play areas including the music play ground in the park in which traditional play equipment is combined with other objects to create a fun play area.

Recycling

There are 12 recycling houses in Augustenborg to take care of the residents' and school's waste with an aim of 90% of waste going to recycling, reuse, or composting. Residents have been supplied with containers for collecting used packaging materials and have a maximum of 130m to their recycling house. An electric vehicle will then collect the waste and take it for recycling.

AUGUSTENBORG 5: RECYCLING CENTRE

Sustainable urban transport

The city's Public Works Unit based in the industrial estate has converted a large part of their vehicle fleet to alternative fuels including electricity, gas and ethanol. This has inspired local residents in an area with low car ownership to start their own car pool as a local community business, operating with ethanol hybrid cars. They have a special arrangement with the industrial estate management to access the ethanol filling station in their compound. In addition, a natural gas filling station opened recently on the main road by Augustenborg for the general public to use.

Earlier in the project, an experimental street train service operated for two years in an attempt to link Augustenborg with other peripheral housing areas to help local residents gain improved access to service centres, health care, banks, post office etc. The purpose built electric trains were able to cut through the neighbourhoods in a way that conventional public transport systems could not achieve. Unfortunately it was not possible to find a commercially viable system in the long term to continue this service and the trains are now in operation elsewhere.

GLUMSLÖV

Sweden

General information

Name: Glumslöv	**Location:** Landskrona, Sweden	**Year:** 2004
Architect: Mernsten Arkitektkontor AB		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Good thermal insulation; environmental respectful materials; heat recovery; energy efficient devices.		
Prizes: Winner of the contest of the municipal house company, AB Landskronahem.		
Sources: www.eco-guide.net/skane/Glumslövshusen_project.php www.ukswedensustainability.org/projects/landskrona.jsp www.iea-shc.org/task28/publications/Sweden_Landskrona.pdf		

Report

In Glumslöv, north of Landskrona, lies 35 terraced houses built in 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 layout of the apartments is quite traditional. All apartments have a living room, a kitchen, a bathroom and a storage. The number of bedrooms varies between one and four. The sizes of the apartments vary between 70 and 115 m² usable floor area.

GLUMSLÖV 1: PLAN

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

The goals of the project were:

- To achieving a maximum rental cost for the apartments of 100 Euro/m² usable floor area.
- To adopt highly thermally efficient construction techniques in order to exclude conventional heating i.e. radiators or under floor heating systems.
- To secure moisture proof buildings.
- To achieve good levels of air tightness.
- To consider the sustainability of materials used.

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/(m²·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 aluminium 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/(m²·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/(m²·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 solar energy is needed for space heating, i.e. during winter, the gains are low. On the other hand, when it is not needed 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, 1m. 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.

Glumslöv 2: General view

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.

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. 70mm into the construction from the inside of the wall.

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.

GLUMSLÖV 3: LOW ENERGY HOUSES

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

ÖSTERÄNG

Sweden

General information

Name: Österäng	**Location:** Kristianstad, Sweden	**Year:** 2004
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** Renewed
Energetic characteristics / Keywords: Good thermal insulation; rainwater use; solar thermal power; photovoltaic power.		
Prizes: _		
Sources: www.eco-guide.net/skane/%C3%96ster%C3%A4ng_project.php?loc_id=2 www.ukswedensustainability.org/projects/osterang.jsp		

Report

A renovation project of 700 multi-occupancy apartments built in the 1970s, owned by the Municipality housing company of Kristianstad, ABK. ABK had particular environmental and quality requirements for the project based on experience from its own construction and management.

Background

When the old dry lake east of the centre of Kristianstad was developed, it soon became home to a number of poor quality buildings. The concrete cracked, drainage was poor, and the damage caused by dampness and leaks meant that the area eventually fell into disrepair. The buildings began to appear more and more dishevelled, causing all sorts of problems. At the start of the 1990s, the low-rise buildings were in such poor condition, that there was no choice but to pull them down or redevelop them.

Österäng 1: General view

Planners opted for the development option for a number of reasons. It would be slightly cheaper to redevelop, the area and pulling down and then rebuilding the buildings would also take longer and would mean that the tenants would have to move out for longer. At the time when it was decided to renovate them, the multifamily houses had at the technical defects of different kinds such as:

- Low quality concrete.
- Leaking roofs.
- Deficits in the drainage system.
- Rotten windows and doors.
- Moisture-problems in bathrooms.
- PCBs (polychlorinated biphenyls), asbestos, moisture and mould.

Implementation

In the early stages, financed by LIP, all environmentally-friendly construction material was prioritised regardless of the maintenance work this required. In later stages the choice of materials was from a LCC perspective. Dangerous materials - for example asbestos, PCB etc - were replaced.

The whole project has a strong environmental profile and the changes have been far-reaching. On the environmental and energy front, the more important changes include additional insulation, the use of renewable energy and the installation of exhaust heating pumps. Environmental benefits have also been achieved through the use of district heating (produced from bio-fuels) instead of direct-acting heating, and the introduction of individual metering.

The area has the first Swedish full scale plant of sun cells, 100 m^2, for electricity production for dwellings. In the year 1999 a large plant for storm water was completed. There is also a plant for waste water with a total area of 80 000 m^2. The design of the plants was carried out in cooperation with the artist Helge Lundström and has been a great attraction in the area.

The total energy saving is in some buildings assessed to about 30%. The project is evaluated by the Institute for Building Ecology. The results of the evaluation are very good.

The redeveloped buildings have been made directly accessible for wheelchair users, allowing handicapped tenants to remain living in their own homes until later in life. A central complex is located at the heart of the area, comprising library, shops, swimming pool, nursery school and Österäng Church. The area also houses a primary and secondary school, upper secondary school and preschools.

Results

- Glazed-in balconies stretching along the exteriors have given the flats new life and light. Glazed-in galleries with communal areas open up on the courtyards.
- Rooms looking out on the courtyards are now designed as living space rather than simply passages to and from residences.
- The environment has been enhanced with ponds and streams to resolve the earlier surface water problem.
- Stone circles, groups of seats and gardens have been installed to encourage life between the buildings, one of the objectives of the redevelopment.
- Each stage of the work generated new expertise which ABK, the letting agents, was able to use to make the next stage a bit different to the last.
- Solar collectors and solar panels have been installed on the roofs of the blocks.
- Heat recovery.
- Installation of broadband connections to all apartments.

Österäng 2: Courtyard

OXTORGET

Sweden

General information

Name: Oxtorget	**Location:** Värnamo, Sweden	**Year:** 2006
Architect: BSV Arkitekter och Ingenjörer AB		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Good thermal insulation; solar thermal power.		
Prizes: _		
Sources: Ulla Janson & Maria Wall, Division of Energy and Building Design, Dept of Architecture and Built Environment, Lund University. www.oxtorget.se		

Report

This building project, consisting of 40 rental apartments built with passive house standard, is a case study within a research project carried out at the Division of Energy and Building Design, Lund University to analyse energy aspects of passive houses in Sweden. The studies also include seeing which obstacles and lack of technologies, products or knowledge that exist in Sweden in order to achieve buildings with a very low energy demand.

Finnvedsbostäder, the city-owned company of rental apartments in Värnamo, were chosen by the local government to develop the area of Oxtorget. First they started planning the project with standard apartments. After presenting the project the neighbours living round the square did not like the plan and appealed against the project.

At the same time as this appealing process, the staff at Finnvedsbostäder went to a conference where they, among other things, discussed the costs of a building over many years and realized how high the running costs are for traditional apartment buildings compared to the cost of the actual construction. Looking at the small running costs for a passive house, they decided to build the houses at Oxtorget as passive houses. It turned out that the neighbours liked the idea of passive houses as well, so the planning of Oxtorget continued.

OXTORGET 1: PLAN

The five houses are of two types, each containing 8 apartments; 2 houses of type A maisonette and 3 of type B maisonette and a furnished attic. Houses A have 2 RK (rooms and a kitchen) and 3 RK respectively. Houses B have 2 RK and 3 RK on one level. Apartments with 4 RK and 5 RK are in two levels (maisonettes) with an internal open staircase. The upper level includes an upper hall, bedrooms, WC/shower and a wardrobe. The hall has connection with the outdoors through the skylight window.

The houses have a concrete structure for a steady temperature, solid and well insulated external walls and floors ¼ of Boverket's allowed leakage air flow rate 0.2 l/s.m^2, windows and doors have a low u-value and balconies and roof overhang protect from too much sun during summer months. A++ and fittings obtained by technology procurement. U-values for the dwellings:

- Windows = 0.1 W/m^{2}K.
- External walls = 0.095 W/m^{2}K.
- External roof = 0.07 W/m^{2}K.
- Doors = 0.6 W/m^{2}K ("arctic line").
- Floor = 0.09 W/m^{2}K.

OXTORGET 2: VIEW

All the apartments have entrance enclosures – an additional uninsulated passage/doorway that during summertime serves as an airing area. There is a cold storage room directly neighbouring with the entrance enclosure. The generous floor-to-ceiling height, 2500 mm, combined with big windows and slanting window bays provide the apartments with light, air and space. In order to strengthen the sense of light, air and space in the apartments a particular significance is attached to the colour scheme where light colours have been used against darker background walls.

Incoming air is heated by outgoing air with a heat recovery of 85 % efficiency. The rest of the heat demand is provided for by household machines, light, computers and the tenants of the apartments. As a back-up, electric heating through the ventilation system can be added cold winter days. The total energy-need is calculated to be 80 kWh/m^2 and year, calculated with heat balance calculation programme IDA. Individual measurements of electricity and hot water will be made in each apartment.

Solar panels are placed on the roofs and are projected to count for one third of the hot water demand. Heat is also recovered from the drain and used to heat the hot water. Each house has a 2000 litre accumulation tank in the basement which is also supported by electricity when needed.

VÄSTRA HAMNEN

Sweden

General information

Name: Västra Hamnen	**Location:** Malmö, Sweden	**Year:** 2001
Architect: various		
Type of Project: Eco-neighbourhood / Eco-city		**Condition:** New
Energetic characteristics / Keywords: Rainwater use; solar thermal power; photovoltaic power; wind power; aquifers exploitation; well designed public transport net; 100% supplied with local produced renewable energy sources.		
Prizes: Chosen as Bo01 City of Tomorrow district.		
Sources: www.energy-cities.eu/IMG/pdf/BO01_EN.pdf http://habitat.aq.upm.es/dubai/02/bp244.html		

Report

Malmö is the third largest city in Sweden with 265,000 inhabitants, strategically situated in the centre of the Öresund region, opposite Copenhagen, with good communications in all directions. The city is a centre of culture, commerce and education.

Malmö was one of the first towns to sign a local partnership contract with the European Commission within the framework of the "Campaign for Take-Off" (CTO). The partnership concerns the development of a new residential area on the Västra Hamnen site, a brownfield located in the harbour area west of Malmö. This new district should be an exemplary example of environmental adaptation in a densely built-up urban area. The first phase of urbanization (400 apartments out of 3000 planned in the long term) was presented and opened to visitors at the European habitat trade fair "Bo01 Ecological City of Tomorrow", in 2001.

VÄSTRA HAMNEN 1: GREEN MAP BO01

The Västra Hamnen district was chosen as the site for the new Bo01 City of Tomorrow district. Although it is an old brownfield site, its proximity to the sea and Ribersborg beach, the most attractive parks in Malmö and the central railway station, makes it a strategic site. The new urban sector will be 100% supplied with renewable energy sources, thus exploiting the only endogenous potential. Near 12 hectares of land were prepared for the first 800 housing units.

Production of energy from local renewable energy sources

The production of electricity is almost totally dependant on wind energy. A 2 MW wind turbine generator has been erected at Norra Hamnen, 3 km from the harbour area west of Malmö. Its annual production is estimated at 6.3 million kWh, which is largely sufficient for the needs of Bo01 (household consumption, heat pumps and recharging station for electric vehicles). An electronic card manages control, command and monitoring operations at the installation. A semi-transparent 120 m² photovoltaic roof offset to act as a sun-shade, has been installed on one of the buildings in the area. The expected annual production is 12,000 kWh and should cover the annual needs of 5 apartments.

Västra Hamnen 2: View

Heat is produced from the exploitation of aquifers (85%) and solar power (15%). The geothermic potential of fractured, saturated calcareous rocks, is used to supply the urban heating network. A first row of five 90 m deep wells is used to raise water at 15°C (hot source), using an extraction pump. This water, after exchanging its heat with the heat-exchanging fluid in the heat pump, is re-injected into the groundwater at a temperature of 5°C through a second row of five wells (cold source). Compressing the fluid in vapour form raises its temperature to 67°C. This heat is transmitted to the heating network via an exchanger. The power of the pump is 1.2 MW and its yield 3.15. More than 4,000 MWh of heat are thus supplied annually. If the aquifer's potential is inadequate, energy is taken directly from the sea. The pump's reversible function also allows for the provision of cooling in summer (3,000 MWh for 2.4 MW power).

Solar collectors provide the extra heat needed for heating and hot water production in the buildings. 1,400 m² have been installed in 8 separate housing units, 1,200 m² of which are flat glazed collectors and 200 m² vacuum collectors. Annual production reaches 525 thermal MWh, i.e. an average of 375 kWh/(m²*a).

To alleviate any problems due to time differences between production and consumption periods, without having recourse to costly storage systems, all the energy producing installations are connected to Malmö's existing electricity and heating networks.

Energy efficiency

The global energy index for the various properties must not exceed 105 kWh/(m²*a) in accordance with the Quality Charter. The building layout and choice of construction materials must help minimize energy expenses linked to heating and environmentally dangerous substances will be avoided. Each housing unit will be equipped with the most efficient installation available with respect to energy consumption.

Local Rainwater Management

Rainwater is treated locally without any connection to the community system and will be cleaned and treated through a surface run-off system. The system consists of green roofs, channels, and dams that hold back the rainwater before reaching a recipient, either the canal or the Öresund. The system also contributes to an increased biological diversity in the area.

Västra Hamnen 3: Green roof

Waste treatment

Collecting stations for 6 fractions are located in the properties. These fractions go to recycling plants. The organic and the other waste fraction go into vacuum waste chutes. The organic waste is taken from there to the biogas plant, where it meets slurry from food waste disposers in 70 apartments, and sewage. The biogas can be used as alternative car fuel, for electricity and heat production, or be pumped back into the area's natural gas grid after further cleaning. The remaining waste is taken to Malmö's waste incineration plant where heat is extracted. The area is attached to Malmö's existing sewage system, except for the food waste disposers that have separate pipes to the collector tank.

Bioclimatic buildings

GÅRDSÅKRA

Sweden

General information

Name: Gårdsåkra	**Location:** Eslöv, Sweden	**Year:** 1983
Architect: Peter Broberg		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; glazed courtyard.		
Prizes: _		
Sources: www.eco-guide.net/skane/G%C3%A5rds%C3%A5kra_project.php		

Report

This is the largest glazed courtyard in Sweden for dwellings. Two buildings are connected with a glazed street and a glazed courtyard, 375 m long and 11-22 m wide. There are 136 apartments, day nursery and a school along the street. The aim from the municipality of Eslöv was to minimise the use of both land and energy and to create a living environment with social qualities.

The architect wished to create a glazed space with good comfort where people could meet great part of the year. The courtyard was an important part of the energy saving efforts. As the temperature in the courtyard will be higher than outdoor, the heat flow through the walls decreases. There are opening windows in the glass roof as well as curtains in order both to avoid over heating in the summer time and reduce the heath radiation during cold nights

GÅRDSÅKRA 1: GLAZED COURTYARD

The air supply to the apartments was taken from the courtyard and by that preheated. However, the air was not only preheated but also contaminated with fumes. Today the ventilation is refurbished and the air supply comes directly from outdoor and there are heat exchangers on the exhausted air.

Initially the street was heated to +5°C but today the street is only kept from freezing. Calculated energy need for space heating and hot water was 100 kWh/m^2, year. However, according to information from Eslövs Bostads AB who owns the dwellings, the measured energy need was in the year 1999 about 160 kWh/m^2, year. After the refurbishment (adjustment of the heating- and ventilation system and heat exchange on the exhausted air) the energy need is about 95 kWh/m^2, year.

The Results performed in the 1980's on the social life in Gårdsåkra showed that the vegetation in the courtyard was much appreciated and that the glazed space contributed to a better social life. The courtyard also caused conflict between peoples wish for a secluded corner and the lively street.

GÅRDSTEN

Sweden

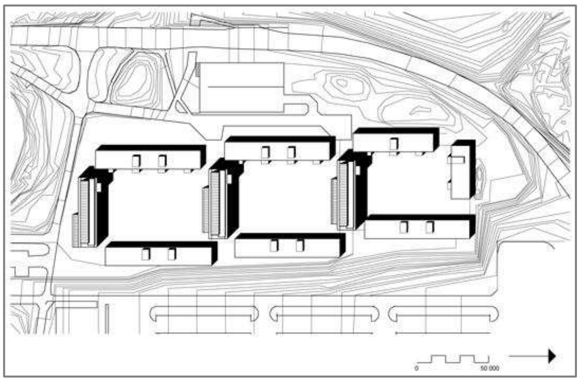
General information

Name: Gårdsten	**Location:** Göteborg, Sweden	**Year:** 2000
Architect: _		
Type of Project: Bioclimatic building		**Condition:** Renewed
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; heat recovery; solar thermal power.		
Prizes: Swedish Sustainable Development Award, 2006		
Sources: www.ukswedensustainability.org www.gardstensbostader.se/data/content/DOCUMENTS/2006511193945647SolarBuildings.pdf		

Report

In the housing area of Gårdsten (Göteborg), the public housing company Gårdstensbostäder has renovated ten residential buildings with a focus on energy efficiency, the integration of renewable energy, sustainable design and improved quality of life. The renovation was planned and performed in close co-operation with the tenants. It was completed in 2000.

The original housing had been developed as part of the 'Million Homes Programme', which operated between 1960 and 1970, but the area declined very rapidly after its construction. The buildings themselves deteriorated, and services became almost non-existent. In the mid 1990s, Gothenburg's municipal housing company, decided to take action to avoid further deterioration of the neighbourhood, and in 1997 Gardstensbostäder was created with the specific role of regenerating this housing area.



GÅRDSTEN 1: PLAN

The solar renovated area is divided into three blocks. One block consists of 2-3 three-storey buildings and 1 seven-storey building. Together with laundry facilities and bicycle storage, a community greenhouse is situated in the ground floor of each seven-storey building. The greenhouse is shared by the tenants living in one block.

GÅRDSTEN 2: GENERAL VIEW

Before the renovation, there were problems with thermal bridges on the east and west façades of the 7-storey buildings. Therefore, 100 mm external insulation of mineral wool covered with plaster was added. The south facing balconies of the 7-storey buildings have been covered with a new glazing system. This consists of frameless single glazing, which can be fully opened during summer. It is designed for preheating of fresh air to the apartments.

Different technologies in the project

- One building equipped with solar air-heated double envelope external walls.
- Old windows are improved with low-E glass or replaced with new timber-framed low-E windows.
- New roofing and extra roof insulation.
- Solar pre-heating of domestic hot water for all flats in the block.
- Solar pre-heating of fresh air through glazed balconies.
- Community greenhouse for all residents.
- New laundries in connection with community greenhouses.
- Composting and recycling replace conventional waste-system.
- Extra insulation of walls exposed to wind.
- Façades are painted.
- Space heating, DHW and water are monitored for each apartment.
- Heat recovery of ventilation air.

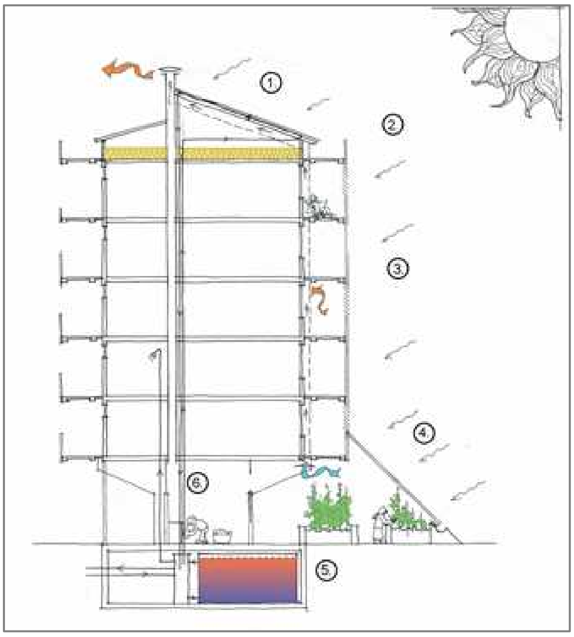
Solar DHW System

The three 7-storey balcony-access buildings, have received new pitched roofs. Prefabricated roof modules of flat plate solar collectors have been installed on the south-facing part of the new roofs. The modules' construction function as both solar collector and roof. The angle of the pitched roof is 30 degrees, which is optimal for a water solar collector in Sweden. Each block has 240 m² water solar collectors and a 20 m³ storage tank. The solar collectors preheat DHW for all apartments on the estate.

Before renovation, there was significant heat loss through the poorly insulated roofs. Extra roof insulation was added under the new pitched roof.

Solar DHW system diagram:

1. Solar collectors for preheating of domestic hot water.
2. Extra insulation.
3. Preheating of ventilation air through glazed balconies.
4. Community greenhouse for all residents.
5. Storage tank for solar heated water, which is distributed to all flats in the block.
6. New laundries.



GÅRDSTEN 3: CROSS SECTION THROUGH 7-STOREY BUILDING

Air heated solar system

An innovative air heated solar system has been applied to a three-storey building. Solar collectors are mounted on the south-facing wall. External insulation has been added to north, east and west, leaving an open space to the original façade, where heated air from the solar collector is transported. Heat is stored in the thermal mass of the original concrete façade elements.

The joints between elements, which before renovation resulted in large heat losses, now allow the warm air into the apartments. When the cooler air reaches the bottom of the wall cavity, it is returned to the solar collector to be reheated. The system is closed and separate from the ventilation system.

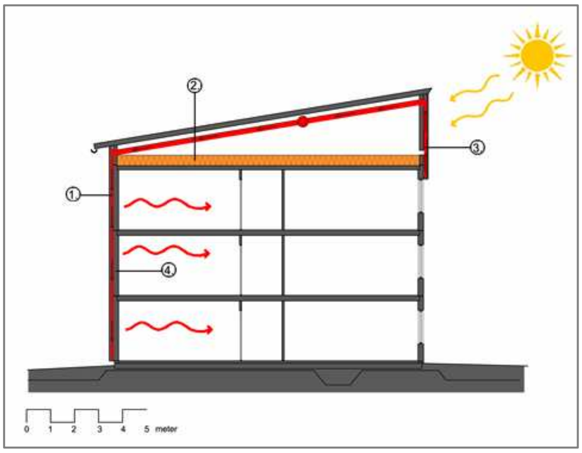
Solar heated air system diagram:

1. The solar heated air is distributed through new double envelope external walls facing north, east and west.

2. New roof with extra insulation replacing the old flat roof.

3. Solar air collectors are integrated in the south facing façade.

4. Solar heat is stored in the old thermal mass walls and released to the building.



GÅRDSTEN 4: CROSS SECTION THROUGH 3-STOREY BUILDING

Solar Glazed Façade

The south facing balconies of the three 7-storey buildings have been covered with a new glazing system. The system consists of frameless single glazing, which can be fully opened during summer, providing good summer ventilation and preventing overheating in apartments. It is designed for preheating of fresh air to the apartments.

Existing damaged windows were replaced by new windows with argon filled low energy glazing to improve energy efficiency. The U-value of these windows was not allowed to be greater than 1,3 W/m²,ºC.

Daylight

Different actions have been taken to improve the daylight situation in the area. The new laundries have been moved from the dark cellars of the 7-storey buildings to the ground floor, where they have replaced bicycle storage rooms and garbage rooms. New windows have been opened up for daylight and views.

Heat Recovery

New heat recovery ventilators (HRVs) have been installed in the new ventilation rooms, situated on the roofs of the 3-storey buildings. The heat exchanger has 70% efficiency.

The old system was a traditional supply and exhaust ventilation system.

Energy consumption

The energy consumption of the dwelling has been reduced from more than 300 kWh/m^{2}y to 200 kWh/m^{2}y, of which 100 kWh/m^{2}y correspond to heating. Before the refurbishment the heating consumption was 200 kWh/m^{2}y. The heated floor area is 19 000 m².

Energy consumption in kWh/m²/y:

a - Reference before renovation

b - Project simulation

c - Project measurement

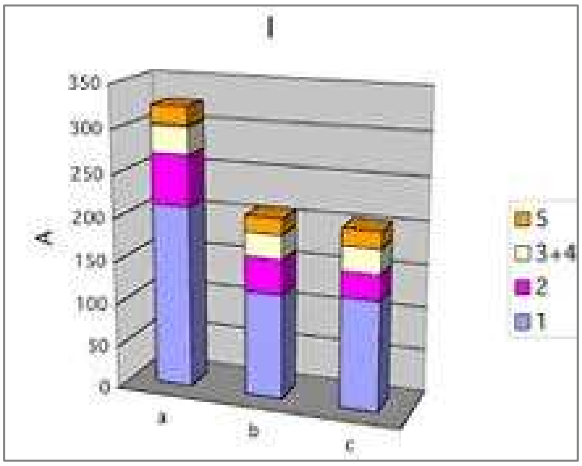
1. Heating

2. Domestic Hot Water

3. Household lighting

4. Cooking

5. Common (electricity)



GÅRDSTEN 5: ENERGY CONSUMPTION DIAGRAM

GUNNESBOSKOLAN

Sweden

General information

Name: Gunnesboskolan	**Location:** Lund, Sweden	**Year:** 1994
Architect: _		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Good thermal insulation; "healthy school".		
Prizes: _		
Sources: www.eco-guide.net/skane/Gunnesboskolan_project.php		

Report

Gunnesboskolan was the first school in Lund based on the municipal's policy document 'healthy schools'. The concept focuses on good daylight in classrooms and working rooms, low noise level from fans and good acoustics in the class rooms.

A 'heavy construction'-concept was used. External walls are duct walls of clay brick. Many internal walls are also of clay brick and the floor structure is of concrete. By that, the structural components contribute to a cooler indoor climate and to decrease the energy need.

The foundation is a concrete slab. Interior floors are of oiled hardwood in class rooms, dining room and samlingssal, of clinker in the entrance halls and of linoleum in office room.

GUNNESBOSKOLAN 1: EXTERIOR VIEW

The room height is at minimum 3.60 m and all class rooms have daylight from two directions. In addition, some class rooms have daylight from roof windows.

The school provides possibilities for outdoor practical work in the gardens and in the park. The gardens can be reached from the class rooms via green houses close to the class rooms. Since some years there are a lot of activities in the school garden and several teachers work with this teaching.

The aim of the outdoor school area design is to make it a place for recreation and rest and a pedagogical resource. The gardens have plenty of species, for example about thirty different Swedish tree species. There is a possibility for each class to have its own cultivation lot and there are several possibilities for sports and exercises.

LOW ENERGY HOUSES

Sweden

General information

Name: Low energy houses	**Location:** Lindås, Sweden	**Year:** 2001
Architect: EFEM arketektkontor		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; good thermal insulation; heat recovery; solar thermal power.		
Prizes: _		
Sources: Maria Wall www.energieffektivabyggnader.se/download/18.360a0d56117c51a2d30800050410/Folder_Lindas_EN.pdf		

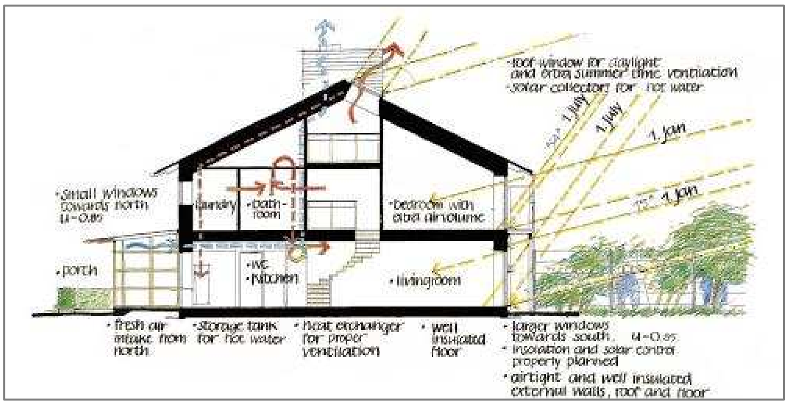
Report

The buildings have been designed to provide a pleasant indoor environment with minimum energy use. Only fully developed and reliable techniques have been used in these dwellings where the unique collaboration between property developer, builders and researchers has resulted in very low energy-needs. Construction costs were approximately equal to those of standard construction techniques.

LINDÅS 1: EXTERIOR VIEW

The traditional heating system has been replaced by a heat exchanger in combination with an exceptionally well insulated construction. Big windows facing south are combined with balconies and roof overhang to shield from too much sun and high temperatures during summer. Owing to the terrace construction with houses of 11m 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.



LINDÅS 1: SUN AND HEAT DIAGRAM

Table 1.1. Insulation:

	U-value (W/m^2K)	Technology
External wall	0.10	Bolt wall with 43 cm isolation
External roof	0.08	Masonite balk med 48 cm isolation.
Floor	0.09	Concrete board with 25 cm isolation.
Windows	0.85	Three glass with two metal layers and krypton gas. Energy transmittance 43%. Light transmittance 63%.
Doors	0.80	

Heating

Supply air is heated by the exhaust air in a heat exchanger. The rest of the heat requirement is covered by heat from the occupants, appliances and lighting. The heat from occupants is equal to an energy increment of ca 1200 kWh/year. Heat gains from lighting, fridge, freezer, cooker and other appliances come to about 2900 kWh/year, provided that the most energy efficient appliances available in the market are used. A part of this is useful to heat the building. The houses have been designed for normal climatic conditions. 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.

Ventilation

The ventilation system consists of a supply and exhaust air unit with a counter-flow heat exchanger which provides 85% heat recovery. In the summer the heat exchanger can be turned off and the house ventilated with only exhaust air and open windows.

Hot water supply

5 m^2 solar panels for each terraced house to count for most of the water heating. The accumulation tank of 500 litres is also supported by electricity when needed.

Results

The residents moved into their terraced houses in 2001. The majority of the residents are content with the temperature of 20-23 ºC. The required bought energy has been somewhat more than expected, but still very low – about 8 000 kWh per year and apartment. This corresponds to an energy-need of 67 kWh per m^2; including heating, hot water and electricity for household demand.

SANKT HANSGÅRDEN

Sweden

General information

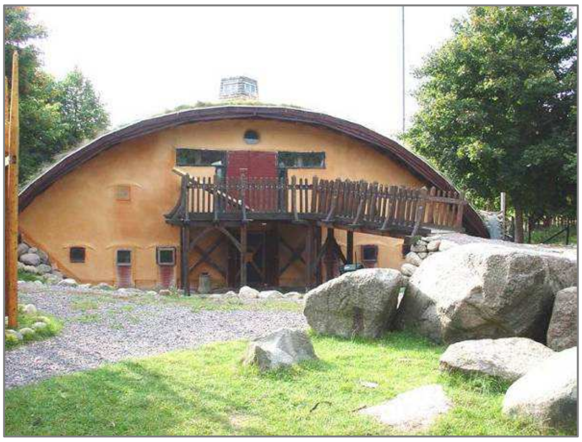
Name: Sankt Hansgården	**Location:** Lund, Sweden	**Year:** 2003
Architect: Lennart Pranter		
Type of Project: Bioclimatic building		**Condition:** New
Energetic characteristics / Keywords: Passive solar design; environmental respectful materials; solar thermal power; geothermal power; wind power; permaculture.		
Prizes: _		
Sources: www.eco-guide.net/skane/Sankt_Hansgården_project.php		

Report

Sankt Hansgården is an after school recreation centre for about 90 children and is also an open activity centre for the public. At St Hansgården, children are given practical teaching in history, ecology, animal care etc. The aim of the teaching is to help the schools to provide practical teaching as a complement to the theoretical teaching.

Perma culture is used as a tool for the design of the area and the buildings. Local resources in addition to the plants and animals at the 'farm' will provide the needs of the teaching and the making of small meals.

The ambition regarding the buildings is that the constructions will clearly contribute to an understanding of how the function of the buildings can be achieved in an ecological way. The children have participated in a great part of the construction work. This gives the children both pride and self confidence.



SANKT HANSGÅRDEN 1: NORTH FAÇADE

The 'farm' building is primarily used for animals and is heated to only +10°C. The heating comes mainly from a mass oven, fired with wood, complemented by solar panels and passive solar heat from a green house on the east gable of the building. The solar panels are connected to a hot water system under a sand storage under the floor in the green house.

The building has natural ventilation which, when needed, can be complemented by a fan. The air supply goes through a 30 m duct. By the earth the air is preheated in winter and cooled in summer.

All building materials are as far as possible reused or produced from locally resources. External walls are constructed from clay and straw and plastered with clay and lime. The clay comes from the site.

On the farm there is a small rotzonsanläggning for wastewater. There is also a small windmill connected to a 24V-battery. All waste from animals and kitchen is composted and used in the garden. In the garden there is a sun dryer for fruits and vegetables. In the kitchen there is a refrigerator cooled by earth

Sankt Hansgården 1: South façade

TABLES

Name	City	Country	Year	Bioclimatic building (type)	Eco-neighbourhood / Eco-city	New	Renewed	Sources
DENMARK								
Agernskrænten	Ballerup	Denmark	1994		-	-		www.ecobuilding.dk
Havrevangen	Hillerod	Denmark	1994		-	-		http://cordis.europa.eu; www.vla.dk
Skotteparken	Ballerup	Denmark	1992		-	-		www.ecobuilding.dk; www.agores.org
Solsikkehaven	Vonsild	Denmark	1996		-	-		http://cordis.europa.eu; www.ecobuilding.dk
Hedebgygade Building	Copenhagen	Denmark	1998 - 2002	- (apartments)			-	www.europeangreencities.com; www.cardiff.ac.uk
Herning	Herning	Denmark	1999	- (residence)		-		www.ecobuilding.dk; www.europeangreencities.com
Lillevangspark	Farum	Denmark	1994	- (dwellings)		-		http://new-learn.info; www.ebst.dk
Økohuse 99	Kolding; Århus; Ikast	Denmark	1998 - 2000	- (dwellings)		-		www.arkitekturbilleder.dk; Kristine H. Lorenzen, COWI; www.vandkunsten.com;
Rockwool's Research Centre	Hedehusene	Denmark	2000	- (company)		-		www1.rockwool.com
Seest	Kolding	Denmark	2006	- (house)		-		www.rockwool.dk
The Royal Playhouse	Copenhagen	Denmark	2008	- (public)		-		www.ltarkitekter.dk; www.cowi.com
NORWAY								
Bjølsen Student Housing	Oslo	Norway	2003		-	-	-	www2.arkitektur.no
Georgernes Verft	Bergen	Norway	1999 - 2002		-	-		www2.arkitektur.no
Kristiansand	Kristiansand	Norway	1995 - 2006		-		-	www2.arkitektur.no; www.kristiansand.kommune.no
Nydalen Powerplant	Oslo	Norway	2007 - 2010		-	-		www2.arkitektur.no; www.nordicenergy.net
Pilestredet Park	Oslo	Norway	1999 - 2006		-		-	www2.arkitektur.no
Borgen Community Centre	Asker	Norway	2005	- (public)			-	http://edit.brita-in-pubs.eu; www.skoleanlegg.utdanningsdirektoratet.no
Gløshaugen	Trondheim	Norway	2000	- (public)			-	www2.arkitektur.no
Grong School	Grong	Norway	1998	- (public)			-	www2.arkitektur.no; www.skoleanlegg.utdanningsdirektoratet.no
Grünerløkka Student Housing	Oslo	Norway	2001	- (residence)			-	www2.arkitektur.no
Klosterenga Ecological Housing	Bergen	Norway	1999	- (apartments)		-		www2.arkitektur.no; Birgit Kollandsrud Friis.

Name	City	Country	Year	Bioclimatic building (type)	Eco-neighbourhood / Eco-city	New	Renewed	Sources

SPAIN

Name	City	Country	Year	Bioclimatic building (type)	Eco-neighbourhood / Eco-city	New	Renewed	Sources
El Toyo	Almería	España	2003		-	-		Margarita de Luxan, architect; www.eltoyo.info
Municipio ecológico	Amayuelas de Abajo (Palencia)	España	2001		-	-		http://habitat.aq.upm.es; María Jesús González, architect. www.elmundo.es;
Residencial Parque Goya	Zaragoza	España	1995 - 2007		-	-		www.viviendaragon.org; José Antonio Turégano, architect
Urbanización Lliri Blau	Massalfassar	España	2003		-	-		www.ecoconstruccion.net
Valdespartera	Zaragoza	España	2001 - 2008		-	-		www.valdespartera.es
Casa Fujy	El Escorial	España	2005	- (house)		-		http://casaoriginal.com
Edificio ACCIONA Solar	Pamplona	España	2007	- (company)		-		www.pvdatabase.org
Call Center de Telefónica Móviles	Toledo	España	2005	- (company)		-		www.construible.es; http://en.urbarama.com
Edificio CENER	Sarriguren	España	2002	- (company)		-		http://www.cener.com
Edificio CENIFER	Imárcoain	España	2002	- (company)		-		http://www.cenifer.com
Edificio Pau Claris	Barcelona	España	2004	- (apartments)			-	Pich-Aguilera Arquitectos.
Edificio de viviendas	San Cristóbal de los Ángeles	España	2005	- (apartments)		-	-	Margarita de Luxan, architect; www.termoarcilla.com

SWEDEN

Name	City	Country	Year	Bioclimatic building (type)	Eco-neighbourhood / Eco-city	New	Renewed	Sources
Augustenborg	Malmö	Sweden	1998 - 2001		-		-	www.ukswedensustainability.org ; www.greenroof.se
Glumslöv	Landskrona	Sweden	2004		-	-		www.ukswedensustainability.org ; www.iea-shc.org
Österäng	Kristianstad	Sweden	2004		-		-	www.ukswedensustainability.org ; www.eco-guide.net
Oxtorget	Värnamo	Sweden	2006		-	-		www.oxtorget.se ; Ulla Janson & Maria Wall
Västra Hamnen	Malmö	Sweden	2001		-	-		www.energy-cities.eu ; http://habitat.aq.upm.es
Gårdsåkra	Eslöv	Sweden	1983	- (apartments)		-		www.eco-guide.net
Gårdsten	Göteborg	Sweden	2000	- (apartments)		-		www.ukswedensustainability.org ; www.gardstenbostader.se
Gunnesboskolan	Lund	Sweden	1994	- (public)		-		www.eco-guide.net
Low energy houses	Lindas	Sweden	2001	- (dwellings)		-		www.energieffektivabyggnader.se ; Maria Wall
Sankt Hansgården	Lund	Sweden	2003	- (public)		-		www.eco-guide.net

Name	1.1.	1.2.	1.3.	1.4.	1.5.	1.6.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	2.9.	2.10.	3.1.	3.2.	3.3.

DENMARK

Name	1.1.	1.2.	1.3.	1.4.	1.5.	1.6.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	2.9.	2.10.	3.1.	3.2.	3.3.
Agernskrænten		-					-	-									-		-
Havrevangen	-	-		-			-	-									-		
Skotteparken		-			-		-	-									-		
Solsikkehaven	-	-					-	-									-		
Hedebgygade Building		-					-	-	-								-		-
Herning	-	-			-		-										-		-
Lillevangspark							-	-	-										
Økohuse 99	-	-	-	-	-		-											-	
Rockwool's Research Centre	-	-						-											
Seest		-																	-
The Royal Playhouse							-										-		-

NORWAY

Name	1.1.	1.2.	1.3.	1.4.	1.5.	1.6.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	2.9.	2.10.	3.1.	3.2.	3.3.
Bjolsen Student Housing		-		-			-			-									
Georgernes Verft		-		-			-								-				-
Kristiansand														-					-
Nydalen Powerplant										-									-
Pilestredet Park				-															-
Borgen Community Centre		-					-			-									-
Gloshaugen									-										-
Grong School	-	-		-			-					-	-						
Grünerlokka Student Housing		-																	-
Klosterenga Ecological Housing	-	-		-	-		-	-											-

Table caption	
1.	Design
1.1.	Passive solar design
1.2.	Good thermal insulation
1.3.	Trombe wall
1.4	Environmental respectful materials
1.5	Rainwater use
1.6	Green roof
2.	Installations
2.1.	Heat recovery
2.2.	Solar thermal power
2.3.	Photovoltaic power
2.4.	Geothermal power
2.5.	Wind power
2.6.	Hydro-electric power
2.7.	Bio-mass
2.8.	Bio-fuel
2.9	Sea water heat pump
2.10.	Aquifers exploitation
3.	Others
3.1	Energy Management System (EMS)
3.2.	Energy efficient devices
3.3.	Other measures

Name	1.1.	1.2.	1.3.	1.4.	1.5.	1.6.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	2.9.	2.10.	3.1.	3.2.	3.3.

SPAIN

Name	1.1.	1.2.	1.3.	1.4.	1.5.	1.6.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	2.9.	2.10.	3.1.	3.2.	3.3.
El Toyo		-						-									-		
Municipio ecológico	-			-				-	-				-						-
Residencial Parque Goya	-	-						-											
Urbanización Lliri Blau	-	-		-		-		-									-		
Valdespartera	-	-		-	-			-											
Casa Fujy	-			-	-			-									-	-	
Edificio ACCIONA Solar	-	-						-	-	-				-			-		
Call Center de Telefónica Móviles	-				-		-	-											
Edificio CENER	-	-		-	-	-		-											
Edificio CENIFER	-		-					-	-										
Edificio Pau Claris	-	-		-	-	-		-											
Edificio de viviendas	-	-						-									-		

SWEDEN

Name	1.1.	1.2.	1.3.	1.4.	1.5.	1.6.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	2.9.	2.10.	3.1.	3.2.	3.3.
Augustenborg		-			-	-	-	-	-										-
Glumslöv		-		-			-											-	
Österäng		-			-		-	-	-										
Oxtorget		-						-											
Västra Hamnen					-			-	-		-					-			-
Gardsakra	-																		-
Gardsten	-	-					-	-											
Gunnesboskolan		-																	-
Low energy houses	-	-					-	-											
Sankt Hansgarden	-			-				-		-	-								-

Table caption

1.	Design
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2.10.	Aquifers exploitation
3.	Others
3.1	Energy Management System (EMS)
3.2.	Energy efficient devices
3.3.	Other measures

INSTITUTIONS

DENMARK

Institutions

Public institutions

Danish Building Research Institute (SBi)

It is under the Ministry of Economic and Business Affairs. SBi develops research-based knowledge to improve buildings and the built environment and carry out a number of activities within the field of bio-climatic architecture.

- **Source:** www.en.sbi.dk.

Danish Technological Institute

It is an independent institute with quite a number of activities within the field of buildings. The division of Energy focus on heat, electricity and ventilation installations and offer training, testing and certification for a number of RES technologies; biomass boilers, solar, passive solar, heat pumps, windows and indoor climate.

- **Source:** www.ibe.dtu.dk.

Private associations and institutions

Danish Association for Sustainable Cities and Buildings

The association is a platform, where a network of municipalities, public authorities, consultants, housing associations, companies and NGOs discuss and exchange knowledge.

- **Source:** www.dcue.dk.

Business Network Passive Houses

It is a network of several researchers, consultants and companies discussing and exchanging knowledge within the field of passive houses.

- **Source:** www.passivhus.aau.dk.

Local Agenda 21

Municipal LA21 coordinator is organized in a network, hosted by the Spatial Planning Department in Denmark. Their work also includes exchange of knowledge in the field of eco-buildings and areas.

- **Source:** www.un.org.

LØB - Landsforeningen Økologisk Byggeri

National Association for Ecological Building Activities.

- **Source:** www.lob.dk.

NORWAY

Institutions

Public institutions

Enova SF

It is a public enterprise owned by the Royal Norwegian Ministry of Petroleum and Energy. Enova SF`s main mission is to contribute to environmentally sound and rational use and production of energy, relying on financial instruments and incentives to stimulate market actors and mechanisms to achieve national energy policy goals.

The establishment of Enova SF signals a shift in Norway`s organization and implementation of its energy efficiency and renewable energy policy. By gathering strategic policy responsibilities in a small, flexible and market oriented organization, Norway has wanted to create a pro-active agency that has the capacity to stimulate energy efficiency by motivating cost-effective and environmentally sound investment decisions. Enova SF enjoys considerable freedom with regard to the choice and composition of its strategic foci and policy measures. Enova SF advises the Ministry in questions relating to energy efficiency and new renewable energy.

- **Source:** www.enova.no.

Norwegian State Housing Bank

It is the main instrument of the Norwegian Parliament, the Norwegian Government and the Ministry of Local Government and Regional Development for the implementation of national housing policy.

- **Source:** www.husbanken.no.

Norwegian Research Council

It plays a vital role in developing and implementing the country's national research strategy, acting as a government adviser, a funding agency and coordinator of research activities. The Research Council is responsible for the administration of most of the public funding available for R&D in the field of energy and water resource management.

- **Source:** www.forskningsradet.no.

Norwegian Water Resources and Energy Directorate (NVE)

It is a directorate under the Ministry of Petroleum and Energy, with responsibility for managing the country's water and non-fossil energy resources and for monitoring the energy market. NVE's mandate is to ensure integrated and environmentally sound management of the country's watercourses, to promote efficient energy markets and cost-effective energy systems and to work to achieve a more efficient use of energy. NVE also has the overall responsibility for maintaining national power supplies. NVE is involved in R&D and international development co-operation.

- **Source:** www.nve.no.

Norwegian University of Science and Technology (NTNU), Trondheim

It represents academic eminence in technology and the natural sciences as well as in other academic disciplines ranging from the social sciences, the arts, medicine and architecture to fine art.

Cross-disciplinary cooperation results in innovative breakthroughs and creative solutions with far-reaching social and economic impact.

- **Source:** www.ntnu.no.

Statsbygg

It is the Directorate of Public Construction and Property. It acts on behalf of the Norwegian government as property manager and advisor in construction and property affairs, and offers governmental organisations premises suited to their needs, either in new or existing buildings.

Statsbygg manages approx. 2,3 million m^2 of floor space, in Norway and abroad. The property portfolio consists of government and cultural buildings, colleges and public administration buildings, royal properties, embassies and diplomatic residences abroad.

It is responsible for organising, planning and completing building projects within set frameworks for budgets, time limits and quality, and offers consultancy and assistance in civil engineering and technical matters to ministries and other governmental organisations. It also cooperates with the public administration, and advises on assessing property needs, planning and acquiring property.

- **Source:** www.statsbygg.no.

Nordic Energy Research

It is an institution which operates under the auspices of the Nordic Council of Ministers. It was established as an institution in 1999 as a continuation of the Nordic Energy Research Programme, which commenced in 1985.

Nordic Energy Research aims to contribute towards promoting a common direction for research, development and information in those areas of the energy spectrum, which are of common Nordic interest. The role of Nordic Energy Research is to create Nordic Opportunities by increasing Nordic expertise and competitiveness, and advancing good coordination measures and common Nordic solutions.

Nordic Energy Research wishes to pursue the five areas of commitment:

- Integration of the energy market.
- Renewable forms of energy.
- Energy efficiency.
- The hydrogen society.
- Consequences of climate change on the energy sector.

- **Source:** www.nordicenergy.org.

Private associations and institutions

Byggemiljø

The construction industry's environmental secretariat is a collaboration between the authorities at KRD, BE and Housing Bank and building industry by Architectural Firms, RIF, BNL, Telfo and Public Construction for building, housing and more environmentally friendly construction. The site's main task is to disseminate information and knowledge about how to build and operate more environmentally friendly buildings.

- **Source:** www.byggemiljo.no.

SINTEF

The *SINTEF* Group is the largest independent research organisation in Scandinavia. Every year, *SINTEF* supports the development of 2000 or so Norwegian and overseas companies via our research and development activity. The Division Architecture and Building Technology focuses on innovations in energy use in buildings to ensure a sustainable development. Building's architectural and technical qualities represent large assets for society, companies and individuals. The department employs 20 researchers with competence in architecture, civil engineering, and HVAC. The research is divided into three main themes: Energy use in buildings, Architectural research, and Facilities Management.

They conduct evaluations and simulations, and we develop theory, methodology, and tools. This knowledge should be put to practice and be used in real life projects by engaging in many construction projects, where co-operation with architects, consultants, users, clients, and building owners is needed.

- **Source:** www.sintef.no.

Norwegian Federation of Co-operative Housing Associations (NBBL: Norske Boligbyggelags Landsforbund)

It is a national membership association representing 89 co-operative housing associations - counting 750.000 individual members and 360.000 housing units in close to 5.000 affiliated housing co-operatives.

These associations, their members, the affiliated housing co-operatives and NBBL respectively, make up the Norwegian Co-operative Housing Movement.

With a population of 4,5 million, this makes NBBL the fourth largest membership - movement in the country. Represented in all urban areas, housing co-operative homes hold a significant share of the housing market in cities. In Oslo is close to 40 % and the national average is 15 %.

- **Source:** www.nbbl.no.

SPAIN

Institutions

Public institutions

Ministry of Housing

This is the Department responsible for exercising the competences of the State's General Administration in the field of housing and land.

- **Source:** www.mviv.es.

Institute for the Diversification and Saving of Energy (IDAE)

This is a Public Corporate Entity, attached to the Ministry of Industry, Tourism and Commerce, and is in charge of jointly coordinating and managing the measures and funds destined to the 2005-2010 Renewable Energy Plan with the Autonomous Communities, in addition to conducting advertising campaigns, technical consulting, the development and financing of projects which are technologically innovative and replicable.

- **Source:** www.idae.es.

Centre of Energy, Environmental and Technology Investigations (CIEMAT)

A public research organisation dependent on the Ministry of Education and Science. The main fields it conducts are R&D activities in, in addition to nuclear energy which was the activity it was dedicated to in its origins are: other energy sources, environmental impact of energy and the development of associated technologies, basic research in the physics of particles and molecular biology.

- **Source:** www.ciemat.es.

National Renewable Energy Centre (CENER)

A Spanish national technology centre dedicated to the research, development and promotion of renewable energies in Spain.

- **Source:** www.cener.com.

Foundation for the Training in Renewable Energies (FFER/CENIFER)

An instrument to promote technical training in the field of renewable energies.

- **Source:** www.cenifer.com.

Solar Energy Institute

It is part of the Polytechnic University of Madrid and has the objective of researching the aspects associated with the development of photovoltaic solar electricity.

- **Source:** www.ies.upm.es.

Technological Institute for Renewable Energies (ITER)

Created by the Cabildo Insular of Tenerife, its objective is to promote work in the research and technological development related to the use of renewable energies, as well as other projects to improve the regional socioeconomic development of the Canary Archipelago.

- **Source:** www.iter.es.

Private associations and institutions

High Council of the College of Architects of Spain

This is the organisation which gathers all the Colleges to achieve the objectives of general common interest. It is also the organisation which represents the Colleges and the profession before the private and public corporations, and before the international organisations, and is the last resort in the corporate world (application of Professional Ethics).

- **Source:** www.cscae.com.

General Council of Technical Architecture of Spain

The Institution which gathers and coordinates the Official Colleges of Quantity Surveyors and Technical Architects and figures as the organisation which represents and defends the interests of the profession in and out of Spain.

- **Source:** www.arquitectura-tecnica.com.

Eduardo Torroja Institute for Construction Science

Belonging to the Consejo Superior de Investigaciones Científicas, it is a centre for research and scientific-technical assistance in the field of construction.

- **Source:** www.ietcc.csic.es.

Association for the Development of the Bioclimatic House

A private and independent association made up of professional and companies from different sectors who want to promote the application of bioclimatic criteria in urbanism and construction, rehabilitation and reform of houses and buildings.

- **Source:** www.casabioclimatica.com.

Institute for Bioconstruction and Renewable Energies (IBER)

A non-profit association dedicated to promoting said subjects, providing information on bioconstruction techniques, ecological materials, renewable energies, etc.

- **Source:** www.bioconstruccion.biz.

Spain Green Building Council

This is the first non-profit national organization of leading companies in the industry of construction (buildings, urbanisations, cities, public works, and spatial planning) which work together to promote that cities and buildings be environmentally responsible, profitable and healthy for the people who live and work in them.

- **Source:** www.spaingbc.org.

Institute of Construction of Castilla and León (ICCL)

Constituted as a private foundation of a scientific-cultural nature, non-profit, which wants to stress all the technical aspects which intervene in the construction process of building work, whether it be Civil, Construction or Rehabilitation.

- **Source:** www.iccl.es.

Spanish Photovoltaic Industry Association

Its main objective is to promote, credit and develop the photovoltaic sector, providing its knowledge and experience to the Spanish market and the responsible authorities at both a national and regional and local levels.

- **Source:** www.asif.org.

Thermal Industry Solar Association

Its mission is to become a meeting forum and a representative of the sector, to debate ideas and reach a consensus on acts which promote and improve the use and development of Thermal Solar Energy in the Spanish State.

- **Source:** www.asit-solar.com.

Spanish Lighting Committee

Its only main purpose is to promote all the activities related with lighting, in its most ample and varied aspects, both scientific and technical, promoting the study, the research, development and innovation, as well as methods, regulations and standardization of lighting.

- **Source:** www.ceisp.com.

SWEDEN

Institutions

Public institutions

National Board of Housing, Building and Planning (Boverket)

It is the central government authority for planning, the management of land and water resources, urban development, building and housing under the Ministry of the Environment. Boverket monitors the function of the legislative system under the Planning and Building Act and related legislation and proposes regulatory changes if necessary. To ensure effective implementation it also provides information to those engaged in planning, housing, construction and building inspection activities.

- **Source:** www.boverket.se.

Swedish Energy Agency

It works towards transforming the Swedish energy system into an ecological and economically sustainable system through guiding state capital towards the area of energy. This is done in collaboration with trade and industry, energy companies, municipalities and the research community. The Swedish Energy Agency is the national authority for energy policy issues.

- **Source:** www.energimyndigheten.se.

Lund University: Division of Energy and Building Design

Their work focuses on aims and means to create energy-efficient buildings, for example by insulating buildings well, and to utilise solar energy and daylight and to use solar shading devices to protect against unwanted solar gains. Effects of various building designs are studied regarding energy use (both for heating and cooling) and thermal and visual indoor climate.

- **Source:** www.lth.se.

The Royal Institute of Technology (KTH), School of Architecture and the Built Environment

Research and teaching is aimed at creating the best possible preconditions for sustainable society. Central components include strategic planning as well as the creation and maintenance of infrastructures for transport, water supply and other utility supply systems.

- **Source:** www.kth.se.

The Chalmers University of Technology, Gothenburg

It is a university of technology in which research and teaching are conducted on a broad front within technology, natural science and architecture.

- **Source:** www.chalmers.se.

Swedish Environmental Research Institute (IVL Svenska Miljöinstitutet)

It offers consulting focused on environmental and sustainability issues. It is the largest body of environmental competence in Sweden. IVL's services include applied research, technological development, environmental monitoring and assessments. Its focus areas are: climate and energy, sustainable building, air and transports, sustainable production, resource-efficient products, water. At present IVL coordinates different projects on low-energy houses.

- **Source:** www.ivl.se.

Private associations and institutions

Forum för Energieffektiva Byggnader

It is a forum to which you can turn for more information on bioclimatic buildings. The forum gathers market information, offers education, specify suggestions on joint regulations for low-energy houses, all to make it easier and to increase the building of more passive and low-energy houses.

- **Source:** www.energieffektivabyggnader.se.

Resurseffektiva Byggnader

This website is a platform for information to proprietors, builders and contractors to make it easier to choose energy efficient components for the buildings.

- **Source:** http://passiivitalo.vtt.fi.

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