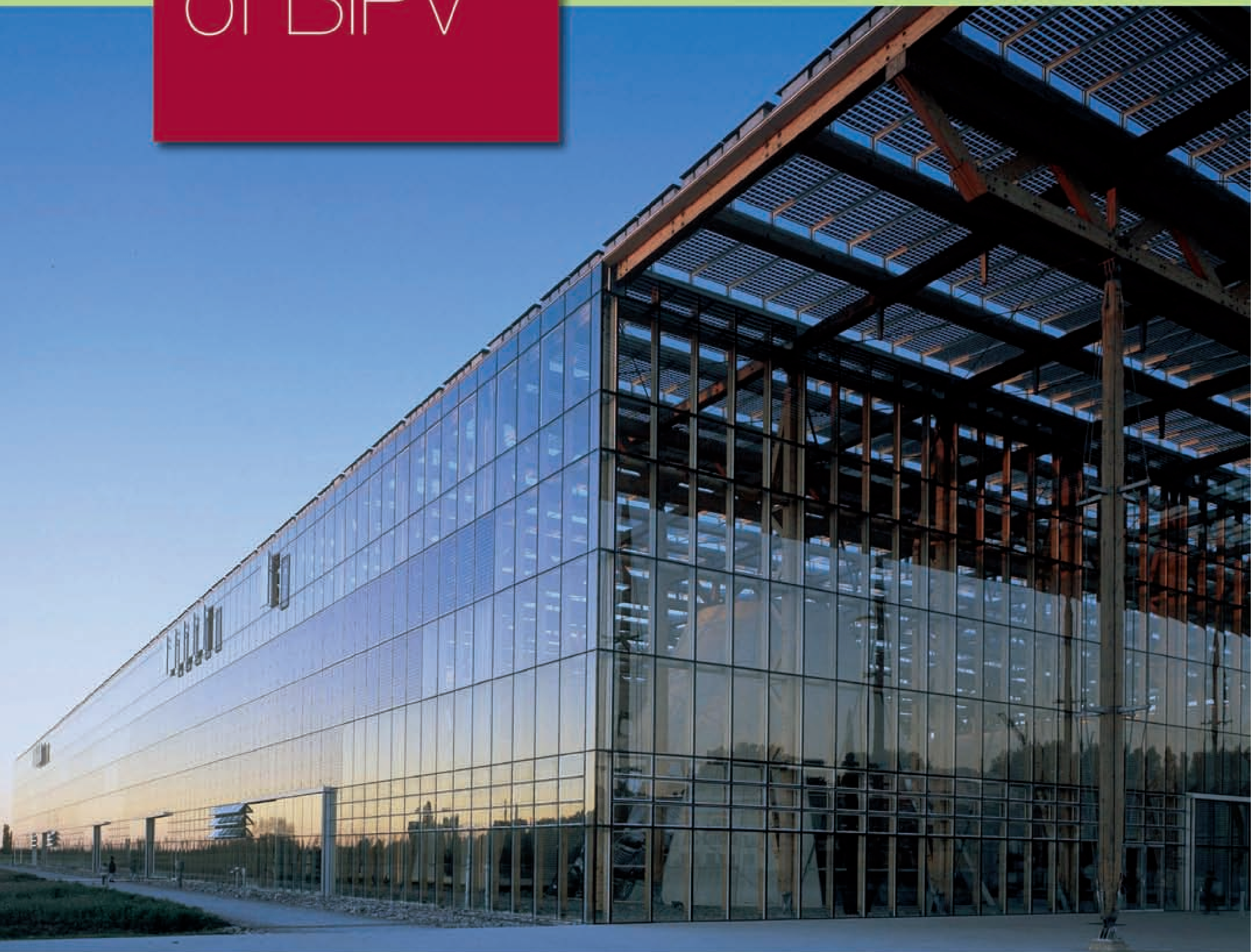
Potential and benefits of BIPV



Promotion of Building Integrated Photovoltaics

EVE Ente Vasco de la Energía

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The Pure Project

PURE project has addressed the promotion of PV integration in the urban environment in five European countries: Spain, Portugal, Italy, Greece and Slovakia. The project has lasted for three years, from January 2006 to December 2008, and has made an special emphasis on the promotion of the 2002/91/EC directive on Energy Performance of Buildings (EPBD).

Energy Agencies, Universities and Technology Centres from selected countries, together with a German PV manufacturer, have taken advantage of best examples and designed a series of promotion activities focused on the agents responsible for the introduction of PV systems in the cities: public bodies, architect associations and building industry professionals.

Proposed objectives have been addressed through a new concept, the PV Demo Relay Node (PVDRN), a kind of facility housing several promotional activities, installed in each selected country and used as a permanent exhibition, a permanent contact point for technical and regulative aspects of PV and to hold conferences and seminars.

The project partners have focused their efforts in improving the following barriers to the development of building integrated PV and EPBD:

- Lack of basic information concerning technical and economical aspects of available solutions. There is a wide group of European countries in which some target groups, such as architects, designers or providers of building appliances, and some key actors (e.g. public bodies) do not have useful information of existing solutions for the integration of PV into the urban environment. The PV-DRNs have acted as the vehicles to carry this information from the technical agents to the key actors and end-users, and have contributed to compile all the available information about technical and economical solutions.
- Lack of awareness about the importance of integrating renewable energies into buildings, in order to save costs and to avoid GHG emissions. The project partners have organized a campaign for end-users in general, to reinforce the use of PV in the EU countries that have been traditionally delayed in terms of the incorporation of new technologies and advances to their society.

The following report represents one of the encouraging measures.

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1 Introduction

PV solar energy involves the direct conversion of sun power into electricity. It does not require either mechanical, thermal or other intermediate steps, nor significant supervision of operation or laborious maintenance.

The sun is a universally accessible renewable energy source, which can bring a definitive solution to the problems of energy dependence. Any limited environmental impact, land occupation and aesthetic issues, can be completely avoided when it is integrated in an urban environment.

The integration of PV in the urban environment and buildings (also called BIPV) offers a vast potential: environmental and economic benefits, encouragement of technological innovations, trends towards bioclimatic architecture, the anticipated supporting legislation, etc. And the possibilities for BIPV are unlimited, since it can be integrated into new or old buildings, car parks, lighting features, canopies, etc. making the most of all the advantages of PV technology.

For instance, if it is installed in the urban environment, BIPV can meet electrical demand where it is needed (almost 40% of European power consumption is due to consumption in buildings), reducing transport and transformation losses. Moreover, when they are incorporated into buildings, new functions cam be found for PV panels. In addition to PV conversion, with the right design they can also provide weather and acoustic protection, thermal regulation, shading, and many other constructive functions.

Despite all these advantages, a number of factors have traditionally limited the spread of BIPV. Most importantly, the cost of generating electricity from BIPV is still higher than for other energy sources. Financial and policy support is therefore needed to develop a strong economy of scale, in order to make BIPV costs competitive by 2015.

This brochure is intended to act as a guide for architects, end-users, public bodies and the general public, in order to give a comprehensible idea of the most important aspects related to BIPV, with particular emphasis on European and Spanish legislation related to PV and specifically how the BIPV systems are treated.

An additional chapter deals offers a review of the most important benefits and potential of PV in general and BIPV in particular. Finally, we provide a compilation of FAQs and a list of PV-related websites.

This brochure will be complemented by another one focusing on the technical solutions and best practices in BIPV. It forms part of the work carried out under the European project PURE, an ALTENER project in the Intelligent Energy Europe program which seeks to promote PV in buildings and in the urban environment in Europe, especially in the six participating countries, characterised by their vast PV potential but low PV implementation.

2 European framework

Source: Biohaus.

The integration of RES in general, and PV in particular, into the urban environment is supported by different regulatory frameworks at European level: on the one hand, RES support policies promote the development of this clean and sustainable energy sources in all EU Member States. On the other hand the new regulations on energy performance in buildings arising out of adaptation of the 2002/91/EC Directive on the Energy Performance of Buildings (EPBD), which has been introduced with the main objectives of reducing the energy consumption in households, increasing the efficiency of systems and in appropriate cases including minimum requirements for the use of RES in the urban environment in order to promote the use of solar (PV and thermal) energy resources in European buildings and Directive 2006/32/EC, on energy end-use efficiency and energy services.

2.1. European Energy Framework

Since the oil crisis of the late 1970s, there has been great concern in the EU with regard to the security of the energy supply, environmental aspects, the competitiveness of the European economy and regional development.

Energy consumption in EU member states is currently growing at between 1 and 2% per year, and if this trend continues, growth of at least 10% is forecast over the next 15 years, as stated in the European Commission's "Green Paper on Energy efficiency or Doing More With Less".

At the same time, approximately 50% of the energy needs of EU member states is currently met by imported energy. This dependency will continue to grow if the present scenario remains unaltered to 70% by 2030. The figure for natural gas is 80% and for oil 90%.

In terms of environmental aspects, current trends suggest that CO_2 emissions, far from stabilising, could be 14% above 1990 levels by 2030. At the present rate of increase in energy consumption, the tensions between a model that is more than 80% based on fossil fuels and the move to advance towards a sustainable environmental policy, will be felt strongly from 2012 on.

The EU's economic competitiveness and regional development are also suffering the consequences of current trends in energy consumption. One example is the negative impact that high oil prices have on growth in GDP. In other words, reduced dependency on oil products directly benefits the European economy.

In the light of this situation, the EU has made a commitment to energy efficiency and the development of more effective energy technologies, and to encouraging local renewable energy sources and a reduced environmental impact.

2.2. Support Policies for RES in Europe

There are currently a wide range of technologies for obtaining energy from renewable sources. Some, such as wind power, small-hydro power, biomass energy and solar thermal have now attained a high degree of technological maturity, economic viability and competitiveness. Others such as solar photovoltaic, despite having reached a considerable degree of technological maturity have yet to achieve economic viability and their development depends to a great extent on the support policies of member states and the EU itself.

Here the EU has designed a series of policies to promote the development of renewable energy sources in general and photovoltaic in particular:

- The "White Paper for a Community Strategy and Action Plan. Energy for the Future: Renewable Sources of Energy" –COM(97) 599 final– which sets a long term target of 12% for the contribution of Renewable Energy Sources (RES) as a whole to total energy consumption in the European Union by 2010. It specifically mentions the installation of 1,000,000 PV systems by 2010, through the initiative for 500,000 façade and roofs for household market. The EU strategic plan also calls for a cumulative installed PV capacity of 3 GWp by 2010, a manufacturing capacity of 1000 MWp/yr and an international PV trade in excess of 40%.

- The Green Paper: "Towards a European Strategy for the security of energy supply: COM (2000) 769 final", which sets a target of doubling renewable energy from 6% in 1996 to 12% in 2010.

- Directive 2001/77/EC on the promotion of electricity produced from Renewable Energy Sources in the internal electricity market (RES-e Directive), with its target of increasing the share of green electricity from 14% to 22% by 2010 (EU-15) and to 21% (EU-25 revised).

- Directive 2002/91/EC on the energy performance of buildings, introduced with the main objective of reducing the energy consumption in households, increasing the efficiency of systems and promoting the use of solar (PV and thermal) energy resources.

- In January 2008, the European Union passed an ambitious raft of measures to combat climate change, involving a commitment to the use of renewable energy, which must account for 20% of the energy consumed in the EU by 2020, and biofuels, as well as targeting reductions in emissions that will place the Union at the forefront of the fight against climate change. Under this plan, by 2020, CO_2 emissions must be 20% lower than in 1990. This percentage could be extended to 30% if other industrialised countries follow suit.

2.3. Directive 2002/91/EC

Directive 2002/91/EC is one of a number of EU initiatives to fight climate change and assure energy supply, and it seeks to impact energy demand as one way of helping solve the two problems.

Services associated with buildings account for approximately one third of the EU's energy consumption. The EC considers that it is possible to make important savings and thus contribute to achieving the targets set for fighting climate change and favouring supply security by adopting initiatives in this area. Measures need to be established at an EU level to tackle these challenges, which affect the entire Union.

The aim of Directive 2002/91/EC on energy efficiency in building is to encourage energy efficiency in buildings (residential and tertiary sectors), taking into account external climate conditions and particular local conditions, as well as internal environmental requirements and the cost-effectiveness ratio, along the lines of Directive 93/767/EEC but establishing more specific actions.

The principal requirements it establishes are as follows:

1. Adoption of a methodology for calculating the integrated energy efficiency of buildings.

2. Application of certain minimum requirements on energy efficiency for new buildings and existing buildings which are subject to major alterations.

3. Energy Certification for Buildings.

4. Regular inspection of boilers and air-conditioning systems, reinforcing the requirements of Directive 93/76/EEC, detailing it and extending it to air-conditioning systems with a capacity of over 12 kW.

The legal, regulatory and administrative provisions required to comply with the terms established in the directive should have come into force before 4 January 2006, but there is an additional period for fully applying energy certification and inspection of boilers and air-conditioning systems, which will conclude on 4 January 2009.

The transposition of EPBD into EU member States legislation is summarized in the table below:

	Work has started	Draft documents available	Documents under public review	Work completed; pending legislative enforcement	Legislative work completed	Practical software/tools available	Practical experience available
Austria	●	●	●			●	
Belgium	●	●	●			●	
Cyprus	●	●					
Czech Republic	●	●				●	●
Denmark	●	●	●		●	●	●
Estonia	●	●					
Finland	●	●				●	
France	●	●	●				
Germany	●	●	●		●	●	●
Greece	●	●	●	●	●		
Hungary	●	●					
Ireland	●	●	●				●
Italy	●	●				●	
Latvia	●	●					
Lithuania	●	●					●
Luxembourg	●	●					
Malta	●	●					
Netherlands	●	●	●			●	●
Poland	●	●					
Portugal	●	●	●	●		●	
Slovakia	●					●	
Slovenia	●	●					●
Spain	●	●	●	●	●	●	
Sweden	●						
United Kingdom	●	●	●			●	●

Source: EPA-NR Survey. National context and need for instruments.

As regards minimum requirements for PV in buildings, most EU Member Sates have yet to develop legislation linked to EPBD transposition. In any case, in almost all the countries specific legislation exists to support PV. This information is summarized in the table below:

POTENTIAL AND BENEFITS OF BIPVPOTENTIAL AND BENEFITS OF BIPVPOTENTIAL AND BENEFITS OF BIPV

	Minimum PV requirements/EPBD transposition	Other PV regulations
Austria	N/A	• Feed-in tariffs annually adjusted by law • Regional investment incentives
Belgium	N/A	• Quota obligation systems • Tradable Green Certificates • Minimum prices for RES-E
Cyprus	N/A	• Grant Scheme for the promotion of RES-E
Czech Republic	N/A	• Feed-in tariffs • Investment grants revision • Improvement of the tariffs
Denmark	N/A	• Premium feed-in tariffs
Estonia	N/A	• Feed–in tariff system with purchase obligation
Finland	N/A	• Energy tax exemption • Investment incentives
France	Enhancement of the impact of RES	• Feed-in tariffs
Germany	N/A	• Feed-in tariffs
Greece	N/A	• Feed-in tariffs • Investment incentives
Hungary	N/A	• Feed–in tariffs • Purchase obligation • Tenders for grants
Ireland	N/A	• Feed-in tariffs
Italy	Under discussion	• Quota obligation system • Tradable Green Certificates • Feed-in tariffs
Latvia	N/A	• Quota obligation system • Feed-in tariffs
Lithuania	N/A	• Feed–in tariffs • Purchase obligation
Luxembourg	N/A	• Feed-in tariffs
Malta	N/A	• Low VAT rate
Netherlands	N/A	• Feed-in tariffs
Poland	N/A	• Green power purchase obligation • Tax exemption
Portugal	Only for solar thermal systems	• Feed-in tariffs • Investment incentives • Tax reductions
Slovakia	N/A	• Feed-in tariffs • Tax incentives
Slovenia	N/A	• Feed-in tariffs • Long term guaranteed contracts • CO_2 taxation • Public funds for environmental investments
Spain	The first country in Europe to adopt a national obligation for buildings to take measures on the minimum use of solar energy (solar thermal or PV) in new buildings or in buildings being remodelled	• Feed-in tariffs • Soft loans • Tax incentives • Regional investments
Sweden	N/A	• Quota obligation system • Tradable Green Certificates
United Kingdom	N/A	• Quota obligation system • Tradable Green Certificates

Source: Sunways.

At this time, only the Spanish Technical Building Code (TBC) includes minimum requirements for PV in certain cases for new and refurbished buildings as a transposition of EPBD into national legislation. The Spanish case may be an example of good practice for other EU members in trying to promote renewables in general and PV in particular in the urban environment.

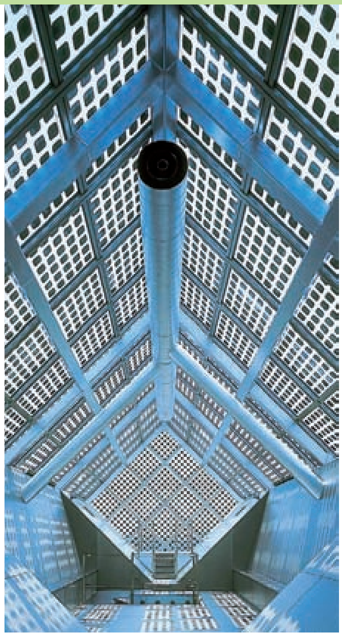
Up to now, legislation on solar PV energy in Spain encouraged an exponential increase in the total installed power, above all from PV farms, due to the feed-in-tariff schemes. The TBC is an important step towards favouring the large-scale implementation of PV systems into buildings, which can be followed by other member states, but in our opinion it is not ambitious enough and additional measures should be considered to make the integration of PV truly compulsory (as is already the case with solar thermal).

Support is needed for the mass integration not only of solar farms, but also of BIPV. The measures contained in the TBC (e.g. percentage of losses) are insufficient for the expected increase. Spain also offers good examples and best practice for municipal legislation and bylaws on the obligation to install PV plants in every new or refurbished building. The number of municipalities with special laws for PV is expected to increase in the coming years.

The first BIPV systems installed in Spain as a result of the TBC are expected by the end of 2007, and the forecast for 2010 is to have 100 new MWp of BIPV systems due to the application of the TBC. This objective will be more easily achieved if additional legislation measures are established.

It is important to take into account that these measures have a multiplying effect as PV energy is a clean, inexhaustible and silent energy which raises public awareness of the energy saving, and it is therefore suitable for urban integration.

3 Spanish Framework


Source: Scheuten Solar.

3.1. Characterisation

Given its geographical location and climate, Spain has high average levels of solar radiation, although there are notable differences between the different regions (autonomous communities). According to data from the Centro de Estudios de la Energía Solar (Solar Power Studies Centre), regions on the north coast get 1,700 hours of sunlight per year, whereas Mediterranean areas enjoy 2,750 hours. The provinces of southern Andalusia have the highest rates of sunshine, at 3,000 hours of sunlight per year.

Spain's photovoltaic industry also accounts for 7% of world production of photovoltaic generators.

In October 2007, installation of photovoltaic plants in Spain was ahead of the capacity envisaged in the **Renewable Energy Plan** (REP) 2005-2010 and by the end of the year total capacity will exceed **1,800 megawatts (MW), five times higher than the target set for 2010.**

A report by Lehman Brothers puts average yearly growth in the industry at 59% to 2012. This will be the point when solar photovoltaic power, with its premiums, will be able to compete in price terms with natural gas.

The report forecasts that the number of installations will rise 100% from 2007 to 2008 (to 856 MW, as compared to 428 MW at the end of last year). It predicts an average growth in the industry of 59% to 2012.

Although the Lehman report forecasts a certain fall-off in the pace of installation from September of this year, it does not predict any 'risk of a very significant fall' for 2009. Indeed, it envisages a 70% increase in the number of installations next year.

3.2. PV Relevant Policy

In August 2005, the Spanish Parliament approved the Renewable Energy Plan 2005-2010 (REP). This plan is a revision of the Plan for the Promotion of Renewable Energy in Spain 2000

-2010, published in 1999. The REP sets a target of meeting at least 12% of total energy consumption with renewable sources in 2010. Specifically in the field of solar photovoltaic energy, the REP targets an increase in photovoltaic power from 363 MWp in the period 2005-2010 to 400 MWp of accumulated installed capacity by 2010.

The implementation of this plan, together with the 2005-2007 Action Plan, and more recently the new 2008-2012 Action Plan (PAE4+), of the Energy Saving and Efficiency Strategy, will reduce energy consumption and offset Spain's external energy dependence, while at the same time making an important contribution to reducing pollution.

The REP establishes a series of measures to achieve these ambitious objectives. In the area of solar photovoltaic these are intended to overcome economic, technological, regulatory and social barriers that currently hinder development. Regional governments, by virtue of their specific powers, have also drawn up energy plans, some of which are general in nature (3E-2010 Plan, Autonomous Community of the Basque Country) and others specific for renewable energy sources (Plan for Promotion of Renewable Energy Sources, Autonomous Community of the Balearic Islands).

Regulation currently under review:

- Renewable Energy Plan 2008-2020 to achieve a 20% contribution from renewable to the energy mix by 2020, within the framework of the EU's targets.
- Energy Saving and Efficiency Plan in Government Buildings.
- 2008-2012 Action Plan on Strategy for Energy Saving and Efficiency in Spain.

Spanish PV incentives system

The Spanish market will continue to enjoy the most attractive premiums in Europe. The Lehman report sets out a number of possible scenarios with regard to recent regulation (with and without a capacity target and with premiums of between 31 and 39 eurocents) and concludes that even in the worst case scenario, with a reduction in payment of over 25%, conditions would still be better than in Germany, the world's largest market in this industry.

Royal Decree 661/2007, of 25 May 2007, governing power production under the special system (renewables and CHP), guarantees practically twice the payment for larger photovoltaic facilities, with that for smaller ones remaining the same, with a guaranteed yield of 7%

This regulation improves payment on less mature technologies, such as biomass and solar thermal, in order to meet the targets of the Renewable Energy Plan 2005-2010, and Spain's commitments at a EU Level. With the development of these technologies, renewable energy in Spain will cover 12% of energy consumption by 2010.

Facilities already in operation before 1 January 2008, when the new decree came into force, which opted to receive the regulated tariff, may continue to avail of the regulation under the previous payment regime of Royal Decree 436/2004 throughout their useful service life.

Source: Sunways.

Producers who choose to sell power on the wholesale market may continue to avail of Royal Decree 436/2004 until 31 December 2012.

As for the payment for this technology, it is worth mentioning the recent approval of Royal Decree 1578/2008, in September 2008, which lowers the premiums by between 29 and 24% with regard to the current economic regime under the aforementioned Royal Decree 661/2007.

This Royal Decree also sets a cap of **400 new MW per year,** of which two thirds is reserved for plants installed on the roofs of buildings and the rest for those sited on the ground. To cushion the impact of this limitation on the photovoltaic industry, in **2009 there will be an additional extraordinary quota of 100 MW and in 2010 of 60 MW** for ground-based plants.

The government's aim in introducing this new legislation is to turn Spain into the "European country that gives most support to solar photovoltaic power". The target is to reach 3,000 MW by 2010 and 10,000 MW by 2020.

With this Royal Decree it is hoped to achieve the technological development that will allow **"renewable energy to account for 20% of Spanish energy consumption by 2020 and 40% of power generation".**

3.3. Incorporation of Directive 2002/91/EC

Directive 2002/91/EC is being transposed into Spanish Law by three Royal Decrees:

1. Royal Decree 314/2006, of 17 March 2006, approving the Technical Building Code.

   The Technical Building Code incorporates Articles 4, 5 and 6 of the Directive on minimum energy efficiency requirements for new and existing buildings.

2. Royal decree approving the revised Regulation on Thermal Installations in Buildings (RTIB), approved by Royal Decree 1751/1998 and amended by Royal Decree 1218/2002 (currently being processed).

   As part of the review of the RTIB, it is necessary to incorporate the minimum energy efficiency requirements for thermal installations and the inspection of boilers and air-conditioning systems (Articles 4, 5, 6, 9 and 10 of the Directive).

3. Royal Decree 47/2007 of 19 January 2007, regulates the basic procedure for certifying energy efficiency in new buildings. The aim of the Decree is to promote the construction of energy efficient buildings and to this end, a uniform marking system has been introduced for the entire Spanish territory, the energy efficiency label. This label allows potential buyers to know the level of energy efficiency of the building without requiring technical knowledge, by just checking whether the rating is close to A (very efficient) or G (very inefficient), like the labels on domestic appliances.

The first of these Royal Decrees comes under the aegis of the Ministry of Housing and the other two are under the joint aegis of the Ministry of Industry, Tourism and Commerce and the Ministry of Housing. In the case of the Energy certification for buildings, it will also affect the Ministry for Health and Consumer Affairs, since it is related to consumers' and users' right to information.

Technical Building Code

The Technical Building Code (TBC) is the legal framework which establishes the demands that have to be met by buildings in terms of the basic requirements of safety and habitability set out in the Building Organisation Act (BOA).

The Technical Building Code contains a Basic Document, HE, devoted to energy saving. The purpose of this Basic Document is to establish the rules and procedures that allow basic energy saving requirements to be met.

The five sections in which this basic document are developed are:

- HE 1. Limitation of Energy Demand.
- HE 2. Efficiency of Thermal Installations.
- HE 3. Energy Efficiency of Lighting Facilities.
- HE 4. Minimum Solar Provision of DHW.
- HE 5. Minimum Photovoltaic Power Contribution.

HE 5. Minimum Photovoltaic Power Contribution

In Basic Document HE5, the TBC establishes that it is compulsory to incorporate photovoltaic procedures for solar energy use and transformation into the system in the following cases:

- Hypermarkets with a total floor area of over 5000 sq metres.
- Multi-shops, malls and leisure centres with a floor area of over 3000 sq metres.
- Storage bays with a floor area of over 10000 sq metres.
- Administrative buildings with a total surface floor of over 4000 sq metres.
- Hotels and guest houses with accommodation for over 100 guests.

- Hospitals and clinics with over 100 beds.
- Pavilions and exhibition centres with a floor area of over 10,000 square metres.

It also establishes the minimum solar photovoltaic electric capacity to be installed, by applying a formula and coefficients defined according to the use of the building (commercial, supermarkets, hospitals, etc.) and the climatic area in which it is built.

Any reduction or elimination of this installation capacity is only possible with justifications in certain cases: when the minimum electric power is covered by other RES; due to architectonic barriers; when suitable radiation conditions do not exist; in cases of refurbishment, when the installation of a PV plant becomes dangerous or is impossible due to local urban legislation; when there are limitations due to the protection of heritage or historic buildings.

Among other aspects, the TBC regulates the size of the facilities and the layout of the modules. In the latter case it distinguishes between three cases: general case, superposition and architectural integration.


Source: MSK.

The new TBC deems that photovoltaic modules are architecturally integrated when they meet both energy and architectural functions (cladding or shading) and, in addition when they replace conventional building elements or are a constituent part of the architectural composition. They are considered to be architecturally superposed when the panels are fitted as an addition to the covering elements of the building.

For each of the above cases, the TBC gives maximum values for losses from orientation and inclination, losses from shade and total losses. If these loss values are exceeded, the PV installation could be replaced by other RES. An important measure to encourage the integration of photovoltaics into the buildings is that permitted losses are greater for integration than for superposition or standard installation.

The TBC also contains measures that affect the maintenance, operation and monitoring of PV systems, which that are applicable for the entire life of the installation.

4 Opportunities for BIPV in Spain

There is an enormous potential for integrating photovoltaic into buildings. There are so many surfaces on the roofs or façades of the buildings all over Europe that a really large proportion of power consumption could be met by producing clean energy with solar panels. In countries such as Germany or Spain, a large quantity of solar power has already been installed, but there are still thousands of square metres left on buildings which could be covered with solar panels.

4.1. Available area for BIPV

The table below summarises the potential area for installing photovoltaic on the surfaces of buildings around the world.

The potential for PV in the building environment is vast. In its report "Photovoltaics in 2010", EPIA gives striking figures of the potential for PV installations on roofs.

Work has started	Net Area in roofs (sq km)	Potential power (GWp)	Potential energy (TWh/year)	Percentage of PV electricity
Europe	3,723	618	494	14.64%
USA	4,563	757	904	19.54%
Japan	1,050	174	159	11.54%
Rest of OECD	1,273	211	230	20.10%
Total	**10,609**	**1,760**	**10,519**	**16.98%**

Potential of BIPV systems: capacity for installation and electricity production. Source: EPIA.

BIPV can be included both in new buildings and refurbished ones, although from a market point of view, the greatest potential for BIPV lies in refurbishment. Previous data is strongly supported by IEA/PVPS Task 7-4 in its report on "Potential for Building integrated Photovoltaics". The table below gives some key figures on the potential for electricity generation and possibilities for installation in Spain.

Country		Residential building	Agriculture building	Industrial building	Commercial building	Historic building	Other buildings	All buildings
Spain	Roof	251.97	78.74	55.12	55.12	-	7.87	448.82
	Façade	94.49	9.84	10.67	27.56	-	2.95	168.31

BIPV Potential (in km²). Source: EPIA "Photovoltaics in 2010. Photovoltaics: Current Status and a Strategy for European Industrial and Market Development to the year 2010". Pp16.

The potential in Spain is even greater than presented here, given the boom in the building industry over recent years.

4.2. Buildings in Spain. Features and Potential

If we focus the analysis of opportunities on the number of potential buildings that could integrate a PV system, then this potential is again huge. An analysis of BIPV potential on the Spanish market is given in the following paragraphs. Most of the data presented is taken from the Spanish national census 2004.

Number of inhabitants of main towns. Influence of BIPV, penetration among the population

Two thirds (64.93%) of the population of Spain lives in towns with a population of over 20,000 inhabitants, and one half in cities of over 50,000. One third of all buildings (33.00%) are in urban areas. The features of buildings in the two areas are entirely different and we therefore make an analysis in two scenarios: buildings in the rural area, and buildings in the urban area. The distribution of buildings by type of area is shown in the table below.

Type of area	Number of buildings	Percentage
Urban Area	2,845,967	33.00 %
Intermediate Area	2,271,607	26.34 %
Rural Area	3,506,301	40.65 %

Above all, BIPV systems are designed to be installed in urban environments, in innovative buildings, more than in villages.

Percentage of historic town centre / “installable” buildings / public buildings / apartment blocks.

The table below shows the distribution by use, regardless of the type of area.

Use of buildings	Number of buildings	Percentage
Buildings for homes	8,613,416	99.88 %
Hotels, hostels, guesthouses	1,330	0.02 %
Public buildings: convents, prisons, military academies, school buildings, hospitals, etc.	9,129	0.11 %

The most promising buildings for integration of PV are the public ones, and also those dedicated to accommodating persons: hotels, hostels. There are almost 10,000 buildings where PV could easily be integrated in Spain.

Density / Proximity between buildings / height of buildings / Uniformity of buildings

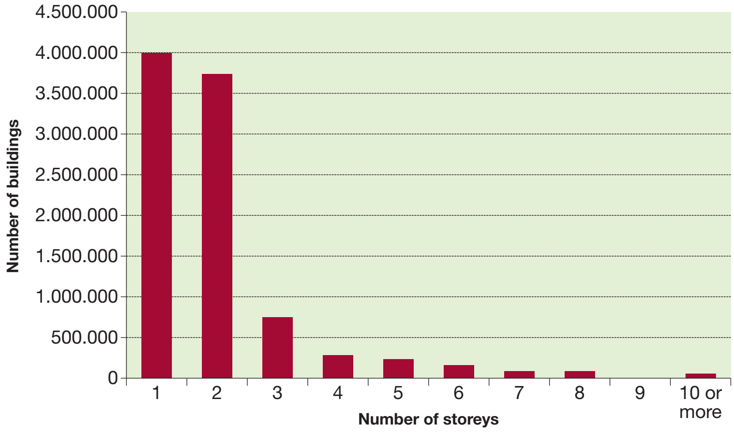
These parameters are very important for establishing the type of technical solution suitable for each specific case. The distance between buildings (density) influences the shade, possibilities for façades, etc.


Source: Scheuten Solar.

Spain has great diversity between regions. A clear example is the population density: Madrid, Basque Country and Cataluña have over 200 inhab/km^2, whilst Extremadura, Castilla La Mancha or Aragon have less than 30 inhab/km^2. If cities of more than 200,000 inhabitants are taken into account, the average density is 1,738.60 inhab/km^2, with cities of over 5,000 inhab/km^2 (Madrid, Sevilla, Bilbao, Valencia), and cities of less than 1000 inhab/km^2 (Vitoria, Zaragoza, Murcia). Density levels of over 1500 imply city topologies with very narrow streets and very high buildings.

One factor of diversity is the height of buildings. The graph below shows the total number of buildings and the number of floors at national level. Most have 1 or 2 storeys, giving a poor level of façade surface.

No. Buildings Vs. No. Storeys

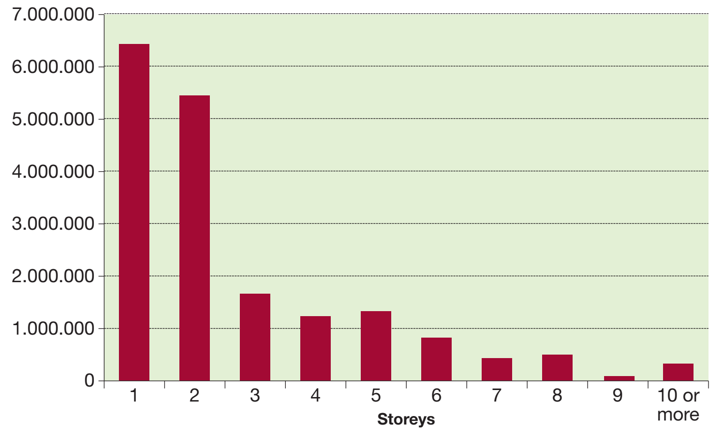


Flats	N° Buildings
1	4,008,934
2	3,762,567
3	740,854
4	263,275
5	217,461
6	120,181
7	60,338
8	61,852
9	10,359
≥10	38,692

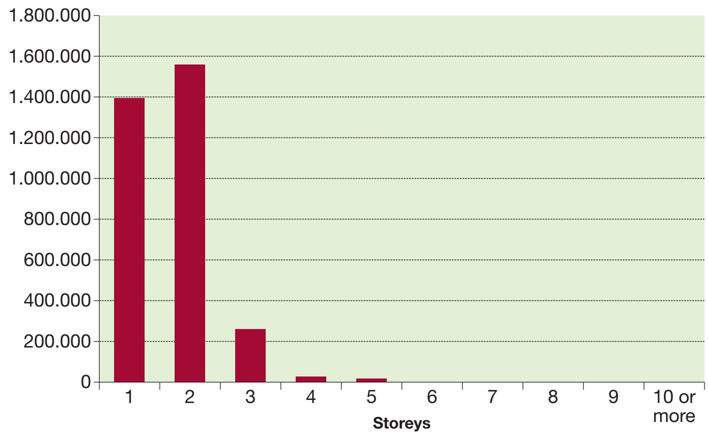
The situation in the urban environment (cities of more than 50.000 inhabitants) shows greater diversity of heights and buildings. The average height is almost 3 storeys.

In municipalities of less than 5,000 inhabitants, the average is 1.68 storeys and the graph shows that most are only 1 or 2 storeys high.

No. Buildings Vs. No. Storeys (>50,000 inhab.)

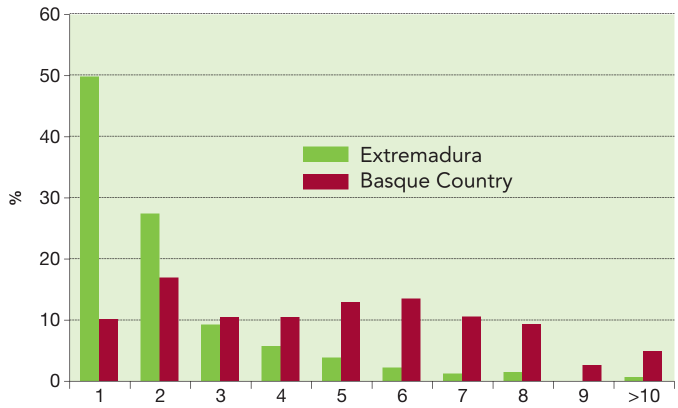


No. Buildings Vs. No. Storeys (<5,000 inhab.)



The height of the buildings varies greatly depending on the region. For instance, in Northern Spain (the Basque Country), buildings are 5-6 storeys high on average (corresponding to regions with greater density), whereas in Extremadura (southern Spain and the hottest region), they usually have 1-2 storeys.

Comparison btw. regions

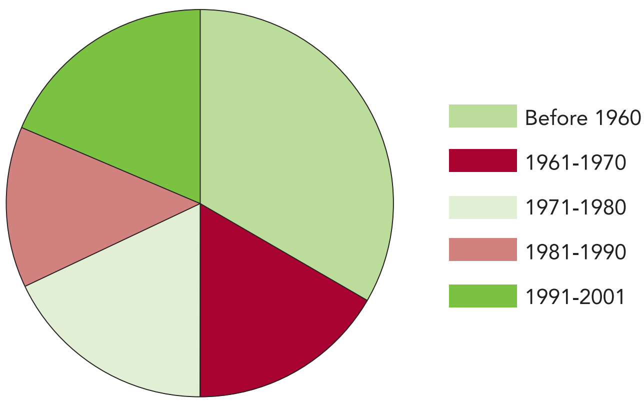


Criteria of aesthetic uniformity

It is important for the integration not to disturb local uniformity, e.g. if all buildings are white, it could be unattractive to introduce a dark PV façade.

Some criteria for analysing the uniformity of buildings include the age and height of buildings. The average age of buildings in towns of more than 50,000 inhabitants is 34.46 years.

Age of buildings (>50,000 inhab.)



The age of Spanish buildings is distributed uniformly, and there is an almost equal percentage of old and new buildings.

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In the case of towns of less than 5,000 inhabitants, the average age rises to 46.12 years, and in many regions the average is over 60. This kind of building requires another type of solution for integrating PV, more appropriate for refurbishment.

Description of the typical building

The features of the typical building and its environment (height, typology, etc.) are:

- Average 2 storeys (1,68 if < 5,000 inhab. and 2.77 for urban areas > 50,000 inhab.).
- 39 years old (46.12 years against 34.46 years for more 50,000 inhab.).
- In both cases (rural and urban areas), buildings are mainly residential. This means that there is a huge potential for BIPV, although there are more facilities for the more than 10,000 public and commercial buildings.
- Buildings with 1 or 2 storeys normally have sloped roofs, made of roof tiles. Buildings in towns usually have large spaces on the flat roof, which means they offer the best conditions for PV plants.
- Spain has a long history and many villages and towns have historical town centres, not available for integration of PV into the building structures, which are protected by local municipal bylaws.

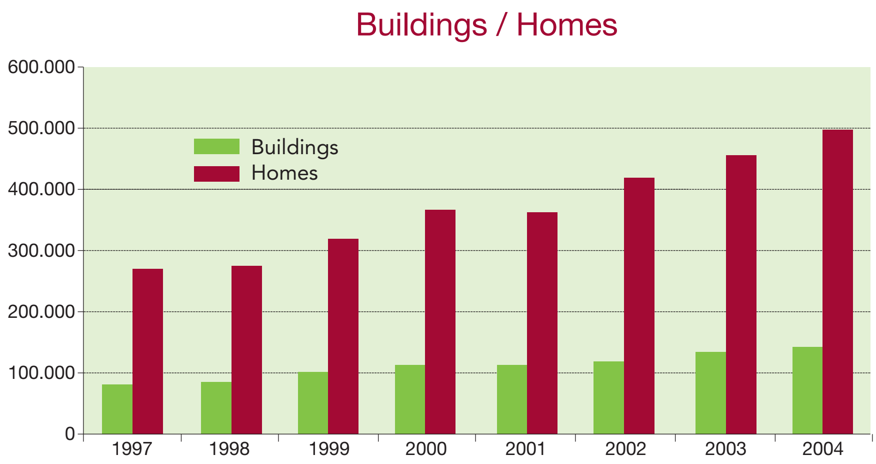
New buildings

Tables and figures

Source: Schüco.

The Spanish population has increased over the last 5 years by 4 million to 44 million. The increase in population is not concentrated in the large cities. This means that new buildings are above all located in small cities and rural areas, where height and features are different.

On the other hand, the development of new buildings in Spain has also increased over recent years, to half a million new buildings in 2004 and 800,000 in 2005. Although there are already more than 20 million homes built (44 million inhabitants), each year Spain builds more than Italy, France, Great Britain and Germany put together. The building sector in Spain is very important (large influence on GDP) and in the future, the country will try to reduce the number of homes and increase retrofitting, which represents an excellent niche for PV. Its increase will opens the possibilities for new PV plants, as many of these buildings belong to the urban area.



4.3. Spanish Legislation on BIPV. Comments on the technical building code (TBC)

BIPV is very dependant on legislation. To date, legislation on solar PV energy in Spain has driven an exponential increase in total installed power, above all PV farms, due to the feed-in-tariff schemes. The TBC has been important in the massive implementation of PV systems into buildings, but it is not ambitious enough and additional measures need to be considered to make integration of PV truly compulsory (as is the case with solar thermal).

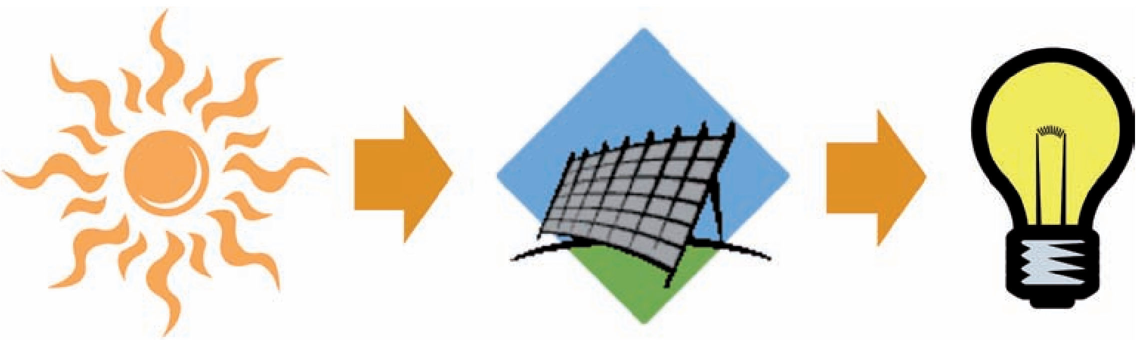
Support is needed not only for the mass integration of solar farms, but also of BIPV. The measures set out in the TBC (e.g. percentage of losses) are insufficient for the anticipated increase. Spain offers good examples and best practice in the area of municipal legislation and bylaws with regard to the obligation to install PV plants in every new or refurbished building. The number of municipalities with special laws for PV is expected to increase in coming years.

The first BIPV systems installed in Spain as a result of the TBC are expected by the end of 2007, and the forecast for 2010 is to have 100 new MWp of BIPV systems due to the application of the TBC. This objective will be more easily achieved if additional legislation measures are established.

A new Royal Decree (RD1578/2008) has now came into force in Spain, which establishes the scenario for PV in coming years. It reduces the feed-in-tariffs for all kinds of facilities. However, for installations integrated into buildings of less than 20 kW, the tariff is €0.34/kWh, whilst in other installations it will be €0.32 /kWh. In addition, the legal procedures for these small installations will be simplified. All these measures are expected to increase the BIPV market in Spain.

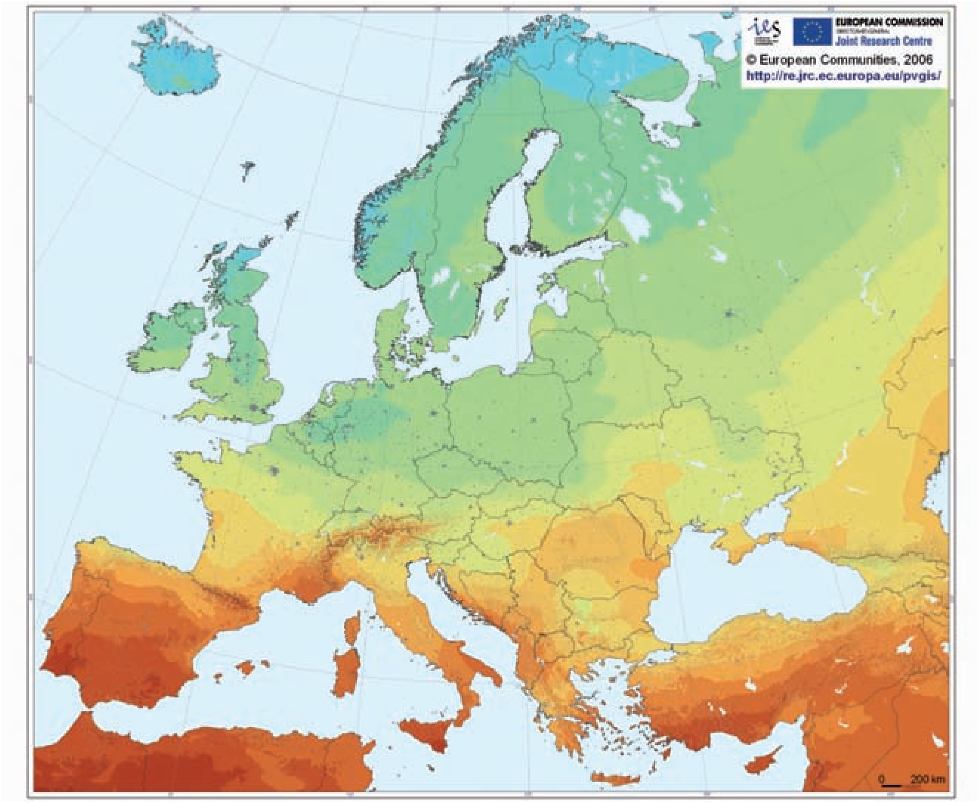
5 The principal benefits of PV

Photovoltaic (or PV) solar energy is the **direct conversion of sun power into electricity.** PV solar energy therefore represents an amazing development compared with other ways of generating electricity, since it is not based on the movement of an inductor inside a magnetic field and therefore does not require mechanical, thermal or other intermediary steps, or significant operation supervision or laborious maintenance.

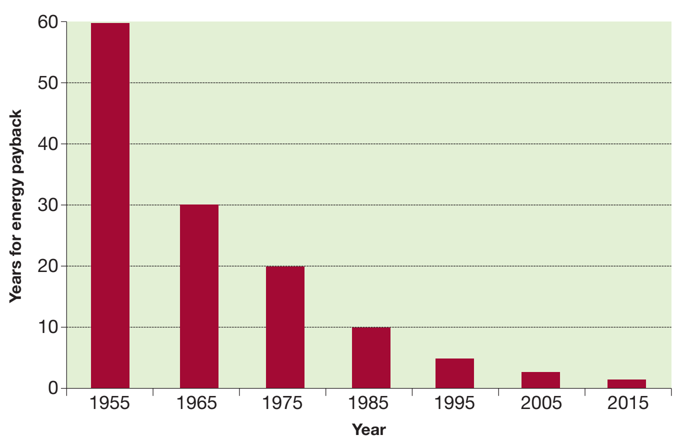


Evidently, the Sun is a **renewable energy source,** which will continue to provide power for another five billion years at least, and it is **universally accessible,** which can definitively solver the problems of energy dependence. In addition, silicon, the raw material most widely used in PV generators, is also one of the earth's most plentiful elements and its extraction does not pose any major technical difficulties. Furthermore, all components of PV panels are **recyclable.**

Photovoltaic Solar Electricity Potential in European Countries



Traditionally, PV was thought not to be profitable in terms of energy, given the large quantity of energy required in the production process, which was never recovered over the lifespan of a PV generator. This may have been true when the technology was still in its infancy, but today, the production energy is recovered in the first two years of performance. Note that PV panels are a proven technology guaranteed for at least 20 years.



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PV solar energy is not only profitable in terms of energy but is also expected to be **economically competitive within the next decade,** at the current rate of reduction in production costs and the rise in electricity tariffs.

Finally, PV solar energy does not give off any form of emissions, waste or noise. Even **its low environmental impact,** land occupation and aesthetic aspects **can be fully overcome by integrating it in an urban environment.**

Source: Scheuten Solar.

All this and much more with BIPV

Indeed, there is a huge potential for integrating PV solar energy into buildings.

On the one hand, by integrating it into the urban environment, BIPV can be made to meet electricity demand precisely where it occurs, thus **reducing transport and transformation losses.**

Source: Scheuten Solar.

On the other hand, **new functions of PV panels** arise when they are incorporated into buildings. As well as PV conversion, with a suitable design it is possible to obtain weather and acoustic protection, thermal regulation, shading, and many other **construction functions.**

Indeed, more and **more innovative materials** are emerging to make BIPV easier and more economic. For instance, both the well-known and mature **thin film** technology and the novel **DYE sensitised solar cells** (DSSC) represent **low cost flexible solutions** for adapting the PV generator to the building.

Source: MSK.

Another way of taking advantage of the incorporation of PV panels into buildings is the **hybrid Photovoltaic Thermal system (PVT),** which is used to **convert the absorbed solar radiation into electricity and heat,** thus increasing the total energy output.

Despite all these advantages and promising technologies, the growth of BIPV has traditionally been hampered by a number of negative factors.

On the one hand, it is reported that BIPV systems are less efficient than large PV plants. The main reason is the appearance of mismatching losses, due to the individual working conditions of each PV panel, which makes it difficult to extract the maximum available power from the PV generator.

Fortunately, string and later multi-string technology and, more recently, AC modules and **new distributed architectures** based on DC/DC converters, **considerably reduce mismatching losses,** as well as offering new advantages, such as greatly **improved monitoring and maintenance** of BIPV installations.

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On the other hand, it is widely considered that mass implantation of BIPV would present a problem for the grid due to its unpredictability. After all, the sun is an unmanageable energy source.

However, **with a suitable storage system** not only would these inconveniences be avoided, but it would even help to **improve the power quality of the distribution network** by means of advanced techniques for grid voltage control and reactive power management. Additionally, a BIPV installation with a storage system provides each building with an **uninterrupted power supply** (UPS).

To sum up, in view of the environmental and economic benefits, the encouraging technological innovations, the current trend towards bioclimatic architecture, and the anticipated supporting legislation, there is clearly a great potential for BIPV.

BIPV is unquestionably the future of our cities. Roofs and façades will go from being a cost to being an investment, with production costs being offset by the production of clean energy in just a few years. Fortunately too, PV is also easily expandable and this promising future is not far away.

Source: MSK.

Source: Scheuten Solar.

6 Frequently asked questions

1. How do photovoltaics work?

Photovoltaics is the direct conversion of sun power into electricity.

Photons of a high enough energy are absorbed by a semiconductor material creating electron/electron hole pairs which come under the influence of an electric field and are conducted through an external circuit.

2. What is the difference between a solar collector and a photovoltaic system?

There are two types of "solar panels", electrical and thermal. The electrical type is generally referred to as a "photovoltaic panel". It is a solid state device or assembly of solid state devices and produces electricity only. The thermal type of panel generally consists of water piping, glass and insulation and is much larger in size. This thermal type of panel is referred as a "solar collector".

3. Why should I use photovoltaics?

Mainly for the following two reasons:

- to cover your energy needs and
- for environmental protection. Each kWh of electricity produced from fossil fuels charges the atmosphere with at least 1kg of CO_2 (the gas most responsible for climate change).

In particular, photovoltaics:

- will operate unattended and require minimum periodic maintenance,
- can be designed for easy expansion. If the power demand increases in the future, the ease and cost of increasing the power supply should be considered,
- are based on proven technology that has shown little degradation in over 15 years of operation.

4. What differentiates an autonomous PV system (off-grid) from an interconnected (on-grid) one?

Interconnected PV systems supply electricity directly to the grid, while autonomous systems directly supply houses or other facilities. Off-grid systems usually use a battery to store the electricity produced.

5. What kind of energy needs can a PV system cover?

Lighting, telecommunications, cooling, sound and generally all the needs that can be covered with energy from conventional technologies.

However PVs are not recommended for the supply of thermal electric appliances, eg cookers, water-heaters, etc. For these uses there are very economical solutions such as solar water-heaters, solar/geothermal air-conditioning or gas heating systems, gas, biomass, etc.

In contrast, requirements lighting and electronics (computers, audio systems, refrigerators, televisions, telecommunications etc.) can easily and economically be met with PV systems.

As a general rule, a 2-3kWp PV can meet the needs of a three-member family.

6. Aren't PVs efficient only on sunny days? What happens on days with no sun or at night?

Electricity production from PV panels, needs solar radiation light, rather than heat. Even on a cloudy winter day, during daylight, PVs produce electricity – albeit with reduced efficiency (on an absolutely overcast day, PV panels will produce 5-20% of maximum power).

In Germany, for example a 3kWp PV on a roof can produce approximately 3,000 kWh a year, enough energy to cover the annual electricity demands of an average household.

7. Which are the disadvantages of the PV systems?

- The initial cost is the main disadvantage of installing a solar energy system, mainly because of the high cost of the semi-conducting materials used in building one.
- Solar panels require quite a large installation area to achieve a good level of efficiency.
- The production of solar energy is influenced by the presence of clouds or pollution in the air.
- No solar energy will be produced at night, although a battery backup system and/or net metering will solve this problem.
- Solar cells produce DC which must be converted into AC (using a grid tie inverter) when used in currently existing distribution grids. This incurs an energy loss of 4-12%.

8. In what ways can a PV system be installed in existing or newly constructed buildings?

There are two chief possibilities:

- Real integration, where PV modules actually replace several building materials, and
- Superposition, where PVs are placed on existing external surfaces of buildings (roofs, façade)

Obviously, the first case is preferable. The most important advantage is a reduction in the indirect cost of the PV system by substituting building materials (such as glass panes, roof and materials and skylights). In addition, full integration into the building structure significantly improves the aesthetics of the construction.

9. What does "BIPV" mean?

BIPV (Building Integrated Photovoltaics) refers to PV systems integrated with the building phase of an item. It means that they are built / constructed along with the item and also planned together with it. They could, however, be built later on (this is superposition). The task requires the cooperation of many different experts, such as architects, civil engineers and PV system designers.

BIPV consists of building materials for the shell of the building, that also act as producers of clean energy from the sun, thus saving costs in terms of both materials and energy.

10. Is my house suitable for photovoltaics?

- PV panels can be used on buildings with a south-facing wall or roof. Chimneys, roof lights, trees or buildings can all shade your panels and need to be taken into consideration when deciding where to position the system as shading makes a huge difference to the performance of the system.
- A typical installation requires at least 7-15 m^2 of roof area.
- PV panels are quire heavy so the roof must be strong if they are to be placed on top of existing tiles. This depends on the technology used.
- If the system is grid-connected, the house should be close to the grid, as otherwise the cost could shoot up.
- For an off-grid system enough space will be needed for the batteries.

11. What are the most common BIPV systems?

- Façade or roof systems added after the building is completed. This is superposition.
- Façade integrated photovoltaic systems built along with a feature.
- Roof-integrated photovoltaic systems built along with a feature.
- "Shadow-voltaic" - PV systems also used as shadowing systems, built along with a feature or added later.
- "Architectural interventions" in stages, parks, squares, streets, etc.

12. Can I walk on PV modules on my roof?

PV modules are most often encapsulated in two layers of tempered low-iron glass or between glass and tedlar (a polymer) so they are flexible and less rigid than 100% glass. This is to give the modules the strength they need to withstand the most severe hail fall.

Nonetheless, PV modules are not designed to be walked on. It is recommended that you protect the modules with lengths of wood before walking on them, just as you would protect other glass roofing materials.

13. How heavy are photovoltaic modules? Does the support structure need to be reinforced?

Standard photovoltaic modules are relatively light, weighing around 10 to 15 kg/m^2. This means that in most circumstances there is no need to reinforce existing structures.

Made-to-order modules may be heavier - insulated double and tripled glazed modules, often used in sunroofs and atriums will be 2 to 3 times heavier. Other factors that may affect the weight of a photovoltaic system are the type of module frame and the connection method selected.

It is essential that PV installations comply with local building regulations and safety codes.

14. How much light does a transparent PV roof element let through?

Transparent PV modules generally come in one of two main types:

- normal cells in a double glass frame; the gaps between the cells are transparent
- thin films deposited on a glass surface; the PV layer is thin enough to let a certain amount of light through.

The gaps between normal PV cells in a double-glass module can be increased or decreased to change the transparency level of the module. Generally, the gaps between cells are such that the transparency is between 5% and 30%. A classic double glass module will have a transparency of roughly 4% to 5%.

The transparency of thin film modules depends on the transparency of the support and the thickness and type of cell used. It is normally around 5% to 10%.

Nearly any degree of transparency can be made to order, but it is common to balance the natural light gains against potential overheating due to increased thermal gain.

15. How much space do I need to install a PV system?

It depends on the technology used. For example, a 3 kWp, Poly-Si needs a south-facing roof area of about 25m^2.

In general, PV technology does not require large areas. In order to cover the entire electricity demand of Europe, 0.7% of its total land area would be sufficient. There is enough available surface which does not compete with other land uses, such as the façades and roofs of buildings.

16. How much does the integrated PV installation will cost?

The cost of the PV system depends on:

- the panel technology (e.g. amorphous silicon panels cost less, but require approximately twice the size of Mono-Si),
- the origin of the panels and other items of equipment (European panels are more expensive but usually more reliable than Chinese ones),
- the size of the PV system (the less the power, the greater the cost per installed kW),
- the difficulty of the installation (inaccessible areas or installations with increased technical difficulty cost more),
- the distance from the grid,
- the energy needs of the building .

The cost per kW installed ranges from €4,200 (for amorphous silicon panels) to €7,500 (for Poly-Si panels). For an initial estimate, the investor can calculate an average target price of €6,000 per installed kW.

System designers know that every decision made during the design of a PV system affects the cost. If the system is oversized because the design is based on unrealistic requirements, the initial cost is increased unnecessarily. If less durable parts are specified, maintenance and replacement costs are increased. The overall estimates of the life-cycle cost of the system can easily double if inappropriate choices are made during system design. Don't let unrealistic specifications or poor assumptions cause unreasonable cost estimates and keep you from using this attractive power source.

17. What is the lifetime of a PV installation? Do PV systems have a high operating cost?

A well-designed and maintained PV system will operate for more than 20 years. The PV module, with no moving parts, has an expected lifetime in excess of 30 years. Experience shows most system problems occur because of poor or sloppy installation. Failed connections, insufficient wire size, components not rated for DC application, and so on, are the main culprits. The next most common cause of problems is the failure of electronic parts (controller, inverter, and protection components).

Generally the operating and maintenance cost of PV systems is low.

18. Why are roof-integrated products so expensive compared to standard modules?

At present, roof-integrated PV modules and systems are still custom-made, requiring a lot of design work and manual manufacturing. If standard solutions for roof-integration could be provided on a larger scale, these product prices would drop to a comparable level.

19. What steps should I follow?

- Describe your energy needs in detail. Record the electrical appliances you use and the time they are turned on. If you are already connected to the grid read over the last year's accounts carefully.
- Follow some simple energy-saving practices. Calculate, even roughly, the expected reduction in electricity consumption.
- Contact dealers and PV installers and report these figures to them. Invite them to see your building and estimate the power that will cover your needs.
- Ask companies to show you some of their previous projects. If possible, visit some of their clients and ask their opinion. Did they meet their needs? Are they satisfied with the quality of work and technical support?
- Study the offers. Ask for details of the proposed system.
- Compare the prices, guarantee and technical support offered by each company.
- Investigate the possibility of investment subsidies in your country.

20. Is it possible to recycle PV panels?

Yes, all components in a solar module can be recycled. The most valuable parts are the solar cells themselves, which can be recycled into new silicon wafers as the basis for new solar cells. The aluminium frames, glass and cables can also be recycled.

21. When will PV be cost-competitive?

In many cases PV is already cost-competitive, especially for stand-alone applications where no access to the distribution grid is available. However, the electricity generation costs for PV systems are still higher than for other energy sources, if the environmental costs of conventional electricity generation are not taken into account. In any event, in Southern Europe, grid-connected PV electricity will be cost-competitive by 2015, due to the expected reduction of PV costs and the present continuous increase in the electricity tariff. Meanwhile, financial support is needed to develop a strong industry with economies of scale. Therefore, in countries with feed-in tariffs, PV is already a very attractive investment.

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