Report on the state of the art in bioclimatic architecture and integration of renewable energies in buildings

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1 REGULATIONS

1.1 Spanish Regulations

Normas Básicas de la Edificación:[1] Condiciones Térmicas de los Edificios (NBE-CT-79)[2]

Through Decree 1490/75, of 12 June, the public Administration took the first measures aiming at the achieving of energy saving by means of an adequate construction of buildings, thus tackling with the problems derived from the rise in the price of energy.

NBE-CT-79 replaced the former Decree (except for articles 6 and 7, fluids' insulation and regulation of installations, which remained in force). This regulation was approved through **Royal Decree 2429/79** of 6 July 1979.

Regulations from year 79 set the thermal conditions required of buildings, as well as the determining features, and defined as application field all kind of completely new buildings, except the ones that, due to their use, should remain open.

Apart from principles aiming at energy saving, the mentioned regulations included other thermal or hygrothermal aspects that affect buildings and their habitability conditions, stressing subjects that had no been regulated before, such condensation phenomena in the building envelope that affect to the building users comfort.

For this NBE purposes, building are thermally defined by the following concepts:
a) Global heat transmission through the whole of the building envelope, defined by its K_G factor.
b) Heat transmission through each of the elements that make up the building envelope, defined by their K factors.
c) Higrothermal performance of envelopes.
d) Air permeability of envelopes.

This regulation forced to meet a number of requirements and conditions, such as:

- That the global thermal factor K_G of a building cannot be higher that a given value, that will be set according to the factor of the climate zone of the site and the type of energy used in the heating system.
- That the K thermal transmission usable factors of envelopes, excluding the spaces, do not rise over certain values, given by the envelope and the climate zone.
- That the thermal resistance and the constructive layout of the envelope elements be such that in the environmental conditions considered by the Regulation, the envelope will not show condensation humidities neither in its interior surface, nor within the envelope mass, that damage its conditions, nor occasional ones that might damage other elements.

[1] *Basic Building Regulations N.B.E*
[2] *Buildings' Thermal Conditions NBE-CT-89*

- It considers as interior environment conditions the use ones, and the exterior conditions are classified according to two climate zones: one based in 15-15 degrees/day data and, the other, in minimum temperatures in the month of January.
- It considers ground temperature according to climate zones and forces to considerate 95% external relative humidity in order to make the calculations.
- It sets the air permeability of a carpentry frame defined by its class of air tightness. According climate zones, the carpentry should be of a given class.

Reglamento de instalaciones de calefacción, climatización y A.C.S[3]

This regulation was approved by **Royal Decree 1618/80** of 4 July (B.O.E. 06-08-80) and came up due to the importance that non industrial thermal installations was reaching and its increase as a result of the increase of the Spanish standard of living. These facts recommended a global administrative action on the sector, aiming at rationalizing the energy consumption, without decreasing the users 'comfort'.

As energy saving issues are closely linked to pollution, quality and safety issues in heating, air conditioning and domestic water heating, and not having a basic regulation about them, it was necessary to draw regulations that set the required rules to get rational energy consumptions, setting at the same time quality, safety levels and defence of the environment measures in those installations.

The object of the present regulation was to define the conditions for installations that use energy with non industrial aims in order to achieve a rational use of the energy, taking into account its quality and safety and the protection of the environment. The systems installed in air, maritime or terrestrial transport means were excluded of these regulations, as they will be regulated by special arrangements.

Among the different requirements stated in the regulations, there are references to additional technical instructions that should be comply with by non industrial thermal installations and will be developed later on.

The regulation also includes the creation of the '*Comisión Permanente para el Ahorro de Energía en Instalaciones Térmicas de la Edificación*'[4] , whose missions are as follows:

a) the study and gathering of new technological advances in energy saving in installations regarded by this regulation, channeling the relevant proposals made by manufacturers, installers, designers, users, maintenance and repairer technicians.
b) to study and propose new technical instructions and improvement of the existing ones when appropriate.
c) to inform of the proposals made about the 'technical recommendations' mentioned in article eight.
d) to analize the obtained results after applying the regulations, proposing the correcting measures where considered appropriate.

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3 *Regulations for heating, air conditioning and hot domestic water installations.*
4 *Permanent Commission for Energy Saving in Thermal Installations in Buildings*

e) to carry out all the research or works commissioned by their superiors.

Instrucciones Técnicas Complementarias I.T.I.C.[5]

The *Instrucciones Técnicas Complementarias* were approved by **Ministry Order of 16 July 1981** (BOE Nº 193, de 13.8.1981), according to the decreed in the *Reglamento de Instalaciones Calefacción, Climatización y Agua Caliente Sanitaria*, with the aim to racionalize its energy consumption.

The regulations comprise the basic regulations of more general and permanent nature, whereas the technical additional instructions comprise the regulations applicable in the present to the aforementioned installations, with the fundamental object of gaining energy savings, and can be reviewed in the future due to the need to be adapted to the development and evolution of technologies.

Reglamento de Instalaciones Térmicas en los Edificios (RITE)[6]

The *Reglamento de Instalaciones de Calefacción, Climatización y Agua Caliente Sanitaria*, approved by Royal Decree 1618/1980, contributed to a great extent to foster and impulse a more rational use of energy in non industrial thermal installations in buildings, generally used to supply in a safe and efficient way with heating, air conditioning and hot domestic water services to meet the needs of thermal comfort and hygiene in buildings.

The experience adquired from its implementation, the technological advances in this field, the new distribution of powers as a result of the State of Autonomous Regions development and, finally, the membership of Spain to the European Union made the drawing of a new regulation necessary, one that based on the previous one, took into consideration the existing factors and continued the advance in the rational use policy established in the *Plan de Ahorro y Eficiencia Energética* [7] included in the *Plan Energético Nacional* [8] 1991-2000.

As a result of adopting different Community provisions in the field of free circulation of goods as well as in the field of rational use of energy and the reduction of carbon dioxide emmissions, it was also necessary to modify the existing regulations to take into account the following Directives of the Council:

- 89/106/EEC on building products
- 92/42/EEC on performance requirements for new hot water boilers fed with liquid and gas fuels.
- 93/76/EEC related to the limitation in carbon dioxide emmissions by means of improving energy performance (SAVE)

[5] *Additional Technical Instructions I.T.I.C*
[6] *Regulation of Thermal Installations in Buildings* (RITE)
[7] *Energy Saving and Efficiency Plan.*
[8] *National Energy Plan.*

The reach of the changes made on the regulations text in force and its additional technical instruccions, both in form and content, recommended to draw a new text to repeal and replace the former one and the developing additional technical instructions. This new text was approved by **Royal Decree 1751/98** of 31 July, that approved the *Reglamento de Instalaciones Térmicas en los Edificios (RITE)* and its *Instrucciones Técnicas Complementarias (ITE)* while creating the *Comisión Asesora para las Instalaciones Térmicas de los Edificios*[9].

The *Comisión Asesora para las Instalaciones Térmicas de los Edificios*, that takes the place of the *Comisión Permanente para el Ahorro de Energía en Instalaciones Térmicas de la Edificación*, will be a standing voting body with the specific mission of advising in issues related to thermal installations in buildings by means of the following actions:

b) To study and propose new technical instructions and review of the existing ones when appropriate.
b) To estudy and collect, when appropriate, the new technical advances in rational use of energy, proposing the adequate changes to the Ministries of Industry, Energy and Public Works and Building, channeling the related suggestions made by public administrations, manufacturers, designers, installers, users and energy maintenance technicians and suppliers.
c) To study international actions on the issue and, particularly, the ones coming from the European Union, proposing the appropriate actions.
d) To analize the obtained results by applying the regulations, proposing the measures and criteria for right interpretation and homogeneous implementation where considered appropriate.

Ley de Ordenación de la Edificación[10] (L.O.E)

Law 38/1999 of 5 November 1999, L.O.E, was conceived in view of the lack of legal bases for building construction, which was mainly regulated by the Civil Code and a variety of regulations that, as a whole, had many gaps in planning the complex process of building, so much in issues related to identification, obligations and risponsibilities of the involved actors as in reference to guarantees to protect the user.

Also, society demanded more and more quality in buildings and that had repercussions on the structural safety and protection against fire as well as on other aspects linked to people's comfort such as protections against noise, thermal insulation or accesibility for people with limited mobility.

The top priority of the LOE was to regulate the building process, updating and completing the legal configuration of the participant agents, setting their obligations in order to establish risponsibilities and cover the users' guarantees by defining the basic requirements for buildings to be complied with.

[9] *Advisory Commission for Thermal Installations in Buildings.*
[10] *Building Planning Law (L.O.E)*

To do so, the building legal concept and the basic principles that should lead this activity were defined and the scope of the Law was delimited, specifying the works both completely new buildings and existing ones to which it would apply.

The Law set the basic requirements that buildings should meet, in a way that users' guarantees would not only be based on technical building requirements but also in the establisment of a caution or safety insurance.

These requirements cover so much building functional nature and safecty aspects as those relative to habitability.

Código Técnico de la Edificación[11] (CTE)

The *Código Técnico de la Edificación* stands as a new structured regulation frame that identifies, arranges and completes the existing technical regulations, pretending to facilitate its aplication and fulfilment, and all that in harmony with European regulations. It was approved on 17 May 2006 by **Royal Decree 314/2006**, and published on BOE of 28 March.

The *Código Técnico de la Edificación* enforces the basic requirements in building set by *Ley de Ordenación de la Edificación*, aiming at guaranteeing people's safety, society comfort, sustainability of building and the environment safeguard.

The approval of the *Código Técnico de la Edificación* means the improvement and updating of the building regulation frame in Spain present at the time, regulated by Royal decree 1650/1977 of 10 June, on building regulations, that implemented the *Normas Básicas de la Edificación* as mandatory in building projects and works. Within this legal frame, several regulations were approved since 1979, which made up an open group cf dispositions that has been meeting different society requirements, but that never got to be a coordinated body in the form of a Technical Building Regulation, similar to the ones existing in other more advanced countries.

With the aim to improve building quality and to promote innovation and sustainability, the CTE sets the basic quality requirements for buildings and installations. By means of this regulation, certain basic building requirements related to people safety and comfort are met. These requirements refer to structural safety and protection against fire as well as healthiness, protection against noise, energy saving or accesibility for people with limited mobility.

Also, the *Código Técnico de la Edificación* creates an equivalent regulation frame to the existent in more advanced countries and levels the national building regulations existent with the current European regulations in this issue. Firstable, with the regulations related to free circulation of building products inside an only European market. Secondly, Directive 2002/91/CE of European Parliament and Council, of 16 December, relative to energy performance in buildings has to be taken into account as it was used to add to the

[11] *Technical Building Regulations (CTE)*

Código Técnico de la Edificación the requirements relative to energy performance in buildings set by that Directive in articles 4,5 and 6.

The *Código Técnico de la Edificación* is divided in two parts, both of them regulatory. The first one comprises the general dispositions (implementation scope, uses classification, etc.) and the requirements buildings have to comply with to meet the building safety and habitability requirements.

The second part is formed by the Basic Documents, whose adequate implementation ensures the achievement of the basic requirements. Those comprise procedures, technical codes and solution examples that permit determine whether the building cumplies with the established standards of service. Those Documents are not excluding. The *Documentos Reconocidos* were created as a complement for the implementation of the Código, those being technical documents, external and independent from the Código, whose use facilitates the compliance of some demands and contribute to the increase of building quality.

Basic Document '*DB-HE Ahorro de Energía*'[12] especifies the objective parameters and the procedures whose compliance ensures the meeting of basic requirements and the overcoming of the minimum quality standard inherent to the basic requirement of energy saving.

1.2 Swedish Regulations

Regulations set by the National Board of Housing, Building and Planning – BBR 2006

On 1 July 2006, the new Swedish regulation on dwellings came into force (*BBR 2006*). In short, this is what the regulation stipulates about energy demand (the regulation also deals with design, durability, fire protection, hygiene and health, environmental aspects, and noise):

For residential buildings, the energy demand must not exceed 110 kWh per m^2 floor area (A_{temp}) in the south of Sweden and 130 kWh per m^2 in the northern part of the country. For residential houses with electric radiators the energy demand must not exceed 75 kWh per m^2 floor area (A_{temp}) in the south of Sweden and 95 kWh per m^2 in the northern part. A_{temp} is the floor area of spaces aimed for heating to more than 10 ^oC. The garage is not taken into account as a part of the floor area. The energy demand may be reduced with energy from solar panels and photovoltaic cells integrated in the building. The highest average u-value for the surrounding building parts must not exceed 0.50 W/m^2K.

For other premises than residential, the specific energy demand must not exceed 100 kWh per m^2 floorarea (A_{temp}) in the south of Sweden and 120 kWh per m^2 in the northern part of the country. Premises with an airflow larger than 0.35 $l/s,m^2$ may add the equivalent of 70(q-0.35) kWh per m^2 floor area (A_{temp})in the south of Sweden and 90(q-0.35) kWh per m^2 floor area in the northern part, where q is the mean air flow for the heating season in $l/s,m^2$. The energy demand may be reduced with energy from solar

[12] *'DB-HE Energy Saving'*

panels and photovoltaic cells integrated in the building. Garages are not taken into account as a part of the floor area (if not a building on its own). The highest average u-value for the surrounding building parts must not exceed 0.70 W/m^{2}K.

For buildings containing both residential spaces and other premises, the regulations are based in proportion to the floor area.

For buildings where the floor area (A_{temp}) is less than 100 m^2, the window and door areas are less than 0.20 A_{temp}, and where there is no demand for cooling; some alternative regulations may be used.

Maximum u-values for the building parts:
U_{roof} 0.13 W/m^{2}K
U_{wall} 0.18 W/m^{2}K
U_{floor} 0.15 W/m^{2}K
U_{window} 1.3 W/m^{2}K
U_{door} 1.3 W/m^{2}K

For residential houses with electric radiators the following maximum u-values for the different building parts must not be exceeded:
U_{roof} 0.08 W/m^{2}K
U_{wall} 0.10 W/m^{2}K
U_{floor} 0.10 W/m^{2}K
U_{window} 1.1 W/m^{2}K
U_{door} 1.1 W/m^{2}K

The average air leakage at +50 Pa must not exceed 0.6 l/s m^2.

If the floor area (A_{temp}) is more than 60m^2, the building must have a ventilation system with heat recovery of 70 % efficiency or a heat pump in the outgoing air.

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 has been taken into consideration but adjusted to the Nordic climate.

Apart from the basic requirements described in BBR 2006 above, the requirements for a *passivhus* is very restrictive for the total use of bought energy (household demand, hot water, heating and cooling). A_{temp} is defined in the same way as in *BBR 2006* (the floor area of spaces aimed for heating to more than 10 ^{o}C).

Maximum output for the building is P_{max} = 10 W/m^2 in the south and P_{max} = 14 W/m^2 in the north of Sweden. The indoor temperature is specified at 20 ^{o}C and heat from persons and household appliances of 4 W/m^2 may be included. For buildings less that 200 m^2 the maximum output is allowed to be 2 W/m^2 higher.

Maximum energy demand (excluding electricity for household appliances), is set at 45 kWh/m^2 in the south of Sweden, and 55 kWh/m^2 in the northern part. For buildings less that 200 m^2 the maximum energy demand is allowed to be 10 kWh/m^2 higher than above.

The use of hot water is presumed to be 20% less than the standard use.

The average air leakage at +/-50 Pa must not exceed 0.3 l/s m^2.

To be able to verify the energy demand for household appliances and heating, the energy use is to be monitored separately on a monthly basis. The hot and cold water use is also to be monitored. The maximum allowed u-value for the windows is 0.9 W/m^2K.

2 REFERENCES

2.1 Denmark

2.1.1 Bioclimatic Buildings

Skotteparken

Skotteparken in Egebjerggård, Ballerup, is an EU Thermie supported experimental building project with 100 solar heating - low-energy dwellings, where the aim is to reduce the gas consumption for heating and domestic hot water with 60% compared to normal building projects. And at the same time reduce the consumption of electricity and water. The apartments in Skotteparken were already built in 1992.

Ballerup is situated 15 kilometres from the capital of Denmark, København, straddling the border between greater København and the countryside. The municipality of Ballerup is the home for approximately 45,000 inhabitants.

The basis for the project was that extra investments in energy saving measures of approx. 8% of the normal building costs should be corresponded to by savings on the operation, especially as regards expenses for heating, water and electricity. 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 in Skotteparken are as follows:

- Extra insulation, which is mostly added in the ceilings with a total thickness of 375 mm. The apartments are aimed airtight making the natural air change as low as 0.1 times per hour
- Thermo glazing is used everywhere with two layer windows with an air gap of 15 mm. The windows have a U-value of approximately 1.4 W/m2K.
- Ventilation system with counter-flow, heat recovery is utilised 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 collector 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 armatures in showers and two-step water saving armatures in kitchens and bathrooms
- Electricity savings
- Rain water from roofs and streets is via open drains carried to a small lake to help maintaining the ground water.

The most innovative aspect are the six, solar heating systems with approximately 100 m^2 of solar collector 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 the summertime. 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.

The results from a finalised monitoring campaign documents 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 m^2 solar collector area in all shows an annual solar heating yield in a normal year of 274 kWh per m^2 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 m^2 solar collector. 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.

The main results for the project in Skotteparken can be summarised as follows:

- The normal amount of energy used for heating and hot water has been reduced of 180 kWh/m2 (normal housing) to 92 kWh/m2 in 1993, to 82 kWh/m2 in 1994, reaching 77 kWh/m2 in 1995.
- 65 % savings of district heating network losses was obtained from the low temperature pulse operation.
- Solar system yields 274 kWh/m2 (which corresponds to 382 kWh/m2 when including saved network losses).
- Heating bills only 4.42 Euro/m2 which equals approximately 40 % of a "normal" heat bill.
- A good economic saving for the tenants based on an extra investment of approximately 8% compared to normal housing and grants from external sources.

Source:

Combined low and solar energy design in Egebjerggård, Denmark; Peder Vejsig Pedersen
SOLAR DISTRICT HEATING – BALLERUP (Denmark); Miljø Afdelingen; Peder Vejsig Pedersen

2.2 Spain

2.2.1 Bioclimatic buildings

CENER Building

This building is located in the City of Innovation, in Sarriguren, Navarre, and it is the headquarters of the *Centro Nacional de Energías Renovables (CENER)*[13], Centre of research and Technology that fosters the technological development of Renewable Energies. Its area is about 5,000 square metres.

The building was designed taking into account the most advanced bioclimatic and environmental criteria for energy saving and environmental care. It has both active and pasive architectural elements, being the outstanding ones:

- Active: Vacuum tube thermal collectors for domestic water heating, and for radiant floor (absorption system) heating and cooling, radiant floor heat/cold; awning, shutters, windows and ventilation automatisms.
- Pasive: Balcony-greenhouse for solar capture for heating; high inertia walls and framing; chimney for ventilation in summer; lower ground floor effect; insulating shutter; sun shading awnings; wind tower to capture north wind and plant cover.

Out of the pasive architectural elements, is worth mentioning the bioclimatic balcony, called 'bioclimatic device', that is located in the upper part of the pavillions where the research ares of the Centre are located. From the environmental point of view, it gives the building the maximum bioclimatic advantage out of solar and wind energy: it collects, transforms, storages and distributes the energy along the respective pavillions. In this balcony there are also integrated most of the active environmental protection means and the cooling effects of the plant covers.

On the other hand, and inside the premises, there are two features that outstand due to their non conventional make, as they include energy saving and sustainability criteria:

- Heat/cold generation: The system is based on absorption cycle, feeding the generator with high temperature water (around 100º C) that comes from the vacuum solar collectors integrated in the building roofs, backed by natural gas boilers.
- Watering system: All plant covers in the building are equipped with a trickle irrigation system (minimum consumption), getting the water out of a tank that collects all the rainwater so, both the rainwater plus the possible remaining water

[13] *National Centre of Renewable Energies (CENER)*

that does not evaporates from the trickle irrigation system will be use for watering in the building.

As for the building materials, the option was not to use reusable or biodegradable elements, choosing those more efficient from the technical and energy point of view.

CENIFER Building

This is a 400 square metre building, located in Imarcoain (Navarre), that belongs to the *Centro Integrado Nacional de Formación en Energías Renovables CENIFER*[14], that is used as demonstrative building, reception building, to impart training, as a conference hall, as training bench for students, apart from the research made by the teachers at the Centre.

It has all type of active and pasive installations to reach an energy balance close to zero: solar thermal installation; water tank to store energy between seasons; heating and cooling through radiant floor and wall; solar photovoltaic installation grid connected; greenhouse with direct solar capture and ventilation; Trombe wall; external insulation of building envelope with ventilated façade; well water cooling and forced ventilation with thermosolar shunt.

Each of the architectural elements and installations used are explained below:

Architectural elements

The **general building envelope** consists of a ventilated façade with high inner thermal energy, made up by five elements:

- External coating made out of ceramic tiles
- 3 cm ventilated chamber
- Thermal insulation made out of 8 cm rockwool.
- High thermal inertia inner wall
- Radiant strip heater

This envelope is completed with inner flooring with radiant floor and a flat trafficable roof that serves as a platform to the pergola that holds the solar thermal and photovoltaic panels.

Among the building pasive solar energy systems, is worth mentioning the **greenhouse**. In summertime, the capturing cover is protected with a system of motor operated slatted shutters, placed inside the external window framing. The upper and lower hatches, motor operated and automatic, open to get a forced ventilation to refresh the air, avoiding the inside to get hot with the air. In winter, the radiation that gets inside the greenhouse is absorbed inside, becoming heat that gets stored in floor and walls, from where is transmitted inside the building through radiation. At the same time, the air inside the greenhouse becomes hot and gets into the building through forced convection by means of some fans located in its upper side. The greenhouse's floor and wall, with a substantial thermal inertia, absorb radiation, storing thermal energy and giving it to the air with delay

[14] *Integrated National Centre for Training in Renewable Energies CENIFER*

and absorption, through convection and long wave, what minimizes losses through the glazing.
It has an estimated thermal output of 10,800 Kwh in winter and 14,245 Kwh both in spring and autumn.

The **Trombe wall** is other of the used pasive systems. It is formed by a glazing wall placed next to a double massive wall that has a little internal ventilated chamber. The solar radiation that reaches the wall and goes through the glazing, heats the external wall, which is painted in a matt dark colour. In turn, this wall heats the inner wall and the circulating air in the chamber between them through radiation. This chamber has automatic hatches and fans.

In summer, these hatches open the chamber to the exterior, getting forced ventilation that avoids the heat getting inside. In winter, the hatches open the internal chamber to the inside of the building, allowing the entrance of hot air. It has a thermal output of 4,970 Kwh in winter and 6,500 Kwh both in spring and autumn. The annual saving in emmissions is 33 kg of SO_2, 10 kg NOx and 2,640 kg CO_2.

The **solar thermal shunt** is for exclusive winter use. It refreshes the inside of the building by means of forced ventilation coming from a shaded landscaped area in the North side of the building. The air is introduced from there through four ceramic conducts, using fans to force ventilation Those conducts are buried at 1.8 m depth and go up to the south façade, where they come into the interior, the air going up towards the roofing shunt as it gets warmer. It has a cooling output of 2,838,000 frigories in summer. The annual saving in emmissions is 6,8 kg of SO2, 2 kg NOx and 545 kg CO2.

Installations

The **solar thermal installation** is made up by 24 2.5 sq.m. useful area panels, located on the building roof and south orientated with a 50º tilt. This way, they make the most of solar radiation to warm the heat transmitting fluid that circulates inside them. They meet 100% of domestic hot water needs and 44% of heating ones. The annual saving in emmissions is 102 kg of SO2, 32 kg NOx and 8.251 kg CO2.

The **big storage tank**, built under the greenhouse, has the function of storing the excedent energy from the solar thermal panels to be used in the heating circuit in days with low solar radiation. It has 40,000 l. capacity, made out of stainless steel and has a perimeter covering of 30 cm of granulated cork that acts as insulation. This extra insulation provides an energy saving estimated in 18%.

The **radiant floor and strip** is made up of a series of reticulated polystyrene conducts, fitted into the floor and wall strips, inside of which circulates water. They absorb heat in summer in the cool well water that circulates inside them, and in winter they release heat through the hot circulating water that comes from the storage tank and has been heated by the solar thermal panels. These radiators can transmit 35,000 kcal/h. The energy saving in this low temperature radiation system compared to the common convection radiators is 23%.

A system based on **cooling through sensor**, which uses subsoil water, floor system water and radiant strip is used to cool the building in summer. The system works with an immersion pump that placed at 8 m depth inside a well in the north face of the building, pumps the water to the radiant elements, circulating along them and returning to phreatic level.
The absorption capacity of this element is 15,000 frigories/h. This system annual saving in emmissions is 3 kg of SO_2, 1 kg NO_x and 248 kg CO_2.

There is a 5 Kw grid connected **solar photovoltaic system** installed in the building. It consists of 68 monocrystalline photovoltaic panels of 80 Wp, placed in the building roof and orientated to south with 30º tilt and 2 2.5 Kw inverters.
The estimated annual output is 7,440 Kwh (20.38 Kwh average daily output). Those outputs intend to meet the building energy consumption. The annual saving in emmissions is 15 kg of SO_2, 4,8 kg NO_x and 1.228 kg CO_2.

2.2.2 Eco-cities

Residencial Parque Goya

In 1995, the *Dirección General de Obras Públicas y Urbanismo del Gobierno de Aragón* y el *Instituto del Suelo y de la Vivienda de Aragón (ISVA)* started to develop a Partial Plan in a 53.7 Ha area in the north of the city of Zaragoza.

The objective was to promote 3,500 officially protected housing and to reduce CO_2 emmissions as specific aim, considering the European Directive 93/76/CEE. The development and building design according to the architectural criteria included in the Partial Plan would account for a potential 60% decrease in the buildings energy demands (heating, cooling, domestic hot water and lighting) compared to the values given by complying with the regulations and a little lower respect to the usual typology of the area.

As a novelty respect to any other previous town planning activity, the Partial Plan of Residencial Parque Goya had some specific clauses in regulating bylaws related to bioclimatic determining factors of buildings.

This action was funded by the European Commission with a Thermie Project (n. BU 178/95) that affected to three buildings in the first stage: parcels P-4 (178 flats), P-11 (50 flats) y PU-9 (26 houses).

Key features

Some of the mandatory concepts in the Partial Plan town planning design or in the Terms and Specifications corcerning all buildings in Parque Residencial Goya are:

- Street orientation, buildings' distribution and heights to favour solar radiation capture in south facing façades.
- Higher insulation than required by regulations (<25%).
- 50% or higher glazing in south façades, with optional glazed balconies, and minimum in north façades.
- Carpentry framing of better quality than required by regulations.
- Plenty of green areas, areas of water and adequately coloured materials.

In the three buildings selected by Project Thermie, the mainly used elements are:

- Use of greenhouse-balconies with thermal load walls.
- Insulation higher than usual, double glazing and top quality carpentry framing regarding infiltrations.
- Collective auxiliary systems with low temperature boilers (high efficiency) or condensation ones and solar thermal collectors.
- Individualized control of heating and domestic hot water consumption.

Location

The residential neighbourghood Parque Goya is located in the city of Zaragoza, capital of the Autonomous Region of Aragón, situated in the centre of the Ebro Valley, 41º39' north latitude.

The climate is Mediterranean, eventhough it has strong continental influences, as it can be seen by the extreme temperatures: high temperatures in summer and low in winter, with NW-NWW winds (*cierzo*) that increase the feeling of discomfort.

The most characteristic climate variables of the zone can be seen in the table below:

Month	Average daily temperature (ºC)	Horizontal solar radiation (MJ/m^2 day)	Vertical solar radiationsouth (MJ/m2 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

Table 1: Climate variables. Data obtained from *Atlas de Radiación Solar de Aragón* and from *Datos Climáticos de Aragón.*

Description

The selected buildings for specific actions represent the three typologies existing in the development (semi-detached hoses PU-9, collective buildings with double corridor P-4 or quadruple corridor P-11).

Insulation and thermal inertia

After the initial studies, the town planning project established as a specific regulation that the insulation value should be 25% higher than defined in the current regulations.

The table below show the U values (W/sq.m.K) corresponding to each building external envelope respect to the values required by Spanish regulations.

U-conductance (W/sq.m.K)	National regulations (NBE-CT-79)	Building P-4 (178 flats)	Building P-11 (50 flats)	Building PU-9 (26 semi-det)
External wall	1,6	0,44	0,64	0,39
Mass walls	1,8	0,88	1,47	1,47
Roofing	1,2	0,22	0,33	0,28
External framing	1,4	0,26	0,42	0,86
South and east windows	5,8	3,3	3,3	3,3
North and east windows	5,8	2,6	2,6	3,3

Thermal bridges in pillars and girders were eliminated through external insulation in order to reduce energy losses. Also, double window framing has been used in façades N and W to reduce transmission or infiltration losses in those façades, affected by the dominant wind, the '*Cierzo*' which can reach high speeds.

The buildings have a high thermal inertia, reinforced in the most compact ones (building P-11), lower in building P-4 and clearly lower in the semi-detached houses. The inertia has been increased by placing the insulation in the external side of the envelope, the roofing and ground floor framing. Also, materials with high inertia were used, such as Airblock (19 cm in P-11) and Termoarcilla (19 cm in P-4 and PU-9).

With this features, the buildings experience slight fluctuations of interior temperature at night, when the auxiliary heating is off. All the same, with night ventilation, the inertia allows to reduce maximum day temperature in a way that most of the time, it remains within comfort conditions.

Solar gain

The buildings' main façade are south orientated with no shadings in winter. This was done all through the development. The area of glazing was increased in all south façades, making also greenhouses with no preheated air. To increase the captation effect and make the most of the captation delay in greenhouses, mass walls were used (29 cm blocks filled with sand and concrete or 19 cm termoarcilla —thermal clay— blocks). The glazing area was reduced in façades east, west and north, as solar captation is very low (N) or can generate overheating in summer (E, W). The inside distribution of the houses leaves the south for living areas, while kitchen, bathrooms and stairs are placed north.

The overheating due to solar captation in summer gets reduced by eaves or mobile elements (shutters). Also, the distribution of the house allows natural ventilation, very convenient in summer nights. The use of clear colour pavement, landscaped areas with gardens and trees also improves comfort in summer, reducing the overheating effect in streets.

Heating and solar collector

The heating system used (low temperature boilers) in each of the three buildings is collective, being more efficient than individual heating systems.

The total installed collector surface in the development in its first stage was 600 sq.m.

Technical results

The three selected buildings were monitored during two years. The interior temperatures of north and south rooms, the greenhouses and the inner temperature of especially built walls were specifically measured. Humidity in the south zone and heating consumption in the houses were also measured. All these parameters were recorded each 10 minutes. The number of monitored houses was 9 in block P-4, 12 in block P-11 and 6 in PU-9.

Starting from consumption and monitored temperatures in the houses, the consumptions were extrapolated to a common scale to get identical interior temperatures (20º C). That was how results showed in table 2 were obtained.

Average annual consumption in kwh/sq.m	2000-2001	2001-2002
P-4 (178 flats, mostly south oriented)	20	21
P-11 (50 flats, 16 out of them facing north)	35	32,5
PU-9 (26 semi-detached houses, south oriented)	48	41

Table 2: Results of unitary heating consumption in the three buildings

2.3 Sweden

2.3.1 Bioclimatic buildings

Lindås

In Lindås, 20 km south of Gothenburg, 20 low-energy terraced houses have been built. 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. Big windows facing south are combined with balconies and roof overhang to shield from too much sun and high temperatures during summer. A roof window gives light also to the middle of the house and can be used to air the house on hot summer days.

The energy-saving features of Lindås are as follows:

- Extra insulation
- **External wall**:
  U-value 0.10 W/m^{2}K
  Bolt wall with 43 cm isolation.
- **External roof**:
  U-value: 0.08 W/m^{2}K
  Masonite balk med 48 cm isolation.
- **Floor**:
  U-value: 0.09 W/m^{2}K
  concrete board with 25 cm isolation.
- **Windows**:
  U-value: 0.85 W/m^{2}K
  Three glass with two metal layers and krypton gas.
- **Doors**:
  U-value: 0.80 W/m^{2}K

- a ventilation system with counter-flow heat recovery of 85 % efficiency

- 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.

The residents moved into their terraced houses in 2001. The majority of the residents are content with the temperature of 20-23 ^{o}C. 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.

http://www.egnahem-goteborg.se/prod/egnahems/dalis2.nsf/535e371e7fd657aec1256a5c0045675f/6280a39fe9d3eb4fc125710f00586292!OpenDocument

Glumslöv, Landskrona

In Glumslöv north of Landskrona lies 35 terraced houses built in 2004. Fully developed and reliable techniques have been used in these dwellings. In a ventilation system with counter-flow heat recovery of 85 % efficiency the incoming air is heated with the outgoing air. The very limited space heating demand is covered by electric resistance heating, 700 W, in the supply air. The total energy demand is calculated as approximately 50-60 kWh/m^2.

U-values for the dwellings:
Windows = 0.9 – 1.0
External walls = 0.10
External Roof = 0.08
Floor = 0.10

http://www.husutanvarmesystem.se/intelligens/sites/reby/filer/T28-C-brochure_Landskrona_SE.pdf

Oxtorget, Värnamo

In Värnamo, 40 apartments with a very low energy need stood ready in 2006. The houses have extra insulation; windows and doors have a low u-value; and balconies and roof overhang protect from too much sun during summer months. 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. 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.

U-values for the dwellings:
Windows = 0.85
External walls = 0.10
External roof = 0.08
Doors = 0.6
Floor = 0.09

http://www.oxtorget.se/eng/index.htm

Frillesås, Kungsbacka

In Kungsbacka, three low-energy dwellings with12 apartments were built in 2006. Roof, walls, windows, doors and floor have a very low u-value. A ventilation system with an

efficient counter-flow heat recovery diminishes the heating demand. Hot water comes from solar panels and district heating.

Lidköping

In Lidköping, a detached house is soon ready for the residents to move into. This is the first low-energy detached house to be built in Sweden. The house is highly isolated and has a ventilation system with an 85 % efficient counter-flow heat recovery. Hot water is heated by district heating. As a back-up, district heating can be used to heat the incoming air in the ventilation system.

U-values for the dwellings:
Windows = 0.85
External walls = 0.09
External roof = 0.07
Doors = 1.0
Floor = 0.1

http://www.tellus.tv/passivhus/

Brogården, Allingsås

These houses, containing 200 apartments, were built in 1970. Now, when it is time for major renovation of the houses, the insulation and heating system will be improved so that the energy demand will be reduced from 216 kWh/m^2 to 92 kWh/m^2. Solar panels and district heating will provide for hot water and the extra heating needed during cold winter days.

U-values for the dwellings:
Windows = 0.8
External walls = 0.14
External roof = 0.10
Doors = 1.0
Floor = 0.25

http://www.alingsashem.se/CM/Templates/Article/general.aspx?cmguid=2d63f1cc-805d-47b1-bdc3-97d355557435d

Hamnhuset, Älvstranden in Gothenburg

This proposed 116 apartment dwelling will be highly isolated with efficient heat recovery in both ventilation system and drain. Solar panels will count for hot water and district heating will be installed as a back-up for heating and hot water. Energy demand is calculated to be 27 kWh/m^2 for heating and hot water and 30 kWh/m^2 for electricity.

Misteröd, Uddevalla

In Uddevalla, 12 terraced houses with 27 apartments are being built.

Storfors, Filipstad

Proposed low-energy school building.

3 TECHNOLOGY: TECHNICAL DATA

Examples

3.1 Passive solar energy

3.2 Trombe walls

3.3 Natural cooling

3.4 District Heating

4 INSTITUTIONS

4.1 Denmark

4.1.1 Public Institutions

SBi is the Danish national building research institute 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.

The Danish Technological Institute 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.

Technical university of Denmark; www.ibe.dtu.dk

4.1.2 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
www.dcue.dk

Business network passive houses, a network of several researchers, consultants and companies discussing and exchanging knowledge within the field of passive houses.
www.passivhus.aau.dk

Local Agenda 21; municipal LA21 coordinators is organised 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.

LØB - Landsforeningen Økologisk Byggeri / National association for Ecological building activities
www.lob.dk

4.2 Spanish Institutions

4.2.1 Public Institutions

The *Ministerio de Vivienda*[15] is the Department risponsible of exert the competences corresponding to the General State Administration in housing and ground issues.

[15] *Ministry of Housing*

www.mviv.es

The *Instituto para la Diversificación y Ahorro de la Energía IDAE*[16] is a Public Managerial Entity, assigned to the Ministry of Industry, Turism and Commerce, whose function is to coordinate and manage together with the Autonomous Regions the measures and funding dedicated to the Action Plan 2005-2007 and the Saving and Energy Efficiency Strategy for Spain and the Plan of Renewable Energies 2005-2010, apart from carrying out dissemination actions, technical advice, development and funding of technological innovation projects that can be repeated.

The *Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas CIEMAT* is a research public body, depending on the Ministry of Education and Science. The main fields for its R&D activities, apart from nuclear energy, that was its original activity in the beginning, are: other energy sources, environmental impact of energy and development of associated technologies, basic reseach in particle physics and molecular biology.
www.ciemat.es

The *Centro Nacional de Energías Renovables* CENER, is a national technological centre dedicated to research, development and promotion of renewable energies in Spain.
www.cener.com

The *Instituto de Energía Solar* is part of the *Universidad Politécnica de Madrid,* being its objective the research of associated aspects to the development of solar photovoltaic electricity.

The *Instituto Tecnológico de Energías Renovables ITER,* created by the Cabildo Insular de Tenerife, has the objective of promote projects of research and technological development related to the use of renewable energies, as well as other projects for the improvement of the regional social and economic development of the Canary Islands.

4.2.2 Private Associations and Institutions

The *Consejo Superior de los Colegios de Arquitectos de España* is the institution that gathers all the Architects Professional Association in order to achieve the general common interest aims. It is also the representing body for Professional Associations and the profession to the public and private corporations, and to international bodies, and the last authority to appeal to via corporation (application of professional Deontology).
www.cscae.com

The *Consejo General de la Arquitectura Técnica de España* is the institution which gathers and coordinates all the Official Professional Associations of Technical Architects and that becomes the body that represents and defends the interests of the profession, in Spain and abroad.
www.arquitectura-tecnica.com

[16] *Institute of Energy Diversification and Saving IDAE*

The *Instituto de Ciencias de la Construcción Eduardo Torroja,* that belongs to the *Consejo Superior de Investigaciones Científicas*, is a centre for research and scientific-technical advice in the area of building.
www.ietcc.csic.es

The *Asociación para el Desarrollo de la Casa Bioclimática* is a private association, independent, made up by professionals and companies from different sector who want to promote the use of bioclimatic criteria in town planning and building and homes and buildings renovation.

The *Instituto de Bioconstrucción y Energías Renovables IBER* is a nonprofit association dedicated to promote such issues, handling information on bioconstruction techniques, ecological materials, renewable energies, etc.

The *Consejo Construcción Verde España* (Spain Green Building Council) is the first nonprofit national association of leading building companies (buildings, developments, towns, public works and town planning), that work together to promote cities and buildings environmental risponsible, profitable and healthy for the people who live or work in them.
www.spaingbc.org

The *Instituto de la Construcción de Castilla y León I.C.C.L.,* was created as a private Foundation of scientific and cultural character, nonprofit, that wants to deal with all the technical aspects that intervene in the process of construction, being Civil, Building or Renovation.
www.iccl.es

CENIFER Foundation for the Training in Renewable Energies is a tool to promote technical training in the field of renewable energies.
www.cenifer.com

The main objective of the *Asociación de la Industria Fotovoltaica* is to promote, prestige and develop the photovoltaic sector, contributing its knowledge and experience to the Spanish market and risponsible authorities, at national, regional and local levels.
www.asif.org

The *Asociación Solar de la Industria Térmica* has the mission to become a meeting and representing forum for the sector, to discuss ideas and reach an agreement on actions to promote and improve the use and development of Solar Thermal Energy in the whole country.
www. asit-solar.com

The *Comité Español de Iluminación* aims at promoting all activities related to lighting, in its widest and varied aspects, scientific and technical, promoting studies, research, development and innovation as well as methods, regulations and standardization related to lighting.
www.ceisp.com

4.3 Swedish Institutions

4.3.1 Public Institutions

The National Board of Housing, Building and Planning – Boverket – 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 Boverket also provides information to those engaged in planning, housing, construction and building inspection activities.

The Swedish Energy Agency 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.

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.

IVL Svenska Miljöinstitutet coordinates different projects on low-energy houses www.ivl.se

4.3.2 Private Associations and Institutions

Forum för Energieffektiva byggnader 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 buildning of more passiv and low-energy houses. http://www.passivhus.nu/

Resurseffektiva byggnader. This website is a platform for information to proprietors, builders and contractors to make it easier to chose energyefficient components for the buildings.
http://www.husutanvarmesystem.se/intelligens/kund/sida.asp?site_id=1&sida=2

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- News from national planning/ Landsplan nyt. Information fra Miljø- og Energiministeriet, Landsplanafdelingen, Kbh.: Miljø- og Energiministeriet, Landsplanafdelingen
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6.2 Relevant Spanish Magazines

- Energías renovables
- Solar News, especializada en el sector de la energía solar
- Nuevas Tecnologías, Revista de eficiencia energética, Sostenibilidad, renovables y gestión técnica de las instalaciones
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- Energética XXI, Revista de Generación de Energía
- Tecno Energía, Revista profesional de energía y medio ambiente
- Revista NAN arquitectura y construcción
- Infodomus, Construcción Sostenible y Edificios Inteligentes
- Tecno Ambiente, Revista profesional de Tecnología y equipamiento de ingeniería ambiental
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- Electra

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- Energi & miljö: tidskrift för VVS, inneklimat och VA
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- Energimagasinet
- Miljöforskning

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The Danish insulation producer - Rockwool; www.rockwool.dk
The Danish Technological Institute; www.teknologisk.dk
Energy windows information; www.energiruder.dk
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The Danish producer of ventilation systems; www.ecovent.com
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Ministerio de la vivienda; www.mviv.es
Secretaría General de la Energía; www.mityc.es/energia
Instituto para la diversificación y el ahorro de la energía; www.idae.es
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT); www.ciemat.es
Centro Nacional de Energías Renovables (CENER); www.cener.com
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Forum för Energieffektiva Byggnader; http://www.passivhus.nu/
Swedish Association of Architects; http://www.arkitekt.se/s14338
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Lunds Universitet; http://www.ebd.lth.se/forskning/passivhus_demonstrationsprojekt/
IVL Svenska Miljöinstitutet; http://www.ivl.se/AnsokningarPassivhusprojekt.htm
ByggaBoDialogen; www.byggabodialogen.se

Report on the state of the art in bioclimatic architecture and integration of renewable energies in buildings

D.2.0.4.1.

CONTENTS

1 REGULATIONS

1.1 Spanish Regulations

Normas Básicas de la Edificación:[1] Condiciones Térmicas de los Edificios (NBE-CT-79)[2]

Through Decree 1490/75, of 12 June, the public Administration took the first measures aiming at the achieving of energy saving by means of an adequate construction of buildings, thus tackling with the problems derived from the rise in the price of energy.

NBE-CT-79 replaced the former Decree (except for articles 6 and 7, fluids' insulation and regulation of installations, which remained in force). This regulation was approved through **Royal Decree 2429/79** of 6 July 1979.

Regulations from year 79 set the thermal conditions required of buildings, as well as the determining features, and defined as application field all kind of completely new buildings, except the ones that, due to their use, should remain open.

Apart from principles aiming at energy saving, the mentioned regulations included other thermal or hygrothermal aspects that affect buildings and their habitability conditions, stressing subjects that had no been regulated before, such condensation phenomena in the building envelope that affect to the building users comfort.

For this NBE purposes, building are thermally defined by the following concepts:
a) Global heat transmission through the whole of the building envelope, defined by its K_G factor.
b) Heat transmission through each of the elements that make up the building envelope, defined by their K factors.
c) Higrothermal performance of envelopes.
d) Air permeability of envelopes.

This regulation forced to meet a number of requirements and conditions, such as:

- That the global thermal factor K_G of a building cannot be higher that a given value, that will be set according to the factor of the climate zone of the site and the type of energy used in the heating system.
- That the K thermal transmission usable factors of envelopes, excluding the spaces, do not rise over certain values, given by the envelope and the climate zone.
- That the thermal resistance and the constructive layout of the envelope elements be such that in the environmental conditions considered by the Regulation, the envelope will not show condensation humidities neither in its interior surface, nor within the envelope mass, that damage its conditions, nor occasional ones that might damage other elements.

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[1] *Basic Building Regulations N.B.E*
[2] *Buildings' Thermal Conditions NBE-CT-89*

- It considers as interior environment conditions the use ones, and the exterior conditions are classified according to two climate zones: one based in 15-15 degrees/day data and, the other, in minimum temperatures in the month of January.
- It considers ground temperature according to climate zones and forces to considerate 95% external relative humidity in order to make the calculations.
- It sets the air permeability of a carpentry frame defined by its class of air tightness. According climate zones, the carpentry should be of a given class.

Reglamento de instalaciones de calefacción, climatización y A.C.S[3]

This regulation was approved by **Royal Decree 1618/80** of 4 July (B.O.E. 06-08-80) and came up due to the importance that non industrial thermal installations was reaching and its increase as a result of the increase of the Spanish standard of living. These facts recommended a global administrative action on the sector, aiming at rationalizing the energy consumption, without decreasing the users ‘comfort’.

As energy saving issues are closely linked to pollution, quality and safety issues in heating, air conditioning and domestic water heating, and not having a basic regulation about them, it was necessary to draw regulations that set the required rules to get rational energy consumptions, setting at the same time quality, safety levels and defence of the environment measures in those installations.

The object of the present regulation was to define the conditions for installations that use energy with non industrial aims in order to achieve a rational use of the energy, taking into account its quality and safety and the protection of the environment. The systems installed in air, maritime or terrestrial transport means were excluded of these regulations, as they will be regulated by special arrangements.

Among the different requirements stated in the regulations, there are references to additional technical instructions that should be comply with by non industrial thermal installations and will be developed later on.

The regulation also includes the creation of the ‘*Comisión Permanente para el Ahorro de Energía en Instalaciones Térmicas de la Edificación*’[4] , whose missions are as follows:

a) the study and gathering of new technological advances in energy saving in installations regarded by this regulation, channeling the relevant proposals made by manufacturers, installers, designers, users, maintenance and repairer technicians.
b) to study and propose new technical instructions and improvement of the existing ones when appropriate.
c) to inform of the proposals made about the ‘technical recommendations’ mentioned in article eight.
d) to analize the obtained results after applying the regulations, proposing the correcting measures where considered appropriate.

[3] *Regulations for heating, air conditioning and hot domestic water installations.*
[4] *Permanent Commission for Energy Saving in Thermal Installations in Buildings*

e) to carry out all the research or works commissioned by their superiors.

Instrucciones Técnicas Complementarias I.T.I.C.[5]

The *Instrucciones Técnicas Complementarias* were approved by **Ministry Order of 16 July 1981** (BOE Nº 193, de 13.8.1981), according to the decreed in the *Reglamento de Instalaciones Calefacción, Climatización y Agua Caliente Sanitaria*, with the aim to racionalize its energy consumption.

The regulations comprise the basic regulations of more general and permanent nature, whereas the technical additional instructions comprise the regulations applicable in the present to the aforementioned installations, with the fundamental object of gaining energy savings, and can be reviewed in the future due to the need to be adapted to the development and evolution of technologies.

Reglamento de Instalaciones Térmicas en los Edificios (RITE)[6]

The *Reglamento de Instalaciones de Calefacción, Climatización y Agua Caliente Sanitaria*, approved by Royal Decree 1618/1980, contributed to a great extent to foster and impulse a more rational use of energy in non industrial thermal installations in buildings, generally used to supply in a safe and efficient way with heating, air conditioning and hot domestic water services to meet the needs of thermal comfort and hygiene in buildings.

The experience adquired from its implementation, the technological advances in this field, the new distribution of powers as a result of the State of Autonomous Regions development and, finally, the membership of Spain to the European Union made the drawing of a new regulation necessary, one that based on the previous one, took into consideration the existing factors and continued the advance in the rational use policy established in the *Plan de Ahorro y Eficiencia Energética* [7] included in the *Plan Energético Nacional* [8] 1991-2000.

As a result of adopting different Community provisions in the field of free circulation of goods as well as in the field of rational use of energy and the reduction of carbon dioxide emmissions, it was also necessary to modify the existing regulations to take into account the following Directives of the Council:

- 89/106/EEC on building products
- 92/42/EEC on performance requirements for new hot water boilers fed with liquid and gas fuels.
- 93/76/EEC related to the limitation in carbon dioxide emmissions by means of improving energy performance (SAVE)

[5] *Additional Technical Instructions I.T.I.C*
[6] *Regulation of Thermal Installations in Buildings* (RITE)
[7] *Energy Saving and Efficiency Plan.*
[8] *National Energy Plan.*

The reach of the changes made on the regulations text in force and its additional technical instruccions, both in form and content, recommended to draw a new text to repeal and replace the former one and the developing additional technical instructions. This new text was approved by **Royal Decree 1751/98** of 31 July, that approved the *Reglamento de Instalaciones Térmicas en los Edificios (RITE)* and its *Instrucciones Técnicas Complementarias (ITE)* while creating the *Comisión Asesora para las Instalaciones Térmicas de los Edificios*[9].

The *Comisión Asesora para las Instalaciones Térmicas de los Edificios*, that takes the place of the *Comisión Permanente para el Ahorro de Energía en Instalaciones Térmicas de la Edificación*, will be a standing voting body with the specific mission of advising in issues related to thermal installations in buildings by means of the following actions:

b) To study and propose new technical instructions and review of the existing ones when appropriate.
b) To estudy and collect, when appropriate, the new technical advances in rational use of energy, proposing the adequate changes to the Ministries of Industry, Energy and Public Works and Building, channeling the related suggestions made by public administrations, manufacturers, designers, installers, users and energy maintenance technicians and suppliers.
c) To study international actions on the issue and, particularly, the ones coming from the European Union, proposing the appropriate actions.
d) To analize the obtained results by applying the regulations, proposing the measures and criteria for right interpretation and homogeneous implementation where considered appropriate.

Ley de Ordenación de la Edificación[10] (L.O.E)

Law 38/1999 of 5 November 1999, L.O.E, was conceived in view of the lack of legal bases for building construction, which was mainly regulated by the Civil Code and a variety of regulations that, as a whole, had many gaps in planning the complex process of building, so much in issues related to identification, obligations and risponsibilities of the involved actors as in reference to guarantees to protect the user.

Also, society demanded more and more quality in buildings and that had repercussions on the structural safety and protection against fire as well as on other aspects linked to people's comfort such as protections against noise, thermal insulation or accesibility for people with limited mobility.

The top priority of the LOE was to regulate the building process, updating and completing the legal configuration of the participant agents, setting their obligations in order to establish risponsibilities and cover the users' guarantees by defining the basic requirements for buildings to be complied with.

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[9] *Advisory Commission for Thermal Installations in Buildings.*
[10] *Building Planning Law (L.O.E)*

To do so, the building legal concept and the basic principles that should lead this activity were defined and the scope of the Law was delimited, specifying the works both completely new buildings and existing ones to which it would apply.

The Law set the basic requirements that buildings should meet, in a way that users' guarantees would not only be based on technical building requirements but also in the establisment of a caution or safety insurance.

These requirements cover so much building functional nature and safecty aspects as those relative to habitability.

Código Técnico de la Edificación[11] (CTE)

The *Código Técnico de la Edificación* stands as a new structured regulation frame that identifies, arranges and completes the existing technical regulations, pretending to facilitate its aplication and fulfilment, and all that in harmony with European regulations. It was approved on 17 May 2006 by **Royal Decree 314/2006**, and published on BOE of 28 March.

The *Código Técnico de la Edificación* enforces the basic requirements in building set by *Ley de Ordenación de la Edificación*, aiming at guaranteeing people's safety, society comfort, sustainability of building and the environment safeguard.

The approval of the *Código Técnico de la Edificación* means the improvement and updating of the building regulation frame in Spain present at the time, regulated by Royal decree 1650/1977 of 10 June, on building regulations, that implemented the *Normas Básicas de la Edificación* as mandatory in building projects and works. Within this legal frame, several regulations were approved since 1979, which made up an open group cf dispositions that has been meeting different society requirements, but that never got to be a coordinated body in the form of a Technical Building Regulation, similar to the ones existing in other more advanced countries.

With the aim to improve building quality and to promote innovation and sustainability, the CTE sets the basic quality requirements for buildings and installations. By means of this regulation, certain basic building requirements related to people safety and comfort are met. These requirements refer to structural safety and protection against fire as well as healthiness, protection against noise, energy saving or accesibility for people with limited mobility.

Also, the *Código Técnico de la Edificación* creates an equivalent regulation frame to the existent in more advanced countries and levels the national building regulations existent with the current European regulations in this issue. Firstable, with the regulations related to free circulation of building products inside an only European market. Secondly, Directive 2002/91/CE of European Parliament and Council, of 16 December, relative to energy performance in buildings has to be taken into account as it was used to add to the

[11] *Technical Building Regulations (CTE)*

Código Técnico de la Edificación the requirements relative to energy performance in buildings set by that Directive in articles 4,5 and 6.

The *Código Técnico de la Edificación* is divided in two parts, both of them regulatory. The first one comprises the general dispositions (implementation scope, uses classification, etc.) and the requirements buildings have to comply with to meet the building safety and habitability requirements.

The second part is formed by the Basic Documents, whose adequate implementation ensures the achievement of the basic requirements. Those comprise procedures, technical codes and solution examples that permit determine whether the building cumplies with the established standards of service. Those Documents are not excluding. The *Documentos Reconocidos* were created as a complement for the implementation of the Código, those being technical documents, external and independent from the Código, whose use facilitates the compliance of some demands and contribute to the increase of building quality.

Basic Document '*DB-HE Ahorro de Energía*'[12] especifies the objective parameters and the procedures whose compliance ensures the meeting of basic requirements and the overcoming of the minimum quality standard inherent to the basic requirement of energy saving.

1.2 Swedish Regulations

Regulations set by the National Board of Housing, Building and Planning – BBR 2006

On 1 July 2006, the new Swedish regulation on dwellings came into force (*BBR 2006*). In short, this is what the regulation stipulates about energy demand (the regulation also deals with design, durability, fire protection, hygiene and health, environmental aspects, and noise):

For residential buildings, the energy demand must not exceed 110 kWh per m^2 floor area (A_{temp}) in the south of Sweden and 130 kWh per m^2 in the northern part of the country. For residential houses with electric radiators the energy demand must not exceed 75 kWh per m^2 floor area (A_{temp}) in the south of Sweden and 95 kWh per m^2 in the northern part. A_{temp} is the floor area of spaces aimed for heating to more than 10 ^oC. The garage is not taken into account as a part of the floor area. The energy demand may be reduced with energy from solar panels and photovoltaic cells integrated in the building. The highest average u-value for the surrounding building parts must not exceed 0.50 W/m^2K.

For other premises than residential, the specific energy demand must not exceed 100 kWh per m^2 floorarea (A_{temp}) in the south of Sweden and 120 kWh per m^2 in the northern part of the country. Premises with an airflow larger than 0.35 $l/s,m^2$ may add the equivalent of 70(q-0.35) kWh per m^2 floor area (A_{temp})in the south of Sweden and 90(q-0.35) kWh per m^2 floor area in the northern part, where q is the mean air flow for the heating season in $l/s,m^2$. The energy demand may be reduced with energy from solar

12 *'DB-HE Energy Saving'*

panels and photovoltaic cells integrated in the building. Garages are not taken into account as a part of the floor area (if not a building on its own). The highest average u-value for the surrounding building parts must not exceed 0.70 W/m^{2}K.

For buildings containing both residential spaces and other premises, the regulations are based in proportion to the floor area.

For buildings where the floor area (A_{temp}) is less than 100 m^2, the window and door areas are less than 0.20 A_{temp}, and where there is no demand for cooling; some alternative regulations may be used.

Maximum u-values for the building parts:
U_{roof} 0.13 W/m^{2}K
U_{wall} 0.18 W/m^{2}K
U_{floor} 0.15 W/m^{2}K
U_{window} 1.3 W/m^{2}K
U_{door} 1.3 W/m^{2}K

For residential houses with electric radiators the following maximum u-values for the different building parts must not be exceeded:
U_{roof} 0.08 W/m^{2}K
U_{wall} 0.10 W/m^{2}K
U_{floor} 0.10 W/m^{2}K
U_{window} 1.1 W/m^{2}K
U_{door} 1.1 W/m^{2}K

The average air leakage at +50 Pa must not exceed 0.6 l/s m^2.

If the floor area (A_{temp}) is more than 60m^2, the building must have a ventilation system with heat recovery of 70 % efficiency or a heat pump in the outgoing air.

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 has been taken into consideration but adjusted to the Nordic climate.

Apart from the basic requirements described in BBR 2006 above, the requirements for a *passivhus* is very restrictive for the total use of bought energy (household demand, hot water, heating and cooling). A_{temp} is defined in the same way as in *BBR 2006* (the floor area of spaces aimed for heating to more than 10 ^{o}C).

Maximum output for the building is P_{max} = 10 W/m^2 in the south and P_{max} = 14 W/m^2 in the north of Sweden. The indoor temperature is specified at 20 ^{o}C and heat from persons and household appliances of 4 W/m^2 may be included. For buildings less that 200 m^2 the maximum output is allowed to be 2 W/m^2 higher.

Maximum energy demand (excluding electricity for household appliances), is set at 45 kWh/m^2 in the south of Sweden, and 55 kWh/m^2 in the northern part. For buildings less that 200 m^2 the maximum energy demand is allowed to be 10 kWh/m^2 higher than above.

The use of hot water is presumed to be 20% less than the standard use.

The average air leakage at +/-50 Pa must not exceed 0.3 l/s m^2.

To be able to verify the energy demand for household appliances and heating, the energy use is to be monitored separately on a monthly basis. The hot and cold water use is also to be monitored. The maximum allowed u-value for the windows is 0.9 W/m^{2}K.

2 REFERENCES

2.1 Denmark

2.1.1 Bioclimatic Buildings

Skotteparken

Skotteparken in Egebjerggård, Ballerup, is an EU Thermie supported experimental building project with 100 solar heating - low-energy dwellings, where the aim is to reduce the gas consumption for heating and domestic hot water with 60% compared to normal building projects. And at the same time reduce the consumption of electricity and water. The apartments in Skotteparken were already built in 1992.

Ballerup is situated 15 kilometres from the capital of Denmark, København, straddling the border between greater København and the countryside. The municipality of Ballerup is the home for approximately 45,000 inhabitants.

The basis for the project was that extra investments in energy saving measures of approx. 8% of the normal building costs should be corresponded to by savings on the operation, especially as regards expenses for heating, water and electricity. 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 in Skotteparken are as follows:

- Extra insulation, which is mostly added in the ceilings with a total thickness of 375 mm. The apartments are aimed airtight making the natural air change as low as 0.1 times per hour
- Thermo glazing is used everywhere with two layer windows with an air gap of 15 mm. The windows have a U-value of approximately 1.4 W/m2K.
- Ventilation system with counter-flow, heat recovery is utilised 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 collector 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 armatures in showers and two-step water saving armatures in kitchens and bathrooms
- Electricity savings
- Rain water from roofs and streets is via open drains carried to a small lake to help maintaining the ground water.

The most innovative aspect are the six, solar heating systems with approximately 100 m^2 of solar collector 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 the summertime. 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.

The results from a finalised monitoring campaign documents 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 m^2 solar collector area in all shows an annual solar heating yield in a normal year of 274 kWh per m^2 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 m^2 solar collector. 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.

The main results for the project in Skotteparken can be summarised as follows:

- The normal amount of energy used for heating and hot water has been reduced of 180 kWh/m2 (normal housing) to 92 kWh/m2 in 1993, to 82 kWh/m2 in 1994, reaching 77 kWh/m2 in 1995.
- 65 % savings of district heating network losses was obtained from the low temperature pulse operation.
- Solar system yields 274 kWh/m2 (which corresponds to 382 kWh/m2 when including saved network losses).
- Heating bills only 4.42 Euro/m2 which equals approximately 40 % of a "normal" heat bill.
- A good economic saving for the tenants based on an extra investment of approximately 8% compared to normal housing and grants from external sources.

Source:

Combined low and solar energy design in Egebjerggård, Denmark; Peder Vejsig Pedersen
SOLAR DISTRICT HEATING – BALLERUP (Denmark); Miljø Afdelingen; Peder Vejsig Pedersen

2.2 Spain

2.2.1 Bioclimatic buildings

CENER Building

This building is located in the City of Innovation, in Sarriguren, Navarre, and it is the headquarters of the *Centro Nacional de Energías Renovables (CENER)*[13], Centre of research and Technology that fosters the technological development of Renewable Energies. Its area is about 5,000 square metres.

The building was designed taking into account the most advanced bioclimatic and environmental criteria for energy saving and environmental care. It has both active and pasive architectural elements, being the outstanding ones:

- Active: Vacuum tube thermal collectors for domestic water heating, and for radiant floor (absorption system) heating and cooling, radiant floor heat/cold; awning, shutters, windows and ventilation automatisms.
- Pasive: Balcony-greenhouse for solar capture for heating; high inertia walls and framing; chimney for ventilation in summer; lower ground floor effect; insulating shutter; sun shading awnings; wind tower to capture north wind and plant cover.

Out of the pasive architectural elements, is worth mentioning the bioclimatic balcony, called ‘bioclimatic device’, that is located in the upper part of the pavillions where the research ares of the Centre are located. From the environmental point of view, it gives the building the maximum bioclimatic advantage out of solar and wind energy: it collects, transforms, storages and distributes the energy along the respective pavillions. In this balcony there are also integrated most of the active environmental protection means and the cooling effects of the plant covers.

On the other hand, and inside the premises, there are two features that outstand due to their non conventional make, as they include energy saving and sustainability criteria:

- Heat/cold generation: The system is based on absorption cycle, feeding the generator with high temperature water (around 100º C) that comes from the vacuum solar collectors integrated in the building roofs, backed by natural gas boilers.
- Watering system: All plant covers in the building are equipped with a trickle irrigation system (minimum consumption), getting the water out of a tank that collects all the rainwater so, both the rainwater plus the possible remaining water

[13] *National Centre of Renewable Energies (CENER)*

that does not evaporates from the trickle irrigation system will be use for watering in the building.

As for the building materials, the option was not to use reusable or biodegradable elements, choosing those more efficient from the technical and energy point of view.

CENIFER Building

This is a 400 square metre building, located in Imarcoain (Navarre), that belongs to the *Centro Integrado Nacional de Formación en Energías Renovables CENIFER*[14], that is used as demonstrative building, reception building, to impart training, as a conference hall, as training bench for students, apart from the research made by the teachers at the Centre.

It has all type of active and pasive installations to reach an energy balance close to zero: solar thermal installation; water tank to store energy between seasons; heating and cooling through radiant floor and wall; solar photovoltaic installation grid connected; greenhouse with direct solar capture and ventilation; Trombe wall; external insulation of building envelope with ventilated façade; well water cooling and forced ventilation with thermosolar shunt.

Each of the architectural elements and installations used are explained below:

Architectural elements

The **general building envelope** consists of a ventilated façade with high inner thermal energy, made up by five elements:

- External coating made out of ceramic tiles
- 3 cm ventilated chamber
- Thermal insulation made out of 8 cm rockwool.
- High thermal inertia inner wall
- Radiant strip heater

This envelope is completed with inner flooring with radiant floor and a flat trafficable roof that serves as a platform to the pergola that holds the solar thermal and photovoltaic panels.

Among the building pasive solar energy systems, is worth mentioning the **greenhouse**. In summertime, the capturing cover is protected with a system of motor operated slatted shutters, placed inside the external window framing. The upper and lower hatches, motor operated and automatic, open to get a forced ventilation to refresh the air, avoiding the inside to get hot with the air. In winter, the radiation that gets inside the greenhouse is absorbed inside, becoming heat that gets stored in floor and walls, from where is transmitted inside the building through radiation. At the same time, the air inside the greenhouse becomes hot and gets into the building through forced convection by means of some fans located in its upper side. The greenhouse's floor and wall, with a substantial thermal inertia, absorb radiation, storing thermal energy and giving it to the air with delay

[14] *Integrated National Centre for Training in Renewable Energies CENIFER*

and absorption, through convection and long wave, what minimizes losses through the glazing.
It has an estimated thermal output of 10,800 Kwh in winter and 14,245 Kwh both in spring and autumn.

The **Trombe wall** is other of the used pasive systems. It is formed by a glazing wall placed next to a double massive wall that has a little internal ventilated chamber. The solar radiation that reaches the wall and goes through the glazing, heats the external wall, which is painted in a matt dark colour. In turn, this wall heats the inner wall and the circulating air in the chamber between them through radiation. This chamber has automatic hatches and fans.

In summer, these hatches open the chamber to the exterior, getting forced ventilation that avoids the heat getting inside. In winter, the hatches open the internal chamber to the inside of the building, allowing the entrance of hot air. It has a thermal output of 4,970 Kwh in winter and 6,500 Kwh both in spring and autumn. The annual saving in emmissions is 33 kg of SO_2, 10 kg NOx and 2,640 kg CO_2.

The **solar thermal shunt** is for exclusive winter use. It refreshes the inside of the building by means of forced ventilation coming from a shaded landscaped area in the North side of the building. The air is introduced from there through four ceramic conducts, using fans to force ventilation Those conducts are buried at 1.8 m depth and go up to the south façade, where they come into the interior, the air going up towards the roofing shunt as it gets warmer. It has a cooling output of 2,838,000 frigories in summer. The annual saving in emmissions is 6,8 kg of SO2, 2 kg NOx and 545 kg CO2.

Installations

The **solar thermal installation** is made up by 24 2.5 sq.m. useful area panels, located on the building roof and south orientated with a 50º tilt. This way, they make the most of solar radiation to warm the heat transmitting fluid that circulates inside them. They meet 100% of domestic hot water needs and 44% of heating ones. The annual saving in emmissions is 102 kg of SO2, 32 kg NOx and 8.251 kg CO2.

The **big storage tank**, built under the greenhouse, has the function of storing the excedent energy from the solar thermal panels to be used in the heating circuit in days with low solar radiation. It has 40,000 l. capacity, made out of stainless steel and has a perimeter covering of 30 cm of granulated cork that acts as insulation. This extra insulation provides an energy saving estimated in 18%.

The **radiant floor and strip** is made up of a series of reticulated polystyrene conducts, fitted into the floor and wall strips, inside of which circulates water. They absorb heat in summer in the cool well water that circulates inside them, and in winter they release heat through the hot circulating water that comes from the storage tank and has been heated by the solar thermal panels. These radiators can transmit 35,000 kcal/h. The energy saving in this low temperature radiation system compared to the common convection radiators is 23%.

A system based on **cooling through sensor**, which uses subsoil water, floor system water and radiant strip is used to cool the building in summer. The system works with an immersion pump that placed at 8 m depth inside a well in the north face of the building, pumps the water to the radiant elements, circulating along them and returning to phreatic level.
The absortion capacity of this element is 15,000 frigories/h. This system annual saving in emmissions is 3 kg of SO_2, 1 kg NO_x and 248 kg CO_2.

There is a 5 Kw grid connected **solar photovoltaic system** installed in the building. It consists of 68 monocrystalline photovoltaic panels of 80 Wp, placed in the building roof and orientated to south with 30º tilt and 2 2.5 Kw inverters.
The estimated annual output is 7,440 Kwh (20.38 Kwh average daily output). Those outputs intend to meet the building energy consumption. The annual saving in emmissions is 15 kg of SO_2, 4,8 kg NO_x and 1.228 kg CO_2.

2.2.2 Eco-cities

Residencial Parque Goya

In 1995, the *Dirección General de Obras Públicas y Urbanismo del Gobierno de Aragón* y el *Instituto del Suelo y de la Vivienda de Aragón (ISVA)* started to develop a Partial Plan in a 53.7 Ha area in the north of the city of Zaragoza.

The objective was to promote 3,500 officially protected housing and to reduce CO_2 emmissions as specific aim, considering the European Directive 93/76/CEE. The development and building design according to the architectural criteria included in the Partial Plan would account for a potential 60% decrease in the buildings energy demands (heating, cooling, domestic hot water and lighting) compared to the values given by complying with the regulations and a little lower respect to the usual typology of the area.

As a novelty respect to any other previous town planning activity, the Partial Plan of Residencial Parque Goya had some specific clauses in regulating bylaws related to bioclimatic determining factors of buildings.

This action was funded by the European Commission with a Thermie Project (n. BU 178/95) that affected to three buildings in the first stage: parcels P-4 (178 flats), P-11 (50 flats) y PU-9 (26 houses).

Key features

Some of the mandatory concepts in the Partial Plan town planning design or in the Terms and Specifications corcerning all buildings in Parque Residencial Goya are:

- Street orientation, buildings' distribution and heights to favour solar radiation capture in south facing façades.
- Higher insulation than required by regulations (<25%).
- 50% or higher glazing in south façades, with optional glazed balconies, and minimum in north façades.
- Carpentry framing of better quality than required by regulations.
- Plenty of green areas, areas of water and adequately coloured materials.

In the three buildings selected by Project Thermie, the mainly used elements are:

- Use of greenhouse-balconies with thermal load walls.
- Insulation higher than usual, double glazing and top quality carpentry framing regarding infiltrations.
- Collective auxiliary systems with low temperature boilers (high efficiency) or condensation ones and solar thermal collectors.
- Individualized control of heating and domestic hot water consumption.

Location

The residential neighbourghood Parque Goya is located in the city of Zaragoza, capital of the Autonomous Region of Aragón, situated in the centre of the Ebro Valley, 41º39' north latitude.

The climate is Mediterranean, eventhough it has strong continental influences, as it can be seen by the extreme temperatures: high temperatures in summer and low in winter, with NW-NWW winds (*cierzo*) that increase the feeling of discomfort.

The most characteristic climate variables of the zone can be seen in the table below:

Month	Average daily temperature (°C)	Horizontal solar radiation (MJ/m^2 day)	Vertical solar radiationsouth (MJ/m2 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

Table 1: Climate variables. Data obtained from *Atlas de Radiación Solar de Aragón* and from *Datos Climáticos de Aragón.*

Description

The selected buildings for specific actions represent the three typologies existing in the development (semi-detached hoses PU-9, collective buildings with double corridor P-4 or quadruple corridor P-11).

Insulation and thermal inertia

After the initial studies, the town planning project established as a specific regulation that the insulation value should be 25% higher than defined in the current regulations.

The table below show the U values (W/sq.m.K) corresponding to each building external envelope respect to the values required by Spanish regulations.

U-conductance (W/sq.m.K)	National regulations (NBE-CT-79)	Building P-4 (178 flats)	Building P-11 (50 flats)	Building PU-9 (26 semi-det)
External wall	1,6	0,44	0,64	0,39
Mass walls	1,8	0,88	1,47	1,47
Roofing	1,2	0,22	0,33	0,28
External framing	1,4	0,26	0,42	0,86
South and east windows	5,8	3,3	3,3	3,3
North and east windows	5,8	2,6	2,6	3,3

Thermal bridges in pillars and girders were eliminated through external insulation in order to reduce energy losses. Also, double window framing has been used in façades N and W to reduce transmission or infiltration losses in those façades, affected by the dominant wind, the '*Cierzo*' which can reach high speeds.

The buildings have a high thermal inertia, reinforced in the most compact ones (building P-11), lower in building P-4 and clearly lower in the semi-detached houses. The inertia has been increased by placing the insulation in the external side of the envelope, the roofing and ground floor framing. Also, materials with high inertia were used, such as Airblock (19 cm in P-11) and Termoarcilla (19 cm in P-4 and PU-9).

With this features, the buildings experience slight fluctuations of interior temperature at night, when the auxiliary heating is off. All the same, with night ventilation, the inertia allows to reduce maximum day temperature in a way that most of the time, it remains within comfort conditions.

Solar gain

The buildings' main façade are south orientated with no shadings in winter. This was done all through the development. The area of glazing was increased in all south façades, making also greenhouses with no preheated air. To increase the captation effect and make the most of the captation delay in greenhouses, mass walls were used (29 cm blocks filled with sand and concrete or 19 cm termoarcilla —thermal clay— blocks). The glazing area was reduced in façades east, west and north, as solar captation is very low (N) or can generate overheating in summer (E, W). The inside distribution of the houses leaves the south for living areas, while kitchen, bathrooms and stairs are placed north.

The overheating due to solar captation in summer gets reduced by eaves or mobile elements (shutters). Also, the distribution of the house allows natural ventilation, very convenient in summer nights. The use of clear colour pavement, landscaped areas with gardens and trees also improves comfort in summer, reducing the overheating effect in streets.

Heating and solar collector

The heating system used (low temperature boilers) in each of the three buildings is collective, being more efficient than individual heating systems.

The total installed collector surface in the development in its first stage was 600 sq.m.

Technical results

The three selected buildings were monitored during two years. The interior temperatures of north and south rooms, the greenhouses and the inner temperature of especially built walls were specifically measured. Humidity in the south zone and heating consumption in the houses were also measured. All these parameters were recorded each 10 minutes. The number of monitored houses was 9 in block P-4, 12 in block P-11 and 6 in PU-9.

Starting from consumption and monitored temperatures in the houses, the consumptions were extrapolated to a common scale to get identical interior temperatures (20º C). That was how results showed in table 2 were obtained.

Average annual consumption in kwh/sq.m	2000-2001	2001-2002
P-4 (178 flats, mostly south oriented)	20	21
P-11 (50 flats, 16 out of them facing north)	35	32,5
PU-9 (26 semi-detached houses, south oriented)	48	41

Table 2: Results of unitary heating consumption in the three buildings

2.3 Sweden

2.3.1 Bioclimatic buildings

Lindås

In Lindås, 20 km south of Gothenburg, 20 low-energy terraced houses have been built. 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. Big windows facing south are combined with balconies and roof overhang to shield from too much sun and high temperatures during summer. A roof window gives light also to the middle of the house and can be used to air the house on hot summer days.

The energy-saving features of Lindås are as follows:

- Extra insulation
- **External wall**:
  U-value 0.10 W/m^{2}K
  Bolt wall with 43 cm isolation.
- **External roof**:
  U-value: 0.08 W/m^{2}K
  Masonite balk med 48 cm isolation.
- **Floor**:
  U-value: 0.09 W/m^{2}K
  concrete board with 25 cm isolation.
- **Windows**:
  U-value: 0.85 W/m^{2}K
  Three glass with two metal layers and krypton gas.
- **Doors**:
  U-value: 0.80 W/m^{2}K

- a ventilation system with counter-flow heat recovery of 85 % efficiency

- 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.

The residents moved into their terraced houses in 2001. The majority of the residents are content with the temperature of 20-23 ^{o}C. 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.

http://www.egnahem-goteborg.se/prod/egnahems/dalis2.nsf/535e371e7fd657aec1256a5c0045675f/6280a39fe9d3eb4fc125710f00586292!OpenDocument

Glumslöv, Landskrona

In Glumslöv north of Landskrona lies 35 terraced houses built in 2004. Fully developed and reliable techniques have been used in these dwellings. In a ventilation system with counter-flow heat recovery of 85 % efficiency the incoming air is heated with the outgoing air. The very limited space heating demand is covered by electric resistance heating, 700 W, in the supply air. The total energy demand is calculated as approximately 50-60 kWh/m^2.

U-values for the dwellings:
Windows = 0.9 – 1.0
External walls = 0.10
External Roof = 0.08
Floor = 0.10

http://www.husutanvarmesystem.se/intelligens/sites/reby/filer/T28-C-brochure_Landskrona_SE.pdf

Oxtorget, Värnamo

In Värnamo, 40 apartments with a very low energy need stood ready in 2006. The houses have extra insulation; windows and doors have a low u-value; and balconies and roof overhang protect from too much sun during summer months. 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. 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.

U-values for the dwellings:
Windows = 0.85
External walls = 0.10
External roof = 0.08
Doors = 0.6
Floor = 0.09

http://www.oxtorget.se/eng/index.htm

Frillesås, Kungsbacka

In Kungsbacka, three low-energy dwellings with12 apartments were built in 2006. Roof, walls, windows, doors and floor have a very low u-value. A ventilation system with an

efficient counter-flow heat recovery diminishes the heating demand. Hot water comes from solar panels and district heating.

Lidköping

In Lidköping, a detached house is soon ready for the residents to move into. This is the first low-energy detached house to be built in Sweden. The house is highly isolated and has a ventilation system with an 85 % efficient counter-flow heat recovery. Hot water is heated by district heating. As a back-up, district heating can be used to heat the incoming air in the ventilation system.

U-values for the dwellings:
Windows = 0.85
External walls = 0.09
External roof = 0.07
Doors = 1.0
Floor = 0.1

http://www.tellus.tv/passivhus/

Brogården, Allingsås

These houses, containing 200 apartments, were built in 1970. Now, when it is time for major renovation of the houses, the insulation and heating system will be improved so that the energy demand will be reduced from 216 kWh/m^2 to 92 kWh/m^2. Solar panels and district heating will provide for hot water and the extra heating needed during cold winter days.

U-values for the dwellings:
Windows = 0.8
External walls = 0.14
External roof = 0.10
Doors = 1.0
Floor = 0.25

http://www.alingsashem.se/CM/Templates/Article/general.aspx?cmguid=2d63f1cc-805d-47b1-bdc3-97d355557435d

Hamnhuset, Älvstranden in Gothenburg

This proposed 116 apartment dwelling will be highly isolated with efficient heat recovery in both ventilation system and drain. Solar panels will count for hot water and district heating will be installed as a back-up for heating and hot water. Energy demand is calculated to be 27 kWh/m^2 for heating and hot water and 30 kWh/m^2 for electricity.

Misteröd, Uddevalla

In Uddevalla, 12 terraced houses with 27 apartments are being built.

Storfors, Filipstad

Proposed low-energy school building.

3 TECHNOLOGY: TECHNICAL DATA

Examples

3.1 Passive solar energy

3.2 Trombe walls

3.3 Natural cooling

3.4 District Heating

4 INSTITUTIONS

4.1 Denmark

4.1.1 Public Institutions

SBi is the Danish national building research institute 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.

The Danish Technological Institute 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.

Technical university of Denmark; www.ibe.dtu.dk

4.1.2 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
www.dcue.dk

Business network passive houses, a network of several researchers, consultants and companies discussing and exchanging knowledge within the field of passive houses.
www.passivhus.aau.dk

Local Agenda 21; municipal LA21 coordinators is organised 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.

LØB - Landsforeningen Økologisk Byggeri / National association for Ecological building activities
www.lob.dk

4.2 Spanish Institutions

4.2.1 Public Institutions

The *Ministerio de Vivienda*[15] is the Department risponsible of exert the competences corresponding to the General State Administration in housing and ground issues.

[15] *Ministry of Housing*

www.mviv.es

The *Instituto para la Diversificación y Ahorro de la Energía IDAE*[16] is a Public Managerial Entity, assigned to the Ministry of Industry, Turism and Commerce, whose function is to coordinate and manage together with the Autonomous Regions the measures and funding dedicated to the Action Plan 2005-2007 and the Saving and Energy Efficiency Strategy for Spain and the Plan of Renewable Energies 2005-2010, apart from carrying out dissemination actions, technical advice, development and funding of technological innovation projects that can be repeated.

The *Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas CIEMAT* is a research public body, depending on the Ministry of Education and Science. The main fields for its R&D activities, apart from nuclear energy, that was its original activity in the beginning, are: other energy sources, environmental impact of energy and development of associated technologies, basic reseach in particle physics and molecular biology.
www.ciemat.es

The *Centro Nacional de Energías Renovables* CENER, is a national technological centre dedicated to research, development and promotion of renewable energies in Spain.
www.cener.com

The *Instituto de Energía Solar* is part of the *Universidad Politécnica de Madrid,* being its objective the research of associated aspects to the development of solar photovoltaic electricity.

The *Instituto Tecnológico de Energías Renovables ITER,* created by the Cabildo Insular de Tenerife, has the objective of promote projects of research and technological development related to the use of renewable energies, as well as other projects for the improvement of the regional social and economic development of the Canary Islands.

4.2.2 Private Associations and Institutions

The *Consejo Superior de los Colegios de Arquitectos de España* is the institution that gathers all the Architects Professional Association in order to achieve the general common interest aims. It is also the representing body for Professional Associations and the profession to the public and private corporations, and to international bodies, and the last authority to appeal to via corporation (application of professional Deontology).
www.cscae.com

The *Consejo General de la Arquitectura Técnica de España* is the institution which gathers and coordinates all the Official Professional Associations of Technical Architects and that becomes the body that represents and defends the interests of the profession, in Spain and abroad.
www.arquitectura-tecnica.com

[16] *Institute of Energy Diversification and Saving IDAE*

The *Instituto de Ciencias de la Construcción Eduardo Torroja,* that belongs to the *Consejo Superior de Investigaciones Científicas*, is a centre for research and scientific-technical advice in the area of building.
www.ietcc.csic.es

The *Asociación para el Desarrollo de la Casa Bioclimática* is a private association, independent, made up by professionals and companies from different sector who want to promote the use of bioclimatic criteria in town planning and building and homes and buildings renovation.

The *Instituto de Bioconstrucción y Energías Renovables IBER* is a nonprofit association dedicated to promote such issues, handling information on bioconstruction techniques, ecological materials, renewable energies, etc.

The *Consejo Construcción Verde España* (Spain Green Building Council) is the first nonprofit national association of leading building companies (buildings, developments, towns, public works and town planning), that work together to promote cities and buildings environmental risponsible, profitable and healthy for the people who live or work in them.
www.spaingbc.org

The *Instituto de la Construcción de Castilla y León I.C.C.L.,* was created as a private Foundation of scientific and cultural character, nonprofit, that wants to deal with all the technical aspects that intervene in the process of construction, being Civil, Building or Renovation.
www.iccl.es

CENIFER Foundation for the Training in Renewable Energies is a tool to promote technical training in the field of renewable energies.
www.cenifer.com

The main objective of the *Asociación de la Industria Fotovoltaica* is to promote, prestige and develop the photovoltaic sector, contributing its knowledge and experience to the Spanish market and risponsible authorities, at national, regional and local levels.
www.asif.org

The *Asociación Solar de la Industria Térmica* has the mission to become a meeting and representing forum for the sector, to discuss ideas and reach an agreement on actions to promote and improve the use and development of Solar Thermal Energy in the whole country.
www. asit-solar.com

The *Comité Español de Iluminación* aims at promoting all activities related to lighting, in its widest and varied aspects, scientific and technical, promoting studies, research, development and innovation as well as methods, regulations and standardization related to lighting.
www.ceisp.com

4.3 Swedish Institutions

4.3.1 Public Institutions

The National Board of Housing, Building and Planning – Boverket – 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 Boverket also provides information to those engaged in planning, housing, construction and building inspection activities.

The Swedish Energy Agency 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.

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.

IVL Svenska Miljöinstitutet coordinates different projects on low-energy houses www.ivl.se

4.3.2 Private Associations and Institutions

Forum för Energieffektiva byggnader 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 buildning of more passiv and low-energy houses. http://www.passivhus.nu/

Resurseffektiva byggnader. This website is a platform for information to proprietors, builders and contractors to make it easier to chose energyefficient components for the buildings.
http://www.husutanvarmesystem.se/intelligens/kund/sida.asp?site_id=1&sida=2

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- News from national planning/ Landsplan nyt. Information fra Miljø- og Energiministeriet, Landsplanafdelingen, Kbh.: Miljø- og Energiministeriet, Landsplanafdelingen
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- The City and Harbour Engineer / Stads- og havneingeniøren, Fagblad for teknik og miljø - Silkeborg: Kommunalteknisk Chefforening
- Landscape / Landskab, Kbh.: Arkitektens Forlag

6.2 Relevant Spanish Magazines

- Energías renovables
- Solar News, especializada en el sector de la energía solar
- Nuevas Tecnologías, Revista de eficiencia energética, Sostenibilidad, renovables y gestión técnica de las instalaciones
- InfoPower, Actualidad y Tecnología de Producción y Uso Eficiente de Energía
- Energética XXI, Revista de Generación de Energía
- Tecno Energía, Revista profesional de energía y medio ambiente
- Revista NAN arquitectura y construcción
- Infodomus, Construcción Sostenible y Edificios Inteligentes
- Tecno Ambiente, Revista profesional de Tecnología y equipamiento de ingeniería ambiental
- El instalador
- Electra

6.3 Relevant Swedish Magazines

- Energi & miljö: tidskrift för VVS, inneklimat och VA
- Bioenergi
- Energimagasinet
- Miljöforskning

7 LINKS OF INTEREST

7.1 Danish Links

The Danish Centre for City Ecology; www.dcue.dk
The Danish Building Institute; www.sbi.dk
The Danish Energy Authority; www.ens.dk
The electricity saving Foundation; www.elsparefonden.dk
Passive house association; www.passivhus.dk/danske_passivhuse.htm
The Danish insulation producer - Rockwool; www.rockwool.dk
The Danish Technological Institute; www.teknologisk.dk
Energy windows information; www.energiruder.dk
The Eco-building project; www.ecobuilding.dk
The Danish producer of ventilation systems; www.ecovent.com
Information web about sustainable buildings; www.groenthus.dk/dk/default.asp

7.2 Spanish Links

Ministerio de la vivienda; www.mviv.es
Secretaría General de la Energía; www.mityc.es/energia
Instituto para la diversificación y el ahorro de la energía; www.idae.es
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT); www.ciemat.es
Centro Nacional de Energías Renovables (CENER); www.cener.com
Asociación de la Industria Fotovoltaica; www.asif.org
Asociación Solar de la Industria Térmica; www.asit-solar.com
Comisión Nacional de la Energía (CNE); www.cne.es
Asociación para el Desarrollo de la Casa Bioclimática; www.casabioclimatica.com
Biblioteca CF+S Ciudades para un futuro más sostenible, http://habitat.aq.upm.es/
Comité Español de Iluminación; www.ceisp.com
Asociación de Constructores Promotores de España; www.apce.es
Asociación de Empresas Constructoras de Ámbito Nacional; www.seopan.es
Fundación Laboral de la Construcción; www.fundacionlaboral.org
Asociación nacional de industriales de materiales aislantes; www.andima.es
Consejo General de la Arquitectura Técnica; www.arquitectura-tecnica.com
Asociación de Empresas Restauradoras del Paisaje y del Medio Ambiente (ASERPYMA); www.aserpyma.es
Bioconstrucción, www.bioconstruccion.biz
Sólo Arquitectura, www.soloarquitectura.com
Construible, www.construible.es

7.3 Swedish Links

The National Board of Housing, Building and Planning – Boverket;
http://www.boverket.se/shopping/ShowItem.aspx?id=2331&epslanguage=SV
Swedish Energy Agency;
http://www.energimyndigheten.se/WEB/STEMEx01Swe.nsf/F_PreGen01?ReadForm&MenuSelect=6E232D2E9C021723C12571E60023A1B3

Forum för Energieffektiva Byggnader; http://www.passivhus.nu/
Swedish Association of Architects; http://www.arkitekt.se/s14338
Västra Götalandsregionen;
http://www.vgregion.se/vgrtemplates/BildRightPage____42135.aspx
Lunds Universitet; http://www.ebd.lth.se/forskning/passivhus_demonstrationsprojekt/
IVL Svenska Miljöinstitutet; http://www.ivl.se/AnsokningarPassivhusprojekt.htm
ByggaBoDialogen; www.byggabodialogen.se

Report on the state of the art in bioclimatic architecture and integration of renewable energies in buildings

D.2.0.4.1.

CONTENTS

1 REGULATIONS

1.1 Spanish Regulations

Normas Básicas de la Edificación:[1] Condiciones Térmicas de los Edificios (NBE-CT-79)[2]

Through Decree 1490/75, of 12 June, the public Administration took the first measures aiming at the achieving of energy saving by means of an adequate construction of buildings, thus tackling with the problems derived from the rise in the price of energy.

NBE-CT-79 replaced the former Decree (except for articles 6 and 7, fluids' insulation and regulation of installations, which remained in force). This regulation was approved through **Royal Decree 2429/79** of 6 July 1979.

Regulations from year 79 set the thermal conditions required of buildings, as well as the determining features, and defined as application field all kind of completely new buildings, except the ones that, due to their use, should remain open.

Apart from principles aiming at energy saving, the mentioned regulations included other thermal or hygrothermal aspects that affect buildings and their habitability conditions, stressing subjects that had no been regulated before, such condensation phenomena in the building envelope that affect to the building users comfort.

For this NBE purposes, building are thermally defined by the following concepts:
a) Global heat transmission through the whole of the building envelope, defined by its K_G factor.
b) Heat transmission through each of the elements that make up the building envelope, defined by their K factors.
c) Higrothermal performance of envelopes.
d) Air permeability of envelopes.

This regulation forced to meet a number of requirements and conditions, such as:

- That the global thermal factor K_G of a building cannot be higher that a given value, that will be set according to the factor of the climate zone of the site and the type of energy used in the heating system.
- That the K thermal transmission usable factors of envelopes, excluding the spaces, do not rise over certain values, given by the envelope and the climate zone.
- That the thermal resistance and the constructive layout of the envelope elements be such that in the environmental conditions considered by the Regulation, the envelope will not show condensation humidities neither in its interior surface, nor within the envelope mass, that damage its conditions, nor occasional ones that might damage other elements.

[1] *Basic Building Regulations N.B.E*
[2] *Buildings' Thermal Conditions NBE-CT-89*

- It considers as interior environment conditions the use ones, and the exterior conditions are classified according to two climate zones: one based in 15-15 degrees/day data and, the other, in minimum temperatures in the month of January.
- It considers ground temperature according to climate zones and forces to considerate 95% external relative humidity in order to make the calculations.
- It sets the air permeability of a carpentry frame defined by its class of air tightness. According climate zones, the carpentry should be of a given class.

Reglamento de instalaciones de calefacción, climatización y A.C.S[3]

This regulation was approved by **Royal Decree 1618/80** of 4 July (B.O.E. 06-08-80) and came up due to the importance that non industrial thermal installations was reaching and its increase as a result of the increase of the Spanish standard of living. These facts recommended a global administrative action on the sector, aiming at rationalizing the energy consumption, without decreasing the users 'comfort'.

As energy saving issues are closely linked to pollution, quality and safety issues in heating, air conditioning and domestic water heating, and not having a basic regulation about them, it was necessary to draw regulations that set the required rules to get rational energy consumptions, setting at the same time quality, safety levels and defence of the environment measures in those installations.

The object of the present regulation was to define the conditions for installations that use energy with non industrial aims in order to achieve a rational use of the energy, taking into account its quality and safety and the protection of the environment. The systems installed in air, maritime or terrestrial transport means were excluded of these regulations, as they will be regulated by special arrangements.

Among the different requirements stated in the regulations, there are references to additional technical instructions that should be comply with by non industrial thermal installations and will be developed later on.

The regulation also includes the creation of the '*Comisión Permanente para el Ahorro de Energía en Instalaciones Térmicas de la Edificación*'[4] , whose missions are as follows:

a) the study and gathering of new technological advances in energy saving in installations regarded by this regulation, channeling the relevant proposals made by manufacturers, installers, designers, users, maintenance and repairer technicians.
b) to study and propose new technical instructions and improvement of the existing ones when appropriate.
c) to inform of the proposals made about the 'technical recommendations' mentioned in article eight.
d) to analize the obtained results after applying the regulations, proposing the correcting measures where considered appropriate.

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[3] *Regulations for heating, air conditioning and hot domestic water installations.*
[4] *Permanent Commission for Energy Saving in Thermal Installations in Buildings*

e) to carry out all the research or works commissioned by their superiors.

Instrucciones Técnicas Complementarias I.T.I.C.[5]

The *Instrucciones Técnicas Complementarias* were approved by **Ministry Order of 16 July 1981** (BOE Nº 193, de 13.8.1981), according to the decreed in the *Reglamento de Instalaciones Calefacción, Climatización y Agua Caliente Sanitaria*, with the aim to racionalize its energy consumption.

The regulations comprise the basic regulations of more general and permanent nature, whereas the technical additional instructions comprise the regulations applicable in the present to the aforementioned installations, with the fundamental object of gaining energy savings, and can be reviewed in the future due to the need to be adapted to the development and evolution of technologies.

Reglamento de Instalaciones Térmicas en los Edificios (RITE)[6]

The *Reglamento de Instalaciones de Calefacción, Climatización y Agua Caliente Sanitaria*, approved by Royal Decree 1618/1980, contributed to a great extent to foster and impulse a more rational use of energy in non industrial thermal installations in buildings, generally used to supply in a safe and efficient way with heating, air conditioning and hot domestic water services to meet the needs of thermal comfort and hygiene in buildings.

The experience adquired from its implementation, the technological advances in this field, the new distribution of powers as a result of the State of Autonomous Regions development and, finally, the membership of Spain to the European Union made the drawing of a new regulation necessary, one that based on the previous one, took into consideration the existing factors and continued the advance in the rational use policy established in the *Plan de Ahorro y Eficiencia Energética*[7] included in the *Plan Energético Nacional*[8] 1991-2000.

As a result of adopting different Community provisions in the field of free circulation of goods as well as in the field of rational use of energy and the reduction of carbon dioxide emmissions, it was also necessary to modify the existing regulations to take into account the following Directives of the Council:

- 89/106/EEC on building products
- 92/42/EEC on performance requirements for new hot water boilers fed with liquid and gas fuels.
- 93/76/EEC related to the limitation in carbon dioxide emmissions by means of improving energy performance (SAVE)

[5] *Additional Technical Instructions I.T.I.C*
[6] *Regulation of Thermal Installations in Buildings* (RITE)
[7] *Energy Saving and Efficiency Plan.*
[8] *National Energy Plan.*

The reach of the changes made on the regulations text in force and its additional technical instruccions, both in form and content, recommended to draw a new text to repeal and replace the former one and the developing additional technical instructions. This new text was approved by **Royal Decree 1751/98** of 31 July, that approved the *Reglamento de Instalaciones Térmicas en los Edificios (RITE)* and its *Instrucciones Técnicas Complementarias (ITE)* while creating the *Comisión Asesora para las Instalaciones Térmicas de los Edificios*[9].

The *Comisión Asesora para las Instalaciones Térmicas de los Edificios*, that takes the place of the *Comisión Permanente para el Ahorro de Energía en Instalaciones Térmicas de la Edificación*, will be a standing voting body with the specific mission of advising in issues related to thermal installations in buildings by means of the following actions:

b) To study and propose new technical instructions and review of the existing ones when appropriate.
b) To estudy and collect, when appropriate, the new technical advances in rational use of energy, proposing the adequate changes to the Ministries of Industry, Energy and Public Works and Building, channeling the related suggestions made by public administrations, manufacturers, designers, installers, users and energy maintenance technicians and suppliers.
c) To study international actions on the issue and, particularly, the ones coming from the European Union, proposing the appropriate actions.
d) To analize the obtained results by applying the regulations, proposing the measures and criteria for right interpretation and homogeneous implementation where considered appropriate.

Ley de Ordenación de la Edificación[10] (L.O.E)

Law 38/1999 of 5 November 1999, L.O.E, was conceived in view of the lack of legal bases for building construction, which was mainly regulated by the Civil Code and a variety of regulations that, as a whole, had many gaps in planning the complex process of building, so much in issues related to identification, obligations and risponsibilities of the involved actors as in reference to guarantees to protect the user.

Also, society demanded more and more quality in buildings and that had repercussions on the structural safety and protection against fire as well as on other aspects linked to people’s comfort such as protections against noise, thermal insulation or accesibility for people with limited mobility.

The top priority of the LOE was to regulate the building process, updating and completing the legal configuration of the participant agents, setting their obligations in order to establish risponsibilities and cover the users’ guarantees by defining the basic requirements for buildings to be complied with.

[9] *Advisory Commission for Thermal Installations in Buildings.*
[10] *Building Planning Law (L.O.E)*

To do so, the building legal concept and the basic principles that should lead this activity were defined and the scope of the Law was delimited, specifying the works both completely new buildings and existing ones to which it would apply.

The Law set the basic requirements that buildings should meet, in a way that users' guarantees would not only be based on technical building requirements but also in the establisment of a caution or safety insurance.

These requirements cover so much building functional nature and safecty aspects as those relative to habitability.

Código Técnico de la Edificación[11] (CTE)

The *Código Técnico de la Edificación* stands as a new structured regulation frame that identifies, arranges and completes the existing technical regulations, pretending to facilitate its aplication and fulfilment, and all that in harmony with European regulations. It was approved on 17 May 2006 by **Royal Decree 314/2006**, and published on BOE of 28 March.

The *Código Técnico de la Edificación* enforces the basic requirements in building set by *Ley de Ordenación de la Edificación*, aiming at guaranteeing people's safety, society comfort, sustainability of building and the environment safeguard.

The approval of the *Código Técnico de la Edificación* means the improvement and updating of the building regulation frame in Spain present at the time, regulated by Royal decree 1650/1977 of 10 June, on building regulations, that implemented the *Normas Básicas de la Edificación* as mandatory in building projects and works. Within this legal frame, several regulations were approved since 1979, which made up an open group cf dispositions that has been meeting different society requirements, but that never got to be a coordinated body in the form of a Technical Building Regulation, similar to the ones existing in other more advanced countries.

With the aim to improve building quality and to promote innovation and sustainability, the CTE sets the basic quality requirements for buildings and installations. By means of this regulation, certain basic building requirements related to people safety and comfort are met. These requirements refer to structural safety and protection against fire as well as healthiness, protection against noise, energy saving or accesibility for people with limited mobility.

Also, the *Código Técnico de la Edificación* creates an equivalent regulation frame to the existent in more advanced countries and levels the national building regulations existent with the current European regulations in this issue. Firstable, with the regulations related to free circulation of building products inside an only European market. Secondly, Directive 2002/91/CE of European Parliament and Council, of 16 December, relative to energy performance in buildings has to be taken into account as it was used to add to the

[11] *Technical Building Regulations (CTE)*

Código Técnico de la Edificación the requirements relative to energy performance in buildings set by that Directive in articles 4,5 and 6.

The *Código Técnico de la Edificación* is divided in two parts, both of them regulatory. The first one comprises the general dispositions (implementation scope, uses classification, etc.) and the requirements buildings have to comply with to meet the building safety and habitability requirements.

The second part is formed by the Basic Documents, whose adequate implementation ensures the achievement of the basic requirements. Those comprise procedures, technical codes and solution examples that permit determine whether the building cumplies with the established standards of service. Those Documents are not excluding. The *Documentos Reconocidos* were created as a complement for the implementation of the Código, those being technical documents, external and independent from the Código, whose use facilitates the compliance of some demands and contribute to the increase of building quality.

Basic Document '*DB-HE Ahorro de Energía*'[12] especifies the objective parameters and the procedures whose compliance ensures the meeting of basic requirements and the overcoming of the minimum quality standard inherent to the basic requirement of energy saving.

1.2 Swedish Regulations

Regulations set by the National Board of Housing, Building and Planning – BBR 2006

On 1 July 2006, the new Swedish regulation on dwellings came into force (*BBR 2006*). In short, this is what the regulation stipulates about energy demand (the regulation also deals with design, durability, fire protection, hygiene and health, environmental aspects, and noise):

For residential buildings, the energy demand must not exceed 110 kWh per m^2 floor area (A_{temp}) in the south of Sweden and 130 kWh per m^2 in the northern part of the country. For residential houses with electric radiators the energy demand must not exceed 75 kWh per m^2 floor area (A_{temp}) in the south of Sweden and 95 kWh per m^2 in the northern part. A_{temp} is the floor area of spaces aimed for heating to more than 10 ^{o}C. The garage is not taken into account as a part of the floor area. The energy demand may be reduced with energy from solar panels and photovoltaic cells integrated in the building. The highest average u-value for the surrounding building parts must not exceed 0.50 W/m^2K.

For other premises than residential, the specific energy demand must not exceed 100 kWh per m^2 floorarea (A_{temp}) in the south of Sweden and 120 kWh per m^2 in the northern part of the country. Premises with an airflow larger than 0.35 l/s,m^2 may add the equivalent of 70(q-0.35) kWh per m^2 floor area (A_{temp})in the south of Sweden and 90(q-0.35) kWh per m^2 floor area in the northern part, where q is the mean air flow for the heating season in l/s,m^2. The energy demand may be reduced with energy from solar

[12] *'DB-HE Energy Saving'*

panels and photovoltaic cells integrated in the building. Garages are not taken into account as a part of the floor area (if not a building on its own). The highest average u-value for the surrounding building parts must not exceed 0.70 W/m^{2}K.

For buildings containing both residential spaces and other premises, the regulations are based in proportion to the floor area.

For buildings where the floor area (A_{temp}) is less than 100 m^2, the window and door areas are less than 0.20 A_{temp}, and where there is no demand for cooling; some alternative regulations may be used.

Maximum u-values for the building parts:
U_{roof} 0.13 W/m^{2}K
U_{wall} 0.18 W/m^{2}K
U_{floor} 0.15 W/m^{2}K
U_{window} 1.3 W/m^{2}K
U_{door} 1.3 W/m^{2}K

For residential houses with electric radiators the following maximum u-values for the different building parts must not be exceeded:
U_{roof} 0.08 W/m^{2}K
U_{wall} 0.10 W/m^{2}K
U_{floor} 0.10 W/m^{2}K
U_{window} 1.1 W/m^{2}K
U_{door} 1.1 W/m^{2}K

The average air leakage at +50 Pa must not exceed 0.6 l/s m^2.

If the floor area (A_{temp}) is more than 60m^2, the building must have a ventilation system with heat recovery of 70 % efficiency or a heat pump in the outgoing air.

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 has been taken into consideration but adjusted to the Nordic climate.

Apart from the basic requirements described in BBR 2006 above, the requirements for a *passivhus* is very restrictive for the total use of bought energy (household demand, hot water, heating and cooling). A_{temp} is defined in the same way as in *BBR 2006* (the floor area of spaces aimed for heating to more than 10 ^{o}C).

Maximum output for the building is P_{max} = 10 W/m^2 in the south and P_{max} = 14 W/m^2 in the north of Sweden. The indoor temperature is specified at 20 ^{o}C and heat from persons and household appliances of 4 W/m^2 may be included. For buildings less that 200 m^2 the maximum output is allowed to be 2 W/m^2 higher.

Maximum energy demand (excluding electricity for household appliances), is set at 45 kWh/m^2 in the south of Sweden, and 55 kWh/m^2 in the northern part. For buildings less that 200 m^2 the maximum energy demand is allowed to be 10 kWh/m^2 higher than above.

The use of hot water is presumed to be 20% less than the standard use.

The average air leakage at +/-50 Pa must not exceed 0.3 l/s m^2.

To be able to verify the energy demand for household appliances and heating, the energy use is to be monitored separately on a monthly basis. The hot and cold water use is also to be monitored. The maximum allowed u-value for the windows is 0.9 W/m^{2}K.

2 REFERENCES

2.1 Denmark

2.1.1 Bioclimatic Buildings

Skotteparken

Skotteparken in Egebjerggård, Ballerup, is an EU Thermie supported experimental building project with 100 solar heating - low-energy dwellings, where the aim is to reduce the gas consumption for heating and domestic hot water with 60% compared to normal building projects. And at the same time reduce the consumption of electricity and water. The apartments in Skotteparken were already built in 1992.

Ballerup is situated 15 kilometres from the capital of Denmark, København, straddling the border between greater København and the countryside. The municipality of Ballerup is the home for approximately 45,000 inhabitants.

The basis for the project was that extra investments in energy saving measures of approx. 8% of the normal building costs should be corresponded to by savings on the operation, especially as regards expenses for heating, water and electricity. 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 in Skotteparken are as follows:

- Extra insulation, which is mostly added in the ceilings with a total thickness of 375 mm. The apartments are aimed airtight making the natural air change as low as 0.1 times per hour
- Thermo glazing is used everywhere with two layer windows with an air gap of 15 mm. The windows have a U-value of approximately 1.4 W/m2K.
- Ventilation system with counter-flow, heat recovery is utilised 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 m^2 solar collector 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 armatures in showers and two-step water saving armatures in kitchens and bathrooms
- Electricity savings
- Rain water from roofs and streets is via open drains carried to a small lake to help maintaining the ground water.

The most innovative aspect are the six, solar heating systems with approximately 100 m^2 of solar collector 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 the summertime. 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.

The results from a finalised monitoring campaign documents 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 m^2 solar collector area in all shows an annual solar heating yield in a normal year of 274 kWh per m^2 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 m^2 solar collector. 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.

The main results for the project in Skotteparken can be summarised as follows:

- The normal amount of energy used for heating and hot water has been reduced of 180 kWh/m2 (normal housing) to 92 kWh/m2 in 1993, to 82 kWh/m2 in 1994, reaching 77 kWh/m2 in 1995.
- 65 % savings of district heating network losses was obtained from the low temperature pulse operation.
- Solar system yields 274 kWh/m2 (which corresponds to 382 kWh/m2 when including saved network losses).
- Heating bills only 4.42 Euro/m2 which equals approximately 40 % of a "normal" heat bill.
- A good economic saving for the tenants based on an extra investment of approximately 8% compared to normal housing and grants from external sources.

Source:

Combined low and solar energy design in Egebjerggård, Denmark; Peder Vejsig Pedersen
SOLAR DISTRICT HEATING – BALLERUP (Denmark); Miljø Afdelingen; Peder Vejsig Pedersen

2.2 Spain

2.2.1 Bioclimatic buildings

CENER Building

This building is located in the City of Innovation, in Sarriguren, Navarre, and it is the headquarters of the *Centro Nacional de Energías Renovables (CENER)*[13], Centre of research and Technology that fosters the technological development of Renewable Energies. Its area is about 5,000 square metres.

The building was designed taking into account the most advanced bioclimatic and environmental criteria for energy saving and environmental care. It has both active and pasive architectural elements, being the outstanding ones:

- Active: Vacuum tube thermal collectors for domestic water heating, and for radiant floor (absorption system) heating and cooling, radiant floor heat/cold; awning, shutters, windows and ventilation automatisms.
- Pasive: Balcony-greenhouse for solar capture for heating; high inertia walls and framing; chimney for ventilation in summer; lower ground floor effect; insulating shutter; sun shading awnings; wind tower to capture north wind and plant cover.

Out of the pasive architectural elements, is worth mentioning the bioclimatic balcony, called 'bioclimatic device', that is located in the upper part of the pavillions where the research ares of the Centre are located. From the environmental point of view, it gives the building the maximum bioclimatic advantage out of solar and wind energy: it collects, transforms, storages and distributes the energy along the respective pavillions. In this balcony there are also integrated most of the active environmental protection means and the cooling effects of the plant covers.

On the other hand, and inside the premises, there are two features that outstand due to their non conventional make, as they include energy saving and sustainability criteria:

- Heat/cold generation: The system is based on absorption cycle, feeding the generator with high temperature water (around 100º C) that comes from the vacuum solar collectors integrated in the building roofs, backed by natural gas boilers.
- Watering system: All plant covers in the building are equipped with a trickle irrigation system (minimum consumption), getting the water out of a tank that collects all the rainwater so, both the rainwater plus the possible remaining water

[13] *National Centre of Renewable Energies (CENER)*

that does not evaporates from the trickle irrigation system will be use for watering in the building.

As for the building materials, the option was not to use reusable or biodegradable elements, choosing those more efficient from the technical and energy point of view.

CENIFER Building

This is a 400 square metre building, located in Imarcoain (Navarre), that belongs to the *Centro Integrado Nacional de Formación en Energías Renovables CENIFER*[14], that is used as demonstrative building, reception building, to impart training, as a conference hall, as training bench for students, apart from the research made by the teachers at the Centre.

It has all type of active and pasive installations to reach an energy balance close to zero: solar thermal installation; water tank to store energy between seasons; heating and cooling through radiant floor and wall; solar photovoltaic installation grid connected; greenhouse with direct solar capture and ventilation; Trombe wall; external insulation of building envelope with ventilated façade; well water cooling and forced ventilation with thermosolar shunt.

Each of the architectural elements and installations used are explained below:

Architectural elements

The **general building envelope** consists of a ventilated façade with high inner thermal energy, made up by five elements:

- External coating made out of ceramic tiles
- 3 cm ventilated chamber
- Thermal insulation made out of 8 cm rockwool.
- High thermal inertia inner wall
- Radiant strip heater

This envelope is completed with inner flooring with radiant floor and a flat trafficable roof that serves as a platform to the pergola that holds the solar thermal and photovoltaic panels.

Among the building pasive solar energy systems, is worth mentioning the **greenhouse**. In summertime, the capturing cover is protected with a system of motor operated slatted shutters, placed inside the external window framing. The upper and lower hatches, motor operated and automatic, open to get a forced ventilation to refresh the air, avoiding the inside to get hot with the air. In winter, the radiation that gets inside the greenhouse is absorbed inside, becoming heat that gets stored in floor and walls, from where is transmitted inside the building through radiation. At the same time, the air inside the greenhouse becomes hot and gets into the building through forced convection by means of some fans located in its upper side. The greenhouse's floor and wall, with a substantial thermal inertia, absorb radiation, storing thermal energy and giving it to the air with delay

[14] *Integrated National Centre for Training in Renewable Energies CENIFER*

and absorption, through convection and long wave, what minimizes losses through the glazing.
It has an estimated thermal output of 10,800 Kwh in winter and 14,245 Kwh both in spring and autumn.

The **Trombe wall** is other of the used pasive systems. It is formed by a glazing wall placed next to a double massive wall that has a little internal ventilated chamber. The solar radiation that reaches the wall and goes through the glazing, heats the external wall, which is painted in a matt dark colour. In turn, this wall heats the inner wall and the circulating air in the chamber between them through radiation. This chamber has automatic hatches and fans.

In summer, these hatches open the chamber to the exterior, getting forced ventilation that avoids the heat getting inside. In winter, the hatches open the internal chamber to the inside of the building, allowing the entrance of hot air. It has a thermal output of 4,970 Kwh in winter and 6,500 Kwh both in spring and autumn. The annual saving in emmissions is 33 kg of SO_2, 10 kg NOx and 2,640 kg CO_2.

The **solar thermal shunt** is for exclusive winter use. It refreshes the inside of the building by means of forced ventilation coming from a shaded landscaped area in the North side of the building. The air is introduced from there through four ceramic conducts, using fans to force ventilation Those conducts are buried at 1.8 m depth and go up to the south façade, where they come into the interior, the air going up towards the roofing shunt as it gets warmer. It has a cooling output of 2,838,000 frigories in summer. The annual saving in emmissions is 6,8 kg of SO2, 2 kg NOx and 545 kg CO2.

Installations

The **solar thermal installation** is made up by 24 2.5 sq.m. useful area panels, located on the building roof and south orientated with a 50º tilt. This way, they make the most of solar radiation to warm the heat transmitting fluid that circulates inside them. They meet 100% of domestic hot water needs and 44% of heating ones. The annual saving in emmissions is 102 kg of SO2, 32 kg NOx and 8.251 kg CO2.

The **big storage tank**, built under the greenhouse, has the function of storing the excedent energy from the solar thermal panels to be used in the heating circuit in days with low solar radiation. It has 40,000 l. capacity, made out of stainless steel and has a perimeter covering of 30 cm of granulated cork that acts as insulation. This extra insulation provides an energy saving estimated in 18%.

The **radiant floor and strip** is made up of a series of reticulated polystyrene conducts, fitted into the floor and wall strips, inside of which circulates water. They absorb heat in summer in the cool well water that circulates inside them, and in winter they release heat through the hot circulating water that comes from the storage tank and has been heated by the solar thermal panels. These radiators can transmit 35,000 kcal/h. The energy saving in this low temperature radiation system compared to the common convection radiators is 23%.

A system based on **cooling through sensor**, which uses subsoil water, floor system water and radiant strip is used to cool the building in summer. The system works with an immersion pump that placed at 8 m depth inside a well in the north face of the building, pumps the water to the radiant elements, circulating along them and returning to phreatic level.
The absortion capacity of this element is 15,000 frigories/h. This system annual saving in emmissions is 3 kg of SO_2, 1 kg NO_x and 248 kg CO_2.

There is a 5 Kw grid connected **solar photovoltaic system** installed in the building. It consists of 68 monocrystalline photovoltaic panels of 80 Wp, placed in the building roof and orientated to south with 30º tilt and 2 2.5 Kw inverters.
The estimated annual output is 7,440 Kwh (20.38 Kwh average daily output). Those outputs intend to meet the building energy consumption. The annual saving in emmissions is 15 kg of SO_2, 4,8 kg NO_x and 1.228 kg CO_2.

2.2.2 Eco-cities

Residencial Parque Goya

In 1995, the *Dirección General de Obras Públicas y Urbanismo del Gobierno de Aragón* y el *Instituto del Suelo y de la Vivienda de Aragón (ISVA)* started to develop a Partial Plan in a 53.7 Ha area in the north of the city of Zaragoza.

The objective was to promote 3,500 officially protected housing and to reduce CO_2 emmissions as specific aim, considering the European Directive 93/76/CEE. The development and building design according to the architectural criteria included in the Partial Plan would account for a potential 60% decrease in the buildings energy demands (heating, cooling, domestic hot water and lighting) compared to the values given by complying with the regulations and a little lower respect to the usual typology of the area.

As a novelty respect to any other previous town planning activity, the Partial Plan of Residencial Parque Goya had some specific clauses in regulating bylaws related to bioclimatic determining factors of buildings.

This action was funded by the European Commission with a Thermie Project (n. BU 178/95) that affected to three buildings in the first stage: parcels P-4 (178 flats), P-11 (50 flats) y PU-9 (26 houses).

Key features

Some of the mandatory concepts in the Partial Plan town planning design or in the Terms and Specifications corcerning all buildings in Parque Residencial Goya are:

- Street orientation, buildings' distribution and heights to favour solar radiation capture in south facing façades.
- Higher insulation than required by regulations (<25%).
- 50% or higher glazing in south façades, with optional glazed balconies, and minimum in north façades.
- Carpentry framing of better quality than required by regulations.
- Plenty of green areas, areas of water and adequately coloured materials.

In the three buildings selected by Project Thermie, the mainly used elements are:

- Use of greenhouse-balconies with thermal load walls.
- Insulation higher than usual, double glazing and top quality carpentry framing regarding infiltrations.
- Collective auxiliary systems with low temperature boilers (high efficiency) or condensation ones and solar thermal collectors.
- Individualized control of heating and domestic hot water consumption.

Location

The residential neighbourghood Parque Goya is located in the city of Zaragoza, capital of the Autonomous Region of Aragón, situated in the centre of the Ebro Valley, 41º39' north latitude.

The climate is Mediterranean, eventhough it has strong continental influences, as it can be seen by the extreme temperatures: high temperatures in summer and low in winter, with NW-NWW winds (*cierzo*) that increase the feeling of discomfort.

The most characteristic climate variables of the zone can be seen in the table below:

Month	Average daily temperature (ºC)	Horizontal solar radiation (MJ/m^2 day)	Vertical solar radiationsouth (MJ/m2 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

Table 1: Climate variables. Data obtained from *Atlas de Radiación Solar de Aragón* and from *Datos Climáticos de Aragón.*

Description

The selected buildings for specific actions represent the three typologies existing in the development (semi-detached hoses PU-9, collective buildings with double corridor P-4 or quadruple corridor P-11).

Insulation and thermal inertia

After the initial studies, the town planning project established as a specific regulation that the insulation value should be 25% higher than defined in the current regulations.

The table below show the U values (W/sq.m.K) corresponding to each building external envelope respect to the values required by Spanish regulations.

U-conductance (W/sq.m.K)	National regulations (NBE-CT-79)	Building P-4 (178 flats)	Building P-11 (50 flats)	Building PU-9 (26 semi-det)
External wall	1,6	0,44	0,64	0,39
Mass walls	1,8	0,88	1,47	1,47
Roofing	1,2	0,22	0,33	0,28
External framing	1,4	0,26	0,42	0,86
South and east windows	5,8	3,3	3,3	3,3
North and east windows	5,8	2,6	2,6	3,3

Thermal bridges in pillars and girders were eliminated through external insulation in order to reduce energy losses. Also, double window framing has been used in façades N and W to reduce transmission or infiltration losses in those façades, affected by the dominant wind, the '*Cierzo*' which can reach high speeds.

The buildings have a high thermal inertia, reinforced in the most compact ones (building P-11), lower in building P-4 and clearly lower in the semi-detached houses. The inertia has been increased by placing the insulation in the external side of the envelope, the roofing and ground floor framing. Also, materials with high inertia were used, such as Airblock (19 cm in P-11) and Termoarcilla (19 cm in P-4 and PU-9).

With this features, the buildings experience slight fluctuations of interior temperature at night, when the auxiliary heating is off. All the same, with night ventilation, the inertia allows to reduce maximum day temperature in a way that most of the time, it remains within comfort conditions.

Solar gain

The buildings' main façade are south orientated with no shadings in winter. This was done all through the development. The area of glazing was increased in all south façades, making also greenhouses with no preheated air. To increase the captation effect and make the most of the captation delay in greenhouses, mass walls were used (29 cm blocks filled with sand and concrete or 19 cm termoarcilla —thermal clay— blocks). The glazing area was reduced in façades east, west and north, as solar captation is very low (N) or can generate overheating in summer (E, W). The inside distribution of the houses leaves the south for living areas, while kitchen, bathrooms and stairs are placed north.

The overheating due to solar captation in summer gets reduced by eaves or mobile elements (shutters). Also, the distribution of the house allows natural ventilation, very convenient in summer nights. The use of clear colour pavement, landscaped areas with gardens and trees also improves comfort in summer, reducing the overheating effect in streets.

Heating and solar collector

The heating system used (low temperature boilers) in each of the three buildings is collective, being more efficient than individual heating systems.

The total installed collector surface in the development in its first stage was 600 sq.m.

Technical results

The three selected buildings were monitored during two years. The interior temperatures of north and south rooms, the greenhouses and the inner temperature of especially built walls were specifically measured. Humidity in the south zone and heating consumption in the houses were also measured. All these parameters were recorded each 10 minutes. The number of monitored houses was 9 in block P-4, 12 in block P-11 and 6 in PU-9.

Starting from consumption and monitored temperatures in the houses, the consumptions were extrapolated to a common scale to get identical interior temperatures (20º C). That was how results showed in table 2 were obtained.

Average annual consumption in kwh/sq.m	2000-2001	2001-2002
P-4 (178 flats, mostly south oriented)	20	21
P-11 (50 flats, 16 out of them facing north)	35	32,5
PU-9 (26 semi-detached houses, south oriented)	48	41

Table 2: Results of unitary heating consumption in the three buildings

2.3 Sweden

2.3.1 Bioclimatic buildings

Lindås

In Lindås, 20 km south of Gothenburg, 20 low-energy terraced houses have been built. 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. Big windows facing south are combined with balconies and roof overhang to shield from too much sun and high temperatures during summer. A roof window gives light also to the middle of the house and can be used to air the house on hot summer days.

The energy-saving features of Lindås are as follows:

- Extra insulation
- **External wall**:
  U-value 0.10 W/m^{2}K
  Bolt wall with 43 cm isolation.
- **External roof**:
  U-value: 0.08 W/m^{2}K
  Masonite balk med 48 cm isolation.
- **Floor**:
  U-value: 0.09 W/m^{2}K
  concrete board with 25 cm isolation.
- **Windows**:
  U-value: 0.85 W/m^{2}K
  Three glass with two metal layers and krypton gas.
- **Doors**:
  U-value: 0.80 W/m^{2}K

- a ventilation system with counter-flow heat recovery of 85 % efficiency

- 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.

The residents moved into their terraced houses in 2001. The majority of the residents are content with the temperature of 20-23 ^{o}C. 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.

http://www.egnahem-goteborg.se/prod/egnahems/dalis2.nsf/535e371e7fd657aec1256a5c0045675f/6280a39fe9d3eb4fc125710f00586292!OpenDocument

Glumslöv, Landskrona

In Glumslöv north of Landskrona lies 35 terraced houses built in 2004. Fully developed and reliable techniques have been used in these dwellings. In a ventilation system with counter-flow heat recovery of 85 % efficiency the incoming air is heated with the outgoing air. The very limited space heating demand is covered by electric resistance heating, 700 W, in the supply air. The total energy demand is calculated as approximately 50-60 kWh/m^2.

U-values for the dwellings:
Windows = 0.9 – 1.0
External walls = 0.10
External Roof = 0.08
Floor = 0.10

http://www.husutanvarmesystem.se/intelligens/sites/reby/filer/T28-C-brochure_Landskrona_SE.pdf

Oxtorget, Värnamo

In Värnamo, 40 apartments with a very low energy need stood ready in 2006. The houses have extra insulation; windows and doors have a low u-value; and balconies and roof overhang protect from too much sun during summer months. 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. 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.

U-values for the dwellings:
Windows = 0.85
External walls = 0.10
External roof = 0.08
Doors = 0.6
Floor = 0.09

http://www.oxtorget.se/eng/index.htm

Frillesås, Kungsbacka

In Kungsbacka, three low-energy dwellings with12 apartments were built in 2006. Roof, walls, windows, doors and floor have a very low u-value. A ventilation system with an

efficient counter-flow heat recovery diminishes the heating demand. Hot water comes from solar panels and district heating.

Lidköping

In Lidköping, a detached house is soon ready for the residents to move into. This is the first low-energy detached house to be built in Sweden. The house is highly isolated and has a ventilation system with an 85 % efficient counter-flow heat recovery. Hot water is heated by district heating. As a back-up, district heating can be used to heat the incoming air in the ventilation system.

U-values for the dwellings:
Windows = 0.85
External walls = 0.09
External roof = 0.07
Doors = 1.0
Floor = 0.1

http://www.tellus.tv/passivhus/

Brogården, Allingsås

These houses, containing 200 apartments, were built in 1970. Now, when it is time for major renovation of the houses, the insulation and heating system will be improved so that the energy demand will be reduced from 216 kWh/m^2 to 92 kWh/m^2. Solar panels and district heating will provide for hot water and the extra heating needed during cold winter days.

U-values for the dwellings:
Windows = 0.8
External walls = 0.14
External roof = 0.10
Doors = 1.0
Floor = 0.25

http://www.alingsashem.se/CM/Templates/Article/general.aspx?cmguid=2d63f1cc-805d-47b1-bdc3-97d355557435d

Hamnhuset, Älvstranden in Gothenburg

This proposed 116 apartment dwelling will be highly isolated with efficient heat recovery in both ventilation system and drain. Solar panels will count for hot water and district heating will be installed as a back-up for heating and hot water. Energy demand is calculated to be 27 kWh/m^2 for heating and hot water and 30 kWh/m^2 for electricity.

Misteröd, Uddevalla

In Uddevalla, 12 terraced houses with 27 apartments are being built.

Storfors, Filipstad

Proposed low-energy school building.

3 TECHNOLOGY: TECHNICAL DATA

Examples

3.1 Passive solar energy

3.2 Trombe walls

3.3 Natural cooling

3.4 District Heating

4 INSTITUTIONS

4.1 Denmark

4.1.1 Public Institutions

SBi is the Danish national building research institute 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.

The Danish Technological Institute 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.

Technical university of Denmark; www.ibe.dtu.dk

4.1.2 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
www.dcue.dk

Business network passive houses, a network of several researchers, consultants and companies discussing and exchanging knowledge within the field of passive houses.
www.passivhus.aau.dk

Local Agenda 21; municipal LA21 coordinators is organised 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.

LØB - Landsforeningen Økologisk Byggeri / National association for Ecological building activities
www.lob.dk

4.2 Spanish Institutions

4.2.1 Public Institutions

The *Ministerio de Vivienda*[15] is the Department risponsible of exert the competences corresponding to the General State Administration in housing and ground issues.

[15] *Ministry of Housing*

www.mviv.es

The *Instituto para la Diversificación y Ahorro de la Energía IDAE*[16] is a Public Managerial Entity, assigned to the Ministry of Industry, Turism and Commerce, whose function is to coordinate and manage together with the Autonomous Regions the measures and funding dedicated to the Action Plan 2005-2007 and the Saving and Energy Efficiency Strategy for Spain and the Plan of Renewable Energies 2005-2010, apart from carrying out dissemination actions, technical advice, development and funding of technological innovation projects that can be repeated.

The *Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas CIEMAT* is a research public body, depending on the Ministry of Education and Science. The main fields for its R&D activities, apart from nuclear energy, that was its original activity in the beginning, are: other energy sources, environmental impact of energy and development of associated technologies, basic reseach in particle physics and molecular biology.
www.ciemat.es

The *Centro Nacional de Energías Renovables* CENER, is a national technological centre dedicated to research, development and promotion of renewable energies in Spain.
www.cener.com

The *Instituto de Energía Solar* is part of the *Universidad Politécnica de Madrid,* being its objective the research of associated aspects to the development of solar photovoltaic electricity.

The *Instituto Tecnológico de Energías Renovables ITER,* created by the Cabildo Insular de Tenerife, has the objective of promote projects of research and technological development related to the use of renewable energies, as well as other projects for the improvement of the regional social and economic development of the Canary Islands.

4.2.2 Private Associations and Institutions

The *Consejo Superior de los Colegios de Arquitectos de España* is the institution that gathers all the Architects Professional Association in order to achieve the general common interest aims. It is also the representing body for Professional Associations and the profession to the public and private corporations, and to international bodies, and the last authority to appeal to via corporation (application of professional Deontology).
www.cscae.com

The *Consejo General de la Arquitectura Técnica de España* is the institution which gathers and coordinates all the Official Professional Associations of Technical Architects and that becomes the body that represents and defends the interests of the profession, in Spain and abroad.
www.arquitectura-tecnica.com

[16] *Institute of Energy Diversification and Saving IDAE*

The *Instituto de Ciencias de la Construcción Eduardo Torroja,* that belongs to the *Consejo Superior de Investigaciones Científicas*, is a centre for research and scientific-technical advice in the area of building.
www.ietcc.csic.es

The *Asociación para el Desarrollo de la Casa Bioclimática* is a private association, independent, made up by professionals and companies from different sector who want to promote the use of bioclimatic criteria in town planning and building and homes and buildings renovation.

The *Instituto de Bioconstrucción y Energías Renovables IBER* is a nonprofit association dedicated to promote such issues, handling information on bioconstruction techniques, ecological materials, renewable energies, etc.

The *Consejo Construcción Verde España* (Spain Green Building Council) is the first nonprofit national association of leading building companies (buildings, developments, towns, public works and town planning), that work together to promote cities and buildings environmental risponsible, profitable and healthy for the people who live or work in them.
www.spaingbc.org

The *Instituto de la Construcción de Castilla y León I.C.C.L.,* was created as a private Foundation of scientific and cultural character, nonprofit, that wants to deal with all the technical aspects that intervene in the process of construction, being Civil, Building or Renovation.
www.iccl.es

CENIFER Foundation for the Training in Renewable Energies is a tool to promote technical training in the field of renewable energies.
www.cenifer.com

The main objective of the *Asociación de la Industria Fotovoltaica* is to promote, prestige and develop the photovoltaic sector, contributing its knowledge and experience to the Spanish market and risponsible authorities, at national, regional and local levels.
www.asif.org

The *Asociación Solar de la Industria Térmica* has the mission to become a meeting and representing forum for the sector, to discuss ideas and reach an agreement on actions to promote and improve the use and development of Solar Thermal Energy in the whole country.
www. asit-solar.com

The *Comité Español de Iluminación* aims at promoting all activities related to lighting, in its widest and varied aspects, scientific and technical, promoting studies, research, development and innovation as well as methods, regulations and standardization related to lighting.
www.ceisp.com

4.3 Swedish Institutions

4.3.1 Public Institutions

The National Board of Housing, Building and Planning – Boverket – 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 Boverket also provides information to those engaged in planning, housing, construction and building inspection activities.

The Swedish Energy Agency 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.

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.

IVL Svenska Miljöinstitutet coordinates different projects on low-energy houses www.ivl.se

4.3.2 Private Associations and Institutions

Forum för Energieffektiva byggnader 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 buildning of more passiv and low-energy houses. http://www.passivhus.nu/

Resurseffektiva byggnader. This website is a platform for information to proprietors, builders and contractors to make it easier to chose energyefficient components for the buildings.
http://www.husutanvarmesystem.se/intelligens/kund/sida.asp?site_id=1&sida=2

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6.2 Relevant Spanish Magazines

- Energías renovables
- Solar News, especializada en el sector de la energía solar
- Nuevas Tecnologías, Revista de eficiencia energética, Sostenibilidad, renovables y gestión técnica de las instalaciones
- InfoPower, Actualidad y Tecnología de Producción y Uso Eficiente de Energía
- Energética XXI, Revista de Generación de Energía
- Tecno Energía, Revista profesional de energía y medio ambiente
- Revista NAN arquitectura y construcción
- Infodomus, Construcción Sostenible y Edificios Inteligentes
- Tecno Ambiente, Revista profesional de Tecnología y equipamiento de ingeniería ambiental
- El instalador
- Electra

6.3 Relevant Swedish Magazines

- Energi & miljö: tidskrift för VVS, inneklimat och VA
- Bioenergi
- Energimagasinet
- Miljöforskning

7 LINKS OF INTEREST

7.1 Danish Links

The Danish Centre for City Ecology; www.dcue.dk
The Danish Building Institute; www.sbi.dk
The Danish Energy Authority; www.ens.dk
The electricity saving Foundation; www.elsparefonden.dk
Passive house association; www.passivhus.dk/danske_passivhuse.htm
The Danish insulation producer - Rockwool; www.rockwool.dk
The Danish Technological Institute; www.teknologisk.dk
Energy windows information; www.energiruder.dk
The Eco-building project; www.ecobuilding.dk
The Danish producer of ventilation systems; www.ecovent.com
Information web about sustainable buildings; www.groenthus.dk/dk/default.asp

7.2 Spanish Links

Ministerio de la vivienda; www.mviv.es
Secretaría General de la Energía; www.mityc.es/energia
Instituto para la diversificación y el ahorro de la energía; www.idae.es
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT); www.ciemat.es
Centro Nacional de Energías Renovables (CENER); www.cener.com
Asociación de la Industria Fotovoltaica; www.asif.org
Asociación Solar de la Industria Térmica; www.asit-solar.com
Comisión Nacional de la Energía (CNE); www.cne.es
Asociación para el Desarrollo de la Casa Bioclimática; www.casabioclimatica.com
Biblioteca CF+S Ciudades para un futuro más sostenible, http://habitat.aq.upm.es/
Comité Español de Iluminación; www.ceisp.com
Asociación de Constructores Promotores de España; www.apce.es
Asociación de Empresas Constructoras de Ámbito Nacional; www.seopan.es
Fundación Laboral de la Construcción; www.fundacionlaboral.org
Asociación nacional de industriales de materiales aislantes; www.andima.es
Consejo General de la Arquitectura Técnica; www.arquitectura-tecnica.com
Asociación de Empresas Restauradoras del Paisaje y del Medio Ambiente (ASERPYMA); www.aserpyma.es
Bioconstrucción, www.bioconstruccion.biz
Sólo Arquitectura, www.soloarquitectura.com
Construible, www.construible.es

7.3 Swedish Links

The National Board of Housing, Building and Planning – Boverket;
http://www.boverket.se/shopping/ShowItem.aspx?id=2331&epslanguage=SV
Swedish Energy Agency;
http://www.energimyndigheten.se/WEB/STEMEx01Swe.nsf/F_PreGen01?ReadForm&MenuSelect=6E232D2E9C021723C12571E60023A1B3

Forum för Energieffektiva Byggnader; http://www.passivhus.nu/
Swedish Association of Architects; http://www.arkitekt.se/s14338
Västra Götalandsregionen;
http://www.vgregion.se/vgrtemplates/BildRightPage____42135.aspx
Lunds Universitet; http://www.ebd.lth.se/forskning/passivhus_demonstrationsprojekt/
IVL Svenska Miljöinstitutet; http://www.ivl.se/AnsokningarPassivhusprojekt.htm
ByggaBoDialogen; www.byggabodialogen.se

Report on the state of the art in bioclimatic architecture and integration of renewable energies in buildings

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CONTENTS

1 REGULATIONS

1.1 Spanish Regulations

Normas Básicas de la Edificación:[1] Condiciones Térmicas de los Edificios (NBE-CT-79)[2]

Through Decree 1490/75, of 12 June, the public Administration took the first measures aiming at the achieving of energy saving by means of an adequate construction of buildings, thus tackling with the problems derived from the rise in the price of energy.

NBE-CT-79 replaced the former Decree (except for articles 6 and 7, fluids' insulation and regulation of installations, which remained in force). This regulation was approved through **Royal Decree 2429/79** of 6 July 1979.

Regulations from year 79 set the thermal conditions required of buildings, as well as the determining features, and defined as application field all kind of completely new buildings, except the ones that, due to their use, should remain open.

Apart from principles aiming at energy saving, the mentioned regulations included other thermal or hygrothermal aspects that affect buildings and their habitability conditions, stressing subjects that had no been regulated before, such condensation phenomena in the building envelope that affect to the building users comfort.

For this NBE purposes, building are thermally defined by the following concepts:
a) Global heat transmission through the whole of the building envelope, defined by its K_G factor.
b) Heat transmission through each of the elements that make up the building envelope, defined by their K factors.
c) Higrothermal performance of envelopes.
d) Air permeability of envelopes.

This regulation forced to meet a number of requirements and conditions, such as:

- That the global thermal factor K_G of a building cannot be higher that a given value, that will be set according to the factor of the climate zone of the site and the type of energy used in the heating system.
- That the K thermal transmission usable factors of envelopes, excluding the spaces, do not rise over certain values, given by the envelope and the climate zone.
- That the thermal resistance and the constructive layout of the envelope elements be such that in the environmental conditions considered by the Regulation, the envelope will not show condensation humidities neither in its interior surface, nor within the envelope mass, that damage its conditions, nor occasional ones that might damage other elements.

[1] *Basic Building Regulations N.B.E*
[2] *Buildings' Thermal Conditions NBE-CT-89*

- It considers as interior environment conditions the use ones, and the exterior conditions are classified according to two climate zones: one based in 15-15 degrees/day data and, the other, in minimum temperatures in the month of January.
- It considers ground temperature according to climate zones and forces to considerate 95% external relative humidity in order to make the calculations.
- It sets the air permeability of a carpentry frame defined by its class of air tightness. According climate zones, the carpentry should be of a given class.

Reglamento de instalaciones de calefacción, climatización y A.C.S[3]

This regulation was approved by **Royal Decree 1618/80** of 4 July (B.O.E. 06-08-80) and came up due to the importance that non industrial thermal installations was reaching and its increase as a result of the increase of the Spanish standard of living. These facts recommended a global administrative action on the sector, aiming at rationalizing the energy consumption, without decreasing the users 'comfort'.

As energy saving issues are closely linked to pollution, quality and safety issues in heating, air conditioning and domestic water heating, and not having a basic regulation about them, it was necessary to draw regulations that set the required rules to get rational energy consumptions, setting at the same time quality, safety levels and defence of the environment measures in those installations.

The object of the present regulation was to define the conditions for installations that use energy with non industrial aims in order to achieve a rational use of the energy, taking into account its quality and safety and the protection of the environment. The systems installed in air, maritime or terrestrial transport means were excluded of these regulations, as they will be regulated by special arrangements.

Among the different requirements stated in the regulations, there are references to additional technical instructions that should be comply with by non industrial thermal installations and will be developed later on.

The regulation also includes the creation of the '*Comisión Permanente para el Ahorro de Energía en Instalaciones Térmicas de la Edificación*'[4] , whose missions are as follows:

a) the study and gathering of new technological advances in energy saving in installations regarded by this regulation, channeling the relevant proposals made by manufacturers, installers, designers, users, maintenance and repairer technicians.
b) to study and propose new technical instructions and improvement of the existing ones when appropriate.
c) to inform of the proposals made about the 'technical recommendations' mentioned in article eight.
d) to analize the obtained results after applying the regulations, proposing the correcting measures where considered appropriate.

3 *Regulations for heating, air conditioning and hot domestic water installations.*
4 *Permanent Commission for Energy Saving in Thermal Installations in Buildings*

e) to carry out all the research or works commissioned by their superiors.

Instrucciones Técnicas Complementarias I.T.I.C.[5]

The *Instrucciones Técnicas Complementarias* were approved by **Ministry Order of 16 July 1981** (BOE Nº 193, de 13.8.1981), according to the decreed in the *Reglamento de Instalaciones Calefacción, Climatización y Agua Caliente Sanitaria*, with the aim to racionalize its energy consumption.

The regulations comprise the basic regulations of more general and permanent nature, whereas the technical additional instructions comprise the regulations applicable in the present to the aforementioned installations, with the fundamental object of gaining energy savings, and can be reviewed in the future due to the need to be adapted to the development and evolution of technologies.

Reglamento de Instalaciones Térmicas en los Edificios (RITE)[6]

The *Reglamento de Instalaciones de Calefacción, Climatización y Agua Caliente Sanitaria*, approved by Royal Decree 1618/1980, contributed to a great extent to foster and impulse a more rational use of energy in non industrial thermal installations in buildings, generally used to supply in a safe and efficient way with heating, air conditioning and hot domestic water services to meet the needs of thermal comfort and hygiene in buildings.

The experience adquired from its implementation, the technological advances in this field, the new distribution of powers as a result of the State of Autonomous Regions development and, finally, the membership of Spain to the European Union made the drawing of a new regulation necessary, one that based on the previous one, took into consideration the existing factors and continued the advance in the rational use policy established in the *Plan de Ahorro y Eficiencia Energética* [7] included in the *Plan Energético Nacional* [8] 1991-2000.

As a result of adopting different Community provisions in the field of free circulation of goods as well as in the field of rational use of energy and the reduction of carbon dioxide emmissions, it was also necessary to modify the existing regulations to take into account the following Directives of the Council:

- 89/106/EEC on building products
- 92/42/EEC on performance requirements for new hot water boilers fed with liquid and gas fuels.
- 93/76/EEC related to the limitation in carbon dioxide emmissions by means of improving energy performance (SAVE)

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[5] *Additional Technical Instructions I.T.I.C*
[6] *Regulation of Thermal Installations in Buildings* (RITE)
[7] *Energy Saving and Efficiency Plan.*
[8] *National Energy Plan.*

The reach of the changes made on the regulations text in force and its additional technical instruccions, both in form and content, recommended to draw a new text to repeal and replace the former one and the developing additional technical instructions. This new text was approved by **Royal Decree 1751/98** of 31 July, that approved the *Reglamento de Instalaciones Térmicas en los Edificios (RITE)* and its *Instrucciones Técnicas Complementarias (ITE)* while creating the *Comisión Asesora para las Instalaciones Térmicas de los Edificios*[9].

The *Comisión Asesora para las Instalaciones Térmicas de los Edificios*, that takes the place of the *Comisión Permanente para el Ahorro de Energía en Instalaciones Térmicas de la Edificación*, will be a standing voting body with the specific mission of advising in issues related to thermal installations in buildings by means of the following actions:

b) To study and propose new technical instructions and review of the existing ones when appropriate.
b) To estudy and collect, when appropriate, the new technical advances in rational use of energy, proposing the adequate changes to the Ministries of Industry, Energy and Public Works and Building, channeling the related suggestions made by public administrations, manufacturers, designers, installers, users and energy maintenance technicians and suppliers.
c) To study international actions on the issue and, particularly, the ones coming from the European Union, proposing the appropriate actions.
d) To analize the obtained results by applying the regulations, proposing the measures and criteria for right interpretation and homogeneous implementation where considered appropriate.

Ley de Ordenación de la Edificación[10] (L.O.E)

Law 38/1999 of 5 November 1999, L.O.E, was conceived in view of the lack of legal bases for building construction, which was mainly regulated by the Civil Code and a variety of regulations that, as a whole, had many gaps in planning the complex process of building, so much in issues related to identification, obligations and risponsibilities of the involved actors as in reference to guarantees to protect the user.

Also, society demanded more and more quality in buildings and that had repercussions on the structural safety and protection against fire as well as on other aspects linked to people's comfort such as protections against noise, thermal insulation or accesibility for people with limited mobility.

The top priority of the LOE was to regulate the building process, updating and completing the legal configuration of the participant agents, setting their obligations in order to establish risponsibilities and cover the users' guarantees by defining the basic requirements for buildings to be complied with.

[9] *Advisory Commission for Thermal Installations in Buildings.*
[10] *Building Planning Law (L.O.E)*

To do so, the building legal concept and the basic principles that should lead this activity were defined and the scope of the Law was delimited, specifying the works both completely new buildings and existing ones to which it would apply.

The Law set the basic requirements that buildings should meet, in a way that users' guarantees would not only be based on technical building requirements but also in the establisment of a caution or safety insurance.

These requirements cover so much building functional nature and safecty aspects as those relative to habitability.

Código Técnico de la Edificación[11] (CTE)

The *Código Técnico de la Edificación* stands as a new structured regulation frame that identifies, arranges and completes the existing technical regulations, pretending to facilitate its aplication and fulfilment, and all that in harmony with European regulations. It was approved on 17 May 2006 by **Royal Decree 314/2006**, and published on BOE of 28 March.

The *Código Técnico de la Edificación* enforces the basic requirements in building set by *Ley de Ordenación de la Edificación*, aiming at guaranteeing people's safety, society comfort, sustainability of building and the environment safeguard.

The approval of the *Código Técnico de la Edificación* means the improvement and updating of the building regulation frame in Spain present at the time, regulated by Royal decree 1650/1977 of 10 June, on building regulations, that implemented the *Normas Básicas de la Edificación* as mandatory in building projects and works. Within this legal frame, several regulations were approved since 1979, which made up an open group cf dispositions that has been meeting different society requirements, but that never got to be a coordinated body in the form of a Technical Building Regulation, similar to the ones existing in other more advanced countries.

With the aim to improve building quality and to promote innovation and sustainability, the CTE sets the basic quality requirements for buildings and installations. By means of this regulation, certain basic building requirements related to people safety and comfort are met. These requirements refer to structural safety and protection against fire as well as healthiness, protection against noise, energy saving or accesibility for people with limited mobility.

Also, the *Código Técnico de la Edificación* creates an equivalent regulation frame to the existent in more advanced countries and levels the national building regulations existent with the current European regulations in this issue. Firstable, with the regulations related to free circulation of building products inside an only European market. Secondly, Directive 2002/91/CE of European Parliament and Council, of 16 December, relative to energy performance in buildings has to be taken into account as it was used to add to the

[11] *Technical Building Regulations (CTE)*

Código Técnico de la Edificación the requirements relative to energy performance in buildings set by that Directive in articles 4,5 and 6.

The *Código Técnico de la Edificación* is divided in two parts, both of them regulatory. The first one comprises the general dispositions (implementation scope, uses classification, etc.) and the requirements buildings have to comply with to meet the building safety and habitability requirements.

The second part is formed by the Basic Documents, whose adequate implementation ensures the achievement of the basic requirements. Those comprise procedures, technical codes and solution examples that permit determine whether the building cumplies with the established standards of service. Those Documents are not excluding. The *Documentos Reconocidos* were created as a complement for the implementation of the Código, those being technical documents, external and independent from the Código, whose use facilitates the compliance of some demands and contribute to the increase of building quality.

Basic Document '*DB-HE Ahorro de Energía*'[12] especifies the objective parameters and the procedures whose compliance ensures the meeting of basic requirements and the overcoming of the minimum quality standard inherent to the basic requirement of energy saving.

1.2 Swedish Regulations

Regulations set by the National Board of Housing, Building and Planning – BBR 2006

On 1 July 2006, the new Swedish regulation on dwellings came into force (*BBR 2006*). In short, this is what the regulation stipulates about energy demand (the regulation also deals with design, durability, fire protection, hygiene and health, environmental aspects, and noise):

For residential buildings, the energy demand must not exceed 110 kWh per m^2 floor area (A_{temp}) in the south of Sweden and 130 kWh per m^2 in the northern part of the country. For residential houses with electric radiators the energy demand must not exceed 75 kWh per m^2 floor area (A_{temp}) in the south of Sweden and 95 kWh per m^2 in the northern part. A_{temp} is the floor area of spaces aimed for heating to more than 10 ^oC. The garage is not taken into account as a part of the floor area. The energy demand may be reduced with energy from solar panels and photovoltaic cells integrated in the building. The highest average u-value for the surrounding building parts must not exceed 0.50 W/m^2K.

For other premises than residential, the specific energy demand must not exceed 100 kWh per m^2 floorarea (A_{temp}) in the south of Sweden and 120 kWh per m^2 in the northern part of the country. Premises with an airflow larger than 0.35 $l/s,m^2$ may add the equivalent of 70(q-0.35) kWh per m^2 floor area (A_{temp})in the south of Sweden and 90(q-0.35) kWh per m^2 floor area in the northern part, where q is the mean air flow for the heating season in $l/s,m^2$. The energy demand may be reduced with energy from solar

[12] *'DB-HE Energy Saving'*

panels and photovoltaic cells integrated in the building. Garages are not taken into account as a part of the floor area (if not a building on its own). The highest average u-value for the surrounding building parts must not exceed 0.70 W/m^{2}K.

For buildings containing both residential spaces and other premises, the regulations are based in proportion to the floor area.

For buildings where the floor area (A_{temp}) is less than 100 m^2, the window and door areas are less than 0.20 A_{temp}, and where there is no demand for cooling; some alternative regulations may be used.

Maximum u-values for the building parts:
U_{roof} 0.13 W/m^{2}K
U_{wall} 0.18 W/m^{2}K
U_{floor} 0.15 W/m^{2}K
U_{window} 1.3 W/m^{2}K
U_{door} 1.3 W/m^{2}K

For residential houses with electric radiators the following maximum u-values for the different building parts must not be exceeded:
U_{roof} 0.08 W/m^{2}K
U_{wall} 0.10 W/m^{2}K
U_{floor} 0.10 W/m^{2}K
U_{window} 1.1 W/m^{2}K
U_{door} 1.1 W/m^{2}K

The average air leakage at +50 Pa must not exceed 0.6 l/s m^2.

If the floor area (A_{temp}) is more than 60m^2, the building must have a ventilation system with heat recovery of 70 % efficiency or a heat pump in the outgoing air.

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 has been taken into consideration but adjusted to the Nordic climate.

Apart from the basic requirements described in BBR 2006 above, the requirements for a *passivhus* is very restrictive for the total use of bought energy (household demand, hot water, heating and cooling). A_{temp} is defined in the same way as in *BBR 2006* (the floor area of spaces aimed for heating to more than 10 ^{o}C).

Maximum output for the building is P_{max} = 10 W/m^2 in the south and P_{max} = 14 W/m^2 in the north of Sweden. The indoor temperature is specified at 20 ^{o}C and heat from persons and household appliances of 4 W/m^2 may be included. For buildings less that 200 m^2 the maximum output is allowed to be 2 W/m^2 higher.

Maximum energy demand (excluding electricity for household appliances), is set at 45 kWh/m^2 in the south of Sweden, and 55 kWh/m^2 in the northern part. For buildings less that 200 m^2 the maximum energy demand is allowed to be 10 kWh/m^2 higher than above.

The use of hot water is presumed to be 20% less than the standard use.

The average air leakage at +/-50 Pa must not exceed 0.3 l/s m^2.

To be able to verify the energy demand for household appliances and heating, the energy use is to be monitored separately on a monthly basis. The hot and cold water use is also to be monitored. The maximum allowed u-value for the windows is 0.9 W/m^{2}K.

2 REFERENCES

2.1 Denmark

2.1.1 Bioclimatic Buildings

Skotteparken

Skotteparken in Egebjerggård, Ballerup, is an EU Thermie supported experimental building project with 100 solar heating - low-energy dwellings, where the aim is to reduce the gas consumption for heating and domestic hot water with 60% compared to normal building projects. And at the same time reduce the consumption of electricity and water. The apartments in Skotteparken were already built in 1992.

Ballerup is situated 15 kilometres from the capital of Denmark, København, straddling the border between greater København and the countryside. The municipality of Ballerup is the home for approximately 45,000 inhabitants.

The basis for the project was that extra investments in energy saving measures of approx. 8% of the normal building costs should be corresponded to by savings on the operation, especially as regards expenses for heating, water and electricity. 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 in Skotteparken are as follows:

- Extra insulation, which is mostly added in the ceilings with a total thickness of 375 mm. The apartments are aimed airtight making the natural air change as low as 0.1 times per hour
- Thermo glazing is used everywhere with two layer windows with an air gap of 15 mm. The windows have a U-value of approximately 1.4 W/m2K.
- Ventilation system with counter-flow, heat recovery is utilised 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 collector 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 armatures in showers and two-step water saving armatures in kitchens and bathrooms
- Electricity savings
- Rain water from roofs and streets is via open drains carried to a small lake to help maintaining the ground water.

The most innovative aspect are the six, solar heating systems with approximately 100 m^2 of solar collector 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 the summertime. 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.

The results from a finalised monitoring campaign documents 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 m^2 solar collector area in all shows an annual solar heating yield in a normal year of 274 kWh per m^2 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 m^2 solar collector. 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.

The main results for the project in Skotteparken can be summarised as follows:

- The normal amount of energy used for heating and hot water has been reduced of 180 kWh/m2 (normal housing) to 92 kWh/m2 in 1993, to 82 kWh/m2 in 1994, reaching 77 kWh/m2 in 1995.
- 65 % savings of district heating network losses was obtained from the low temperature pulse operation.
- Solar system yields 274 kWh/m2 (which corresponds to 382 kWh/m2 when including saved network losses).
- Heating bills only 4.42 Euro/m2 which equals approximately 40 % of a "normal" heat bill.
- A good economic saving for the tenants based on an extra investment of approximately 8% compared to normal housing and grants from external sources.

Source:

Combined low and solar energy design in Egebjerggård, Denmark; Peder Vejsig Pedersen
SOLAR DISTRICT HEATING – BALLERUP (Denmark); Miljø Afdelingen; Peder Vejsig Pedersen

2.2 Spain

2.2.1 Bioclimatic buildings

CENER Building

This building is located in the City of Innovation, in Sarriguren, Navarre, and it is the headquarters of the *Centro Nacional de Energías Renovables (CENER)*[13], Centre of research and Technology that fosters the technological development of Renewable Energies. Its area is about 5,000 square metres.

The building was designed taking into account the most advanced bioclimatic and environmental criteria for energy saving and environmental care. It has both active and pasive architectural elements, being the outstanding ones:

- Active: Vacuum tube thermal collectors for domestic water heating, and for radiant floor (absorption system) heating and cooling, radiant floor heat/cold; awning, shutters, windows and ventilation automatisms.
- Pasive: Balcony-greenhouse for solar capture for heating; high inertia walls and framing; chimney for ventilation in summer; lower ground floor effect; insulating shutter; sun shading awnings; wind tower to capture north wind and plant cover.

Out of the pasive architectural elements, is worth mentioning the bioclimatic balcony, called 'bioclimatic device', that is located in the upper part of the pavillions where the research ares of the Centre are located. From the environmental point of view, it gives the building the maximum bioclimatic advantage out of solar and wind energy: it collects, transforms, storages and distributes the energy along the respective pavillions. In this balcony there are also integrated most of the active environmental protection means and the cooling effects of the plant covers.

On the other hand, and inside the premises, there are two features that outstand due to their non conventional make, as they include energy saving and sustainability criteria:

- Heat/cold generation: The system is based on absorption cycle, feeding the generator with high temperature water (around 100º C) that comes from the vacuum solar collectors integrated in the building roofs, backed by natural gas boilers.
- Watering system: All plant covers in the building are equipped with a trickle irrigation system (minimum consumption), getting the water out of a tank that collects all the rainwater so, both the rainwater plus the possible remaining water

[13] *National Centre of Renewable Energies (CENER)*

that does not evaporates from the trickle irrigation system will be use for watering in the building.

As for the building materials, the option was not to use reusable or biodegradable elements, choosing those more efficient from the technical and energy point of view.

CENIFER Building

This is a 400 square metre building, located in Imarcoain (Navarre), that belongs to the *Centro Integrado Nacional de Formación en Energías Renovables CENIFER*[14], that is used as demonstrative building, reception building, to impart training, as a conference hall, as training bench for students, apart from the research made by the teachers at the Centre.

It has all type of active and pasive installations to reach an energy balance close to zero: solar thermal installation; water tank to store energy between seasons; heating and cooling through radiant floor and wall; solar photovoltaic installation grid connected; greenhouse with direct solar capture and ventilation; Trombe wall; external insulation of building envelope with ventilated façade; well water cooling and forced ventilation with thermosolar shunt.

Each of the architectural elements and installations used are explained below:

Architectural elements

The **general building envelope** consists of a ventilated façade with high inner thermal energy, made up by five elements:

- External coating made out of ceramic tiles
- 3 cm ventilated chamber
- Thermal insulation made out of 8 cm rockwool.
- High thermal inertia inner wall
- Radiant strip heater

This envelope is completed with inner flooring with radiant floor and a flat trafficable roof that serves as a platform to the pergola that holds the solar thermal and photovoltaic panels.

Among the building pasive solar energy systems, is worth mentioning the **greenhouse**. In summertime, the capturing cover is protected with a system of motor operated slatted shutters, placed inside the external window framing. The upper and lower hatches, motor operated and automatic, open to get a forced ventilation to refresh the air, avoiding the inside to get hot with the air. In winter, the radiation that gets inside the greenhouse is absorbed inside, becoming heat that gets stored in floor and walls, from where is transmitted inside the building through radiation. At the same time, the air inside the greenhouse becomes hot and gets into the building through forced convection by means of some fans located in its upper side. The greenhouse's floor and wall, with a substantial thermal inertia, absorb radiation, storing thermal energy and giving it to the air with delay

[14] *Integrated National Centre for Training in Renewable Energies CENIFER*

and absorption, through convection and long wave, what minimizes losses through the glazing.
It has an estimated thermal output of 10,800 Kwh in winter and 14,245 Kwh both in spring and autumn.

The **Trombe wall** is other of the used pasive systems. It is formed by a glazing wall placed next to a double massive wall that has a little internal ventilated chamber. The solar radiation that reaches the wall and goes through the glazing, heats the external wall, which is painted in a matt dark colour. In turn, this wall heats the inner wall and the circulating air in the chamber between them through radiation. This chamber has automatic hatches and fans.

In summer, these hatches open the chamber to the exterior, getting forced ventilation that avoids the heat getting inside. In winter, the hatches open the internal chamber to the inside of the building, allowing the entrance of hot air. It has a thermal output of 4,970 Kwh in winter and 6,500 Kwh both in spring and autumn. The annual saving in emmissions is 33 kg of SO_2, 10 kg NOx and 2,640 kg CO_2.

The **solar thermal shunt** is for exclusive winter use. It refreshes the inside of the building by means of forced ventilation coming from a shaded landscaped area in the North side of the building. The air is introduced from there through four ceramic conducts, using fans to force ventilation Those conducts are buried at 1.8 m depth and go up to the south façade, where they come into the interior, the air going up towards the roofing shunt as it gets warmer. It has a cooling output of 2,838,000 frigories in summer. The annual saving in emmissions is 6,8 kg of SO2, 2 kg NOx and 545 kg CO2.

Installations

The **solar thermal installation** is made up by 24 2.5 sq.m. useful area panels, located on the building roof and south orientated with a 50º tilt. This way, they make the most of solar radiation to warm the heat transmitting fluid that circulates inside them. They meet 100% of domestic hot water needs and 44% of heating ones. The annual saving in emmissions is 102 kg of SO2, 32 kg NOx and 8.251 kg CO2.

The **big storage tank**, built under the greenhouse, has the function of storing the excedent energy from the solar thermal panels to be used in the heating circuit in days with low solar radiation. It has 40,000 l. capacity, made out of stainless steel and has a perimeter covering of 30 cm of granulated cork that acts as insulation. This extra insulation provides an energy saving estimated in 18%.

The **radiant floor and strip** is made up of a series of reticulated polystyrene conducts, fitted into the floor and wall strips, inside of which circulates water. They absorb heat in summer in the cool well water that circulates inside them, and in winter they release heat through the hot circulating water that comes from the storage tank and has been heated by the solar thermal panels. These radiators can transmit 35,000 kcal/h. The energy saving in this low temperature radiation system compared to the common convection radiators is 23%.

A system based on **cooling through sensor**, which uses subsoil water, floor system water and radiant strip is used to cool the building in summer. The system works with an immersion pump that placed at 8 m depth inside a well in the north face of the building, pumps the water to the radiant elements, circulating along them and returning to phreatic level.
The absortion capacity of this element is 15,000 frigories/h. This system annual saving in emmissions is 3 kg of SO_2, 1 kg NO_x and 248 kg CO_2.

There is a 5 Kw grid connected **solar photovoltaic system** installed in the building. It consists of 68 monocrystalline photovoltaic panels of 80 Wp, placed in the building roof and orientated to south with 30º tilt and 2 2.5 Kw inverters.
The estimated annual output is 7,440 Kwh (20.38 Kwh average daily output). Those outputs intend to meet the building energy consumption. The annual saving in emmissions is 15 kg of SO_2, 4,8 kg NO_x and 1.228 kg CO_2.

2.2.2 Eco-cities

Residencial Parque Goya

In 1995, the *Dirección General de Obras Públicas y Urbanismo del Gobierno de Aragón* y el *Instituto del Suelo y de la Vivienda de Aragón (ISVA)* started to develop a Partial Plan in a 53.7 Ha area in the north of the city of Zaragoza.

The objective was to promote 3,500 officially protected housing and to reduce CO_2 emmissions as specific aim, considering the European Directive 93/76/CEE. The development and building design according to the architectural criteria included in the Partial Plan would account for a potential 60% decrease in the buildings energy demands (heating, cooling, domestic hot water and lighting) compared to the values given by complying with the regulations and a little lower respect to the usual typology of the area.

As a novelty respect to any other previous town planning activity, the Partial Plan of Residencial Parque Goya had some specific clauses in regulating bylaws related to bioclimatic determining factors of buildings.

This action was funded by the European Commission with a Thermie Project (n. BU 178/95) that affected to three buildings in the first stage: parcels P-4 (178 flats), P-11 (50 flats) y PU-9 (26 houses).

Key features

Some of the mandatory concepts in the Partial Plan town planning design or in the Terms and Specifications corcerning all buildings in Parque Residencial Goya are:

- Street orientation, buildings' distribution and heights to favour solar radiation capture in south facing façades.
- Higher insulation than required by regulations (<25%).
- 50% or higher glazing in south façades, with optional glazed balconies, and minimum in north façades.
- Carpentry framing of better quality than required by regulations.
- Plenty of green areas, areas of water and adequately coloured materials.

In the three buildings selected by Project Thermie, the mainly used elements are:

- Use of greenhouse-balconies with thermal load walls.
- Insulation higher than usual, double glazing and top quality carpentry framing regarding infiltrations.
- Collective auxiliary systems with low temperature boilers (high efficiency) or condensation ones and solar thermal collectors.
- Individualized control of heating and domestic hot water consumption.

Location

The residential neighbourghood Parque Goya is located in the city of Zaragoza, capital of the Autonomous Region of Aragón, situated in the centre of the Ebro Valley, 41°39' north latitude.

The climate is Mediterranean, eventhough it has strong continental influences, as it can be seen by the extreme temperatures: high temperatures in summer and low in winter, with NW-NWW winds (*cierzo*) that increase the feeling of discomfort.

The most characteristic climate variables of the zone can be seen in the table below:

Month	Average daily temperature (°C)	Horizontal solar radiation (MJ/m^2 day)	Vertical solar radiationsouth (MJ/m2 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

Table 1: Climate variables. Data obtained from *Atlas de Radiación Solar de Aragón* and from *Datos Climáticos de Aragón.*

Description

The selected buildings for specific actions represent the three typologies existing in the development (semi-detached hoses PU-9, collective buildings with double corridor P-4 or quadruple corridor P-11).

Insulation and thermal inertia

After the initial studies, the town planning project established as a specific regulation that the insulation value should be 25% higher than defined in the current regulations.

The table below show the U values (W/sq.m.K) corresponding to each building external envelope respect to the values required by Spanish regulations.

U-conductance (W/sq.m.K)	National regulations (NBE-CT-79)	Building P-4 (178 flats)	Building P-11 (50 flats)	Building PU-9 (26 semi-det)
External wall	1,6	0,44	0,64	0,39
Mass walls	1,8	0,88	1,47	1,47
Roofing	1,2	0,22	0,33	0,28
External framing	1,4	0,26	0,42	0,86
South and east windows	5,8	3,3	3,3	3,3
North and east windows	5,8	2,6	2,6	3,3

Thermal bridges in pillars and girders were eliminated through external insulation in order to reduce energy losses. Also, double window framing has been used in façades N and W to reduce transmission or infiltration losses in those façades, affected by the dominant wind, the '*Cierzo*' which can reach high speeds.

The buildings have a high thermal inertia, reinforced in the most compact ones (building P-11), lower in building P-4 and clearly lower in the semi-detached houses. The inertia has been increased by placing the insulation in the external side of the envelope, the roofing and ground floor framing. Also, materials with high inertia were used, such as Airblock (19 cm in P-11) and Termoarcilla (19 cm in P-4 and PU-9).

With this features, the buildings experience slight fluctuations of interior temperature at night, when the auxiliary heating is off. All the same, with night ventilation, the inertia allows to reduce maximum day temperature in a way that most of the time, it remains within comfort conditions.

Solar gain

The buildings' main façade are south orientated with no shadings in winter. This was done all through the development. The area of glazing was increased in all south façades, making also greenhouses with no preheated air. To increase the captation effect and make the most of the captation delay in greenhouses, mass walls were used (29 cm blocks filled with sand and concrete or 19 cm termoarcilla —thermal clay— blocks). The glazing area was reduced in façades east, west and north, as solar captation is very low (N) or can generate overheating in summer (E, W). The inside distribution of the houses leaves the south for living areas, while kitchen, bathrooms and stairs are placed north.

The overheating due to solar captation in summer gets reduced by eaves or mobile elements (shutters). Also, the distribution of the house allows natural ventilation, very convenient in summer nights. The use of clear colour pavement, landscaped areas with gardens and trees also improves comfort in summer, reducing the overheating effect in streets.

Heating and solar collector

The heating system used (low temperature boilers) in each of the three buildings is collective, being more efficient than individual heating systems.

The total installed collector surface in the development in its first stage was 600 sq.m.

Technical results

The three selected buildings were monitored during two years. The interior temperatures of north and south rooms, the greenhouses and the inner temperature of especially built walls were specifically measured. Humidity in the south zone and heating consumption in the houses were also measured. All these parameters were recorded each 10 minutes. The number of monitored houses was 9 in block P-4, 12 in block P-11 and 6 in PU-9.

Starting from consumption and monitored temperatures in the houses, the consumptions were extrapolated to a common scale to get identical interior temperatures (20º C). That was how results showed in table 2 were obtained.

Average annual consumption in kwh/sq.m	2000-2001	2001-2002
P-4 (178 flats, mostly south oriented)	20	21
P-11 (50 flats, 16 out of them facing north)	35	32,5
PU-9 (26 semi-detached houses, south oriented)	48	41

Table 2: Results of unitary heating consumption in the three buildings

2.3 Sweden

2.3.1 Bioclimatic buildings

Lindås

In Lindås, 20 km south of Gothenburg, 20 low-energy terraced houses have been built. 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. Big windows facing south are combined with balconies and roof overhang to shield from too much sun and high temperatures during summer. A roof window gives light also to the middle of the house and can be used to air the house on hot summer days.

The energy-saving features of Lindås are as follows:

- Extra insulation
- **External wall**:
  U-value 0.10 W/m^{2}K
  Bolt wall with 43 cm isolation.
- **External roof**:
  U-value: 0.08 W/m^{2}K
  Masonite balk med 48 cm isolation.
- **Floor**:
  U-value: 0.09 W/m^{2}K
  concrete board with 25 cm isolation.
- **Windows**:
  U-value: 0.85 W/m^{2}K
  Three glass with two metal layers and krypton gas.
- **Doors**:
  U-value: 0.80 W/m^{2}K

- a ventilation system with counter-flow heat recovery of 85 % efficiency

- 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.

The residents moved into their terraced houses in 2001. The majority of the residents are content with the temperature of 20-23 ^{o}C. 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.

http://www.egnahem-goteborg.se/prod/egnahems/dalis2.nsf/535e371e7fd657aec1256a5c0045675f/6280a39fe9d3eb4fc125710f00586292!OpenDocument

Glumslöv, Landskrona

In Glumslöv north of Landskrona lies 35 terraced houses built in 2004. Fully developed and reliable techniques have been used in these dwellings. In a ventilation system with counter-flow heat recovery of 85 % efficiency the incoming air is heated with the outgoing air. The very limited space heating demand is covered by electric resistance heating, 700 W, in the supply air. The total energy demand is calculated as approximately 50-60 kWh/m^2.

U-values for the dwellings:
Windows = 0.9 – 1.0
External walls = 0.10
External Roof = 0.08
Floor = 0.10

http://www.husutanvarmesystem.se/intelligens/sites/reby/filer/T28-C-brochure_Landskrona_SE.pdf

Oxtorget, Värnamo

In Värnamo, 40 apartments with a very low energy need stood ready in 2006. The houses have extra insulation; windows and doors have a low u-value; and balconies and roof overhang protect from too much sun during summer months. 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. 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.

U-values for the dwellings:
Windows = 0.85
External walls = 0.10
External roof = 0.08
Doors = 0.6
Floor = 0.09

http://www.oxtorget.se/eng/index.htm

Frillesås, Kungsbacka

In Kungsbacka, three low-energy dwellings with12 apartments were built in 2006. Roof, walls, windows, doors and floor have a very low u-value. A ventilation system with an

efficient counter-flow heat recovery diminishes the heating demand. Hot water comes from solar panels and district heating.

Lidköping

In Lidköping, a detached house is soon ready for the residents to move into. This is the first low-energy detached house to be built in Sweden. The house is highly isolated and has a ventilation system with an 85 % efficient counter-flow heat recovery. Hot water is heated by district heating. As a back-up, district heating can be used to heat the incoming air in the ventilation system.

U-values for the dwellings:
Windows = 0.85
External walls = 0.09
External roof = 0.07
Doors = 1.0
Floor = 0.1

http://www.tellus.tv/passivhus/

Brogården, Allingsås

These houses, containing 200 apartments, were built in 1970. Now, when it is time for major renovation of the houses, the insulation and heating system will be improved so that the energy demand will be reduced from 216 kWh/m^2 to 92 kWh/m^2. Solar panels and district heating will provide for hot water and the extra heating needed during cold winter days.

U-values for the dwellings:
Windows = 0.8
External walls = 0.14
External roof = 0.10
Doors = 1.0
Floor = 0.25

http://www.alingsashem.se/CM/Templates/Article/general.aspx?cmguid=2d63f1cc-805d-47b1-bdc3-97d355557435d

Hamnhuset, Älvstranden in Gothenburg

This proposed 116 apartment dwelling will be highly isolated with efficient heat recovery in both ventilation system and drain. Solar panels will count for hot water and district heating will be installed as a back-up for heating and hot water. Energy demand is calculated to be 27 kWh/m^2 for heating and hot water and 30 kWh/m^2 for electricity.

Misteröd, Uddevalla

In Uddevalla, 12 terraced houses with 27 apartments are being built.

Storfors, Filipstad

Proposed low-energy school building.

3 TECHNOLOGY: TECHNICAL DATA

Examples

3.1 Passive solar energy

3.2 Trombe walls

3.3 Natural cooling

3.4 District Heating

4 INSTITUTIONS

4.1 Denmark

4.1.1 Public Institutions

SBi is the Danish national building research institute 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.

The Danish Technological Institute 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.

Technical university of Denmark; www.ibe.dtu.dk

4.1.2 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
www.dcue.dk

Business network passive houses, a network of several researchers, consultants and companies discussing and exchanging knowledge within the field of passive houses.
www.passivhus.aau.dk

Local Agenda 21; municipal LA21 coordinators is organised 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.

LØB - Landsforeningen Økologisk Byggeri / National association for Ecological building activities
www.lob.dk

4.2 Spanish Institutions

4.2.1 Public Institutions

The *Ministerio de Vivienda*[15] is the Department risponsible of exert the competences corresponding to the General State Administration in housing and ground issues.

[15] *Ministry of Housing*

www.mviv.es

The *Instituto para la Diversificación y Ahorro de la Energía IDAE*[16] is a Public Managerial Entity, assigned to the Ministry of Industry, Turism and Commerce, whose function is to coordinate and manage together with the Autonomous Regions the measures and funding dedicated to the Action Plan 2005-2007 and the Saving and Energy Efficiency Strategy for Spain and the Plan of Renewable Energies 2005-2010, apart from carrying out dissemination actions, technical advice, development and funding of technological innovation projects that can be repeated.

The *Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas CIEMAT* is a research public body, depending on the Ministry of Education and Science. The main fields for its R&D activities, apart from nuclear energy, that was its original activity in the beginning, are: other energy sources, environmental impact of energy and development of associated technologies, basic reseach in particle physics and molecular biology.
www.ciemat.es

The *Centro Nacional de Energías Renovables* CENER, is a national technological centre dedicated to research, development and promotion of renewable energies in Spain.
www.cener.com

The *Instituto de Energía Solar* is part of the *Universidad Politécnica de Madrid,* being its objective the research of associated aspects to the development of solar photovoltaic electricity.

The *Instituto Tecnológico de Energías Renovables ITER,* created by the Cabildo Insular de Tenerife, has the objective of promote projects of research and technological development related to the use of renewable energies, as well as other projects for the improvement of the regional social and economic development of the Canary Islands.

4.2.2 Private Associations and Institutions

The *Consejo Superior de los Colegios de Arquitectos de España* is the institution that gathers all the Architects Professional Association in order to achieve the general common interest aims. It is also the representing body for Professional Associations and the profession to the public and private corporations, and to international bodies, and the last authority to appeal to via corporation (application of professional Deontology).
www.cscae.com

The *Consejo General de la Arquitectura Técnica de España* is the institution which gathers and coordinates all the Official Professional Associations of Technical Architects and that becomes the body that represents and defends the interests of the profession, in Spain and abroad.
www.arquitectura-tecnica.com

[16] *Institute of Energy Diversification and Saving IDAE*

The *Instituto de Ciencias de la Construcción Eduardo Torroja,* that belongs to the *Consejo Superior de Investigaciones Científicas*, is a centre for research and scientific-technical advice in the area of building.
www.ietcc.csic.es

The *Asociación para el Desarrollo de la Casa Bioclimática* is a private association, independent, made up by professionals and companies from different sector who want to promote the use of bioclimatic criteria in town planning and building and homes and buildings renovation.

The *Instituto de Bioconstrucción y Energías Renovables IBER* is a nonprofit association dedicated to promote such issues, handling information on bioconstruction techniques, ecological materials, renewable energies, etc.

The *Consejo Construcción Verde España* (Spain Green Building Council) is the first nonprofit national association of leading building companies (buildings, developments, towns, public works and town planning), that work together to promote cities and buildings environmental risponsible, profitable and healthy for the people who live or work in them.
www.spaingbc.org

The *Instituto de la Construcción de Castilla y León I.C.C.L.,* was created as a private Foundation of scientific and cultural character, nonprofit, that wants to deal with all the technical aspects that intervene in the process of construction, being Civil, Building or Renovation.
www.iccl.es

CENIFER Foundation for the Training in Renewable Energies is a tool to promote technical training in the field of renewable energies.
www.cenifer.com

The main objective of the *Asociación de la Industria Fotovoltaica* is to promote, prestige and develop the photovoltaic sector, contributing its knowledge and experience to the Spanish market and risponsible authorities, at national, regional and local levels.
www.asif.org

The *Asociación Solar de la Industria Térmica* has the mission to become a meeting and representing forum for the sector, to discuss ideas and reach an agreement on actions to promote and improve the use and development of Solar Thermal Energy in the whole country.
www. asit-solar.com

The *Comité Español de Iluminación* aims at promoting all activities related to lighting, in its widest and varied aspects, scientific and technical, promoting studies, research, development and innovation as well as methods, regulations and standardization related to lighting.
www.ceisp.com

4.3 Swedish Institutions

4.3.1 Public Institutions

The National Board of Housing, Building and Planning – Boverket – 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 Boverket also provides information to those engaged in planning, housing, construction and building inspection activities.

The Swedish Energy Agency 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.

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.

IVL Svenska Miljöinstitutet coordinates different projects on low-energy houses www.ivl.se

4.3.2 Private Associations and Institutions

Forum för Energieffektiva byggnader 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 buildning of more passiv and low-energy houses. http://www.passivhus.nu/

Resurseffektiva byggnader. This website is a platform for information to proprietors, builders and contractors to make it easier to chose energyefficient components for the buildings.
http://www.husutanvarmesystem.se/intelligens/kund/sida.asp?site_id=1&sida=2

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- *Development of energy efficiency and sound buildings in Denmark (in Danish).* Udvikling af energieffektivt og sundt boligbyggeri i Danmark, Cenergia Energy Consultants 2003.

- *Ecology in the single family house (in Danish)*. Økologi i parcelhuset Henrik Grove - Århus: Modtryk, 1998. - 160 sider
- *Ecology and architecture quality (in Danish)*. Økologi og arkitektonisk kvalitet, Anne Beim, Lena Larsen, Natalie Mossin. København: Arkitektskolens Forlag, 2002. - 88 sider : ill
- *Ecological solutions in cities - status for knowledge and experiences*. Byøkologiske løsninger - Status for viden og erfaringer, Udarbejdet for Boligministeriet af Institut for Planlægning (IFP), Danmarks Tekniske Universitet af Niels-Arne Jensen m.fl Kbh.: Boligministeriet, 1998. - 398 sider
- *Energy and Architecture (in Danish)*. Energi og Arkitektur - en eksempelsamling af nyere byggerier Udarbejdet for Energistyrelsen af SBI ved Søren Aggerholm og Ole Svensson 1995; SBI - rapport 242. - 75 sider.
- *Green structure in city ecology perspective - process and methods in Egebjergård and Skotteparken (in Danish)*. Grøn struktur i byøkologisk perspektiv - Proces og metoder i Egebjerggård og i Skotteparken, Susanne Guldager, Ulrik Reeh, Bengt Persson, Karen Attwell og Christine Nuppenau; Serie: Park- og Landskabsserien, nr. 22; Miljø- og Energiministeriet og Forskningscentret for Skov & Landskab 1998. - 120 sider.
- *Copenhagen - a sustainable city (in Danish)*. København - En bæredygtig storby, Udarbejdet af Rådet for Bæredygtig Udvikling i Københavns Kommune 2001. - 30 sider.
- *The urban environment and planning- Exampels from Denmark.* Miljø- og Energiministeriet, landsplanafdelingen, Peter Hartoft-Nielsen 1995. - 70 sider.
- *Økologisk byggeri i Danmark/Danish ecological building*, Redaktion: Kim Dirckinck-Holmfeld m.fl. Kbh.,: Arkitektens forlag, 1994. - 127 sider

5.2 Selected Spanish Literature

- Energía solar fotovoltaica - Tobajas Vázquez, Manuel - Barcelona: CEYSA, DL 2002
- *Guía de la edificación sostenible: calidad energética y medioambiental en edificación.* Madrid: Ministerio de Fomento. Dirección General de la Vivienda, la Arquitectura y el Urbanismo; Instituto para la Diversificación y Ahorro de la Energia. Miner; Barcelona: Institut Cerdà, 1999
- *Arquitectura y clima: manual de diseño bioclimático para arquitectos y urbanistas* - Olgyay, Victor; Serra Florensa, Rafael – Barcelona: Gustavo Gili, 1998
- *Técnicas arquitectónicas y constructivas de acondicionamiento ambiental - Bedoya Frutos, C; Neila, J.- Ediciones munilla- Leria. 1997.*
- *Energía solar en la edificación* - Publicación del centro de investigaciones energéticas, medioambientales y tecnológicas (ciemat). 1997.
- *Turismo, Territorio y Medio Ambiente. El caso del Plan Insular de Lanzarote Prats* - Palazuelo, F. - Colegio Oficial de Arquitectos de Madrid, 1996.
- *Vivienda social bioclimática. Un nuevo barrio en Osuna* - López de Asiain, J. - Publicación de la Escuela Técnica Superior de Arquitectura de Sevilla (ETSAS). 1996.

- *Arquitectura y energía natural* - Serra, R; Coch, H. – Barcelona: Ediciones UPC, 1995.
- *Ciudad y urbanismo a finales del siglo XX* - López de Lucio, R - Servicio de Publicaciones de la Universidad de Valencia, 1993.
- *Clima, lugar y arquitectura. Manual de diseño bioclimático*. - Serra, Rafael - Progensa, 1993.
- *Los Sistemas Urbanos* - FERRER, M. - Editorial Sintesis. Barcelona, 1992.
- *La ciudad como proyecto. Recuperación, Transformación de los Centros Históricos Europeos* – Varios - U. I. Menéndez Pelayo / Generalitat Valenciana Santander, 1992
- *Clima, Territorio y Urbanismo* - Fariña Tojo, J. - Departamento de Publicaciones de la Escuela Técnica Superior de Arquitectura de Madrid, 1990.
- *Arquitectura Solar. Aspectos Pasivos, Bioclimatismo e Iluminación Natural* - Yañez Paradera, G. - Ministerio de Obras Públicas y Urbanismo, 1988.
- *Bases para el diseño solar pasivo* – García Arroyo, A. – Madrid: Instituto Eduardo Torroja. CSIC, 1987.
- *Acondicionamiento y Energía Solar en Arquitectura* - Bedoya C. & Neila J. - Colegio Oficial de Arquitectos de Madrid, 1986
- *Condiciones Higrotérmicas de Confort en los Edificios* - Alaman, Aurelio - Madrid : Instituto Eduardo Torroja de la Construcción y el Cemento, 1985.
- *Energía Solar, Edificación y Clima* - Yañez Parareda, G. - Ministerio de Obras Públicas y Urbanismo de Madrid, 1982.
- *Diseño y Optimización Funcional de las Zonas Verdes Urbanas* - Dirección General de Acción Territorial y Urbanismo de Madrid - Ministerio de Obras Públicas y Urbanismo (1982).
- *Las Energías Alternativas en la Arquitectura* - Bedoya Frutos C. & Neila J. - Colegio Oficial de Arquitectos de Madrid, 1982.
- *Clima y Urbanismo* - Usle Álvarez, J. - Escuela Técnica Superior de Arquitectura de Madrid, 1980.
- *Arquitectura Solar* - Navajas, P. - Colegio Oficial de Arquitectos de Madrid, 1980
- *Normativa Urbanística y Arquitectónica sobre la Vivienda Rural en la Provincia de Madrid* - Navajas, P. - Consejería de Ordenación del Territorio, Medio Ambiente y Vivienda, 1980.
- *Instalaciones Urbanas, Tecnología e Infraestructura Territorial* - Rubio Requena, P.M. - Control Ambiental. Madrid, 1979.

5.3 Selected Swedish Literature

- *Marknadsöversikt för passivhus och lågenergihus i Sverige 2006,* October 2006, http://www.passivhus.nu/Projektrapport_Marknadsanalys.pdf
- *Definitioner av energieffektiva bostäder — Passivhus*, March 2007, http://www.passivhus.nu/rapporter/FEBY%20Rapport%20nr3_passivhus_remissversion_8%20mars.pdf
- *ByggaBoDialogen,* educational material for energy efficient building, Boverket 2006, www.byggabodialogen.se

- *Miljökonsekvenser av ny energiteknik: solceller, absorptionsvärmepumpar, energihushållning* – Anne-Marie Tillman, Stockholm: Byggforskning; 1993:4
- *Bygg snålt med egen energi* – Stefan Larsson, Stockholm: Svensk byggtjänst, 2005
- *Energi och bebyggelse*: *teknik och politik* – Stockholm: Formas, 2005
- *Byggekologi: kunskaper för ett hållbart byggande* – Varis Bokalders, Stockholm: Svensk byggtjänst, 2004

6 MAGAZINES

6.1 Relevant Danish Magazines

- Association for Danish city ecology /Foreningen Dansk Byøkologi
- Renewable Energy and Environment /Vedvarende Energi og Miljø
- Byplan /City plans, Kbh.: Arkitektens Forlag
- News from national planning/ Landsplan nyt. Information fra Miljø- og Energiministeriet, Landsplanafdelingen, Kbh.: Miljø- og Energiministeriet, Landsplanafdelingen
- Members magazine for the Association of Danish City Ecology/ Medlemsblad for Foreningen Dansk Byøkologi, Århus: Foreningen Dansk Byøkologi.
- News Magazine for Danish Municipalities /Nyhedsmagasinet Danske Kommuner, Kbh.: Kommunernes Landsforening
- The City and Harbour Engineer / Stads- og havneingeniøren, Fagblad for teknik og miljø - Silkeborg: Kommunalteknisk Chefforening
- Landscape / Landskab, Kbh.: Arkitektens Forlag

6.2 Relevant Spanish Magazines

- Energías renovables
- Solar News, especializada en el sector de la energía solar
- Nuevas Tecnologías, Revista de eficiencia energética, Sostenibilidad, renovables y gestión técnica de las instalaciones
- InfoPower, Actualidad y Tecnología de Producción y Uso Eficiente de Energía
- Energética XXI, Revista de Generación de Energía
- Tecno Energía, Revista profesional de energía y medio ambiente
- Revista NAN arquitectura y construcción
- Infodomus, Construcción Sostenible y Edificios Inteligentes
- Tecno Ambiente, Revista profesional de Tecnología y equipamiento de ingeniería ambiental
- El instalador
- Electra

6.3 Relevant Swedish Magazines

- Energi & miljö: tidskrift för VVS, inneklimat och VA
- Bioenergi
- Energimagasinet
- Miljöforskning

7 LINKS OF INTEREST

7.1 Danish Links

The Danish Centre for City Ecology; www.dcue.dk
The Danish Building Institute; www.sbi.dk
The Danish Energy Authority; www.ens.dk
The electricity saving Foundation; www.elsparefonden.dk
Passive house association; www.passivhus.dk/danske_passivhuse.htm
The Danish insulation producer - Rockwool; www.rockwool.dk
The Danish Technological Institute; www.teknologisk.dk
Energy windows information; www.energiruder.dk
The Eco-building project; www.ecobuilding.dk
The Danish producer of ventilation systems; www.ecovent.com
Information web about sustainable buildings; www.groenthus.dk/dk/default.asp

7.2 Spanish Links

Ministerio de la vivienda; www.mviv.es
Secretaría General de la Energía; www.mityc.es/energia
Instituto para la diversificación y el ahorro de la energía; www.idae.es
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT); www.ciemat.es
Centro Nacional de Energías Renovables (CENER); www.cener.com
Asociación de la Industria Fotovoltaica; www.asif.org
Asociación Solar de la Industria Térmica; www.asit-solar.com
Comisión Nacional de la Energía (CNE); www.cne.es
Asociación para el Desarrollo de la Casa Bioclimática; www.casabioclimatica.com
Biblioteca CF+S Ciudades para un futuro más sostenible, http://habitat.aq.upm.es/
Comité Español de Iluminación; www.ceisp.com
Asociación de Constructores Promotores de España; www.apce.es
Asociación de Empresas Constructoras de Ámbito Nacional; www.seopan.es
Fundación Laboral de la Construcción; www.fundacionlaboral.org
Asociación nacional de industriales de materiales aislantes; www.andima.es
Consejo General de la Arquitectura Técnica; www.arquitectura-tecnica.com
Asociación de Empresas Restauradoras del Paisaje y del Medio Ambiente (ASERPYMA); www.aserpyma.es
Bioconstrucción, www.bioconstruccion.biz
Sólo Arquitectura, www.soloarquitectura.com
Construible, www.construible.es

7.3 Swedish Links

The National Board of Housing, Building and Planning – Boverket;
http://www.boverket.se/shopping/ShowItem.aspx?id=2331&epslanguage=SV
Swedish Energy Agency;
http://www.energimyndigheten.se/WEB/STEMEx01Swe.nsf/F_PreGen01?ReadForm&MenuSelect=6E232D2E9C021723C12571E60023A1B3

Forum för Energieffektiva Byggnader; http://www.passivhus.nu/
Swedish Association of Architects; http://www.arkitekt.se/s14338
Västra Götalandsregionen;
http://www.vgregion.se/vgrtemplates/BildRightPage____42135.aspx
Lunds Universitet; http://www.ebd.lth.se/forskning/passivhus_demonstrationsprojekt/
IVL Svenska Miljöinstitutet; http://www.ivl.se/AnsokningarPassivhusprojekt.htm
ByggaBoDialogen; www.byggabodialogen.se