Chapter 4
Solar Photovoltaic Power in Spain

Expansion Factors and Emerging Landscapes

Matías Mérida-Rodríguez, Sergio Reyes-Corredera, Santiago Pardo-García, and Belén Zayas-Fernández

Abstract Favourable geographical conditions and firm governmental support have resulted in a strong growth of photovoltaic energy in Spain in the last decade, especially in the period 2007–2008. This has led to an important economic development of this industrial sector and the appearance of many effects in both rural and urban landscapes. Nevertheless, in the last years, the situation of the photovoltaic sector has changed noticeably, as the exponential growth of installations and the arrival of economic crisis have provoked the adoption of more restrictive laws, which have opened a period of stagnation and uncertainty. In contrast with other countries, in Spain, ground-mounted solar PV plants have predominated, transforming many rural environments. Some studies which address the impact of these systems and the social perception about them have appeared recently. They also suggest criteria in order to improve their integration in buildings and landscapes. In this chapter, an overview about the deployment of Spanish photovoltaic sector is offered, as well as about the factors which have caused its rise and fall and the consequences of these processes in the landscape.

Keywords Renewable energy landscapes • Solar PV plants • Spanish photovoltaic laws • Social perception • Urban photovoltaic systems

4.1 Introduction

[AU1] Spain is a paradigmatic example of the development of solar photovoltaic power both due to its rapid expansion and to its current state of decline. With this in mind, this chapter sets out to reach three goals: to offer an overview of the deployment of this sector in Spain, to systematise the reasons for its rise and subsequent fall and to

M. Mérida-Rodríguez (✉) • S. Reyes-Corredera • S. Pardo-García • B. Zayas-Fernández
Dpto.de Geografía, Facultad de Filosofía y Letras, University of Málaga,
Campus de Teatinos, s/n. 29071, Málaga, Spain
e-mail: mmerida@uma.es; sergioreyes@colgeo.org; pardo@uma.es; belenzayas@uma.es

M. Frolova et al. (eds.), *Renewable Energies and European Landscapes*,
DOI 10.1007/978-94-017-9843-3_4

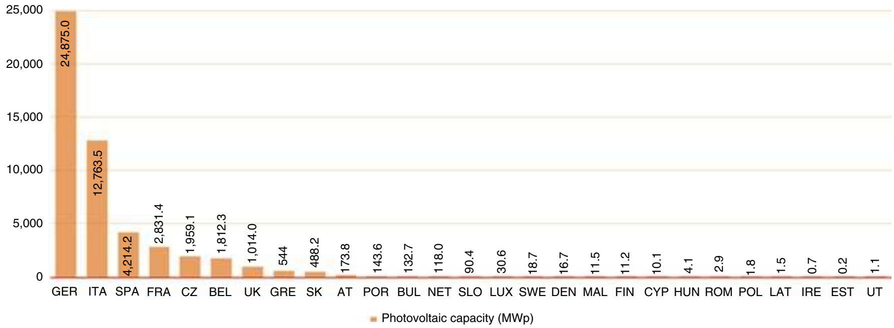

Fig. 4.1 Total installed power in European countries, 2011 (Source: Eurobserv-ER 2012)

analyse the repercussions that its development has had on the landscape. The chapter is divided into three parts that deal with each of these objectives.

Due to the recent nature of the phenomenon, little research has been done on the development of photovoltaic energy in Spain and even less on its repercussions on the landscape. The characteristics of the development of photovoltaic energy in this country were analysed by Espejo (2004) and more recently by Prados (2010a, b), Ortells and Querol (2011), Espejo (2012) and de la Hoz et al. (2013) and in technical and statistical reports by public bodies (IDEA 2011a) and professional associations (ASIF 2009, 2011). At a regional level, the case of Castilla y León was studied by Baraja and Herrero (2010), while Cañizares (2011) focused on particular areas of Castilla-La Mancha. The consequences for the landscape and for the territory have been analysed together with other renewable energies by Prados et al. (2012) and specifically for the case of photovoltaic energy by Mérida (2010) and Mérida et al. (2012). Meanwhile, research by Caamaño (2009) focused particularly on its development in urban areas and the way it is treated in planning systems (Caamaño et al. 2009). Architectural integration of photovoltaic installations was studied by Martín (2008, 2011), Martín and Fernández (2007) and Lloret et al. (1999). Another group of studies, including those by Tudela and Serrano (2006), Frolova and Pérez Pérez (2008), Prados (2010b) and Mérida et al. (2012), addressed the social perception of photovoltaic energy development. Finally, various technical studies have drawn up good practice codes (Comunidad de Madrid 2009) (Fig. 4.1).

4.2 Development of Photovoltaic Energy Production in Spain

The solar PV power sector in Spain has been developing at a spectacular rate in recent years, as have other renewable energy sources. The need to reduce Spain's high dependence on fossil fuels, the cost of which had risen alarmingly due to constant price hikes during the years prior to the current economic crisis, made renewable energies, including photovoltaic energy, an increasingly attractive alternative.

At the same time, various requirements to reduce CO_2 emissions were established by the European Union and in international agreements on climate change. Specifically, EU Directive 2009/28/EC required member states to be producing 20 % of their energy consumption and 40 % of their electricity from renewable sources by the year 2020. Between 2003 and 2012, the installed photovoltaic power capacity in Spain has multiplied by several digits leaping from 27 MW in 2003 to 4,214 MW in 2011, well above official forecasts of 371 MW in 2010.

This expansion reached its peak in 2007 and 2008 (IDAE 2011a), with an exponential level of growth based on and fuelled by strong economic support from the government, attracting speculative investments that helped create a photovoltaic bubble. In 2008, more capacity was installed in Spain than anywhere else in the world (around 45 % of the global total), and by the end of the year, it had a total installed capacity of 3,300 MW, second only to Germany. Since then, the economic crisis and the new regulations have halted this growth drastically, and Spain's position in the international ranking has fallen back sharply. In 2010, 392 MW were installed, putting Spain in sixth place in Europe, a long way behind the 7,408 MW installed by Germany, and also trailing other countries such as Italy, the Czech Republic, France and Belgium. Total installed power capacity in Spain in 2011 was 4,214.2 MW, about a third of the total in Italy (12,763.5 MW), while other countries such as France (2,831.4 MW) that had been growing quickly in recent years were catching up fast (Eurobserv-ER 2012).

From the business point of view, the development of the photovoltaic market led to the creation of a buoyant, innovative, new industrial sector, which at its peak employed around 60,000 people, according to the sector's business association, ASIF (*Asociación de la Industria Fotovoltaica*, Photovoltaic Industry Association). However, the impact of the crisis, growing international competition (especially from modules manufactured in China, which has led to a trade conflict with the European Union) and the resulting halt to new projects dealt a severe blow to this industry leading to drastic job cuts, bringing the total down to the current figure of around 7,000 workers. In spite of these problems, Spain still has an important photovoltaic industry. Currently, there are about 40 companies engaged in the manufacture of photovoltaic system components, making it one of the most innovative branches of Spanish industry. The reduction of subsidies in the domestic market in recent years has led these companies to look further afield for business, and they have won contracts in different parts of the world, in which, unlike Spain, photovoltaic energy is currently developing at an intense rapid rate.

Within Spain, most of the installed capacity is concentrated in regions in the centre and south of the country. If we take the figures for 2010 as a reference (ASIF 2011), Castilla-La Mancha had 857 MW, followed by Andalusia (713), Extremadura (464) and Castilla y León (387 MW). In other regions of the country, development has been much slower. In the north of Spain (Basque Country, Asturias, Cantabria, Galicia), this is because the climate is less favourable (fewer hours of sunshine) and in other areas, such as Madrid, because of legal restrictions and competition from other land uses.

Most of this development came in the form of solar PV power plants rather than in roof installations, which accounted for only 2.2 % in 2008 (ASIF 2009). The Spanish model was therefore quite unlike that followed by other countries such as Germany (Prados 2010a), where the proportion of roof-mounted solar PV installations is much higher, at an estimated 40 %. Nonetheless, the clear dominance of ground-mounted PV power plants over roof-mounted systems has made it much more difficult for the industry to adapt to the new scenario created by the economic crisis.

4.3 Factors Contributing to the Expansion of Photovoltaic Energy

There are various factors that have contributed to the development of photovoltaic energy production in Spain. Here, we distinguish between those of a geographic nature and those of a legal and economic nature, which are closely intertwined.

Spain's latitudinal position and its climate conditions mean that it has great potential for the development of solar energy due to the high number of hours of sunshine it receives and the intensity of solar radiation. With the exception of the northern regions, practically all the Iberian Peninsula receives more than 2,000 h of sunshine a year, with the southern half and a large part of the islands receiving more than 2,800. The solar radiation figures are also very high, over 3.5 kWh/m^2 in almost all the country except for the northern flank and over 4.5 kWh/m^2 in the south-east of the Peninsula and in certain areas of its south-western quarter and above all in the Canary Islands (AEMET 2005).

Spain has the additional advantage of having large extensions of free land in which to locate solar installations. On the one hand, it has vast flat or topographically relatively even spaces in particular in the *Meseta of Castile* and also in the large river valleys lying beyond it, such as the Ebro and Guadalquivir valleys, and in the plateau areas of various mountain ranges. An additional advantage is that many of these areas have very low populations at least compared to the national and European averages, in particular in those areas in which renewable energies have reached a certain degree of saturation (Frolova and Pérez Pérez 2008). While the average population density in Spain in 2011 was 93 people/km^2, in most of the country's inland regions, the figure was much lower at less than 30 people/km^2, and there are many large, almost unpopulated areas. By contrast, the most densely populated areas such as the Mediterranean coast and Madrid have almost no photovoltaic energy installations, except logically for those situated on roofs. At the same time, these large open spaces are generally otherwise used for extensive and sometimes marginal farming with low yields per hectare, with the result that those offering new economic alternatives are normally greeted with open arms.

The development of solar PV power in Spain has been shaped to a large extent by the legislative and regulatory framework in position during its different phases.

For this reason, the changes in the regulations have been mirrored by an uneven growth pattern in the installed power capacity. The first national legislation governing the sector was passed at the end of the 1990s. Law 54/1997 (Boletín Oficial del Estado 1997), on the electricity sector, and the Decree of 23 December 1998 (Boletín Oficial del Estado 1998), which implemented it, established a special regime for renewable energy systems by offering production premiums (often known as feed-in tariffs) above market prices and guaranteeing their access to the electricity grid. The Renewable Energies Plan 2000–2010 set a target for 2010 that 12 % of generated power should come from renewable sources, a target that was maintained when the Renewable Energies Plan was revised for the period 2005–2010 (IDAE 2005). A qualitatively importantly leap forward occurred in 2006 when photovoltaic energy was included in the Technical Building Code (TBE) (Boletín Oficial del Estado 2006), which made it obligatory to install photovoltaic systems in certain large buildings with high energy consumption levels.

This first stage, up until 2006, did not have a large direct impact on the growth in this sector, although it did lay the foundations for its subsequent development. It was only later with Royal Decree 436/2004 (Boletín Oficial del Estado 2004), and above all with Royal Decree 661/2007 (Boletín Oficial del Estado 2007), that the government made a firm commitment to boost the growth of this sector by extending the premium system to medium- and large-scale plants. It also guaranteed the future continuity of these subsidies, so eliminating uncertainties and enabling possible investors to estimate the period within which they would recover their initial investment and the subsequent profits they would earn. When this decree came into force, there was an enormous expansion in photovoltaic energy installations, a fact enhanced by the decision, once the ceiling of installed capacity set out in the Renewable Energies Plan 2005 (IDAE 2005) had been reached, to extend for a further year the possibility of bringing new plants into the premium system. In addition to these incentives, the progressive cheapening of the basic materials (solar panels) and their increasing efficiency meant that photovoltaic energy was now a fantastic business opportunity, to the extent that speculative investors also jumped on the bandwagon. If during the year 2007 a capacity of 544 MW was installed (bringing the accumulated total to 690 MW), in 2008 the figure was almost five times higher at 2,707 MW with an accumulated total capacity of 3,397 MW (IDAE 2011a). Until that date, many laws that affected the PV systems had been approved by the different autonomous regions in Spain. The degree of legal complexity developed in each region has proved to be linked with the ratio of implementation of PV on-floor systems in those years (de la Hoz et al. 2013).

This exponential growth (known as the photovoltaic bubble) occurred for purely economic reasons and was not the result of an energy planning process. This led to a corresponding large increase in public spending to pay for the production premiums, just at a time when the first signs of economic crisis were appearing, and within the sector, there were growing concerns about what was known as the 'tariff deficit', i.e. the difference between the high cost of the energy system and the relatively low income it generated. In response to this situation, a new legislative framework was drawn up in Royal Decree 1578/2008 (Boletín Oficial del Estado 2008).

This regulation reduced the premiums and established a procedure of pre-assignation of tariffs for photovoltaic installations, which distinguished between ground-mounted installations (photovoltaic plants) and those installed on roofs; the latter which until then had been in a very small minority would now be prioritised and would receive higher premiums. In order to limit further expansion, annual quotas were established for each type of production, and these were more restrictive for ground-mounted installations. In this context, the government approved the Renewable Energies Plan 2011–2020 (IDAE 2011a), which went further than the objectives set by Directive 2009/28/EC, setting targets for renewable energies for 2020 of 22.7 % of primary energy production and 42.3 % of electricity.

The worsening of the economic crisis has led to the introduction of new laws in which the premiums for photovoltaic installations have been reduced even further. In Royal Decree-Law 14/2010 (Boletín Oficial del Estado 2010), a limit was placed on the number of hours in which photovoltaic plants that received premiums could operate, in accordance with the climate zoning system set out in the TBC (Boletín Oficial del Estado 2006). On similar lines, Royal Decree-Law 1/2012 (Boletín Oficial del Estado 2012) approved the suspension of financial incentives and premiums for the installation of new electricity production plants, including those using renewable energy sources. Finally, Royal Decree-Law 2/2013 (Boletín Oficial del Estado 2013) established new reductions in the system of premiums either by changing the method of calculating them or by removing the option of choosing between the market price and the premium system (Fig. 4.2).

As a result, the photovoltaic sector in Spain is now in a situation of uncertainty and stagnation. The export of technology and the search for contracts abroad have

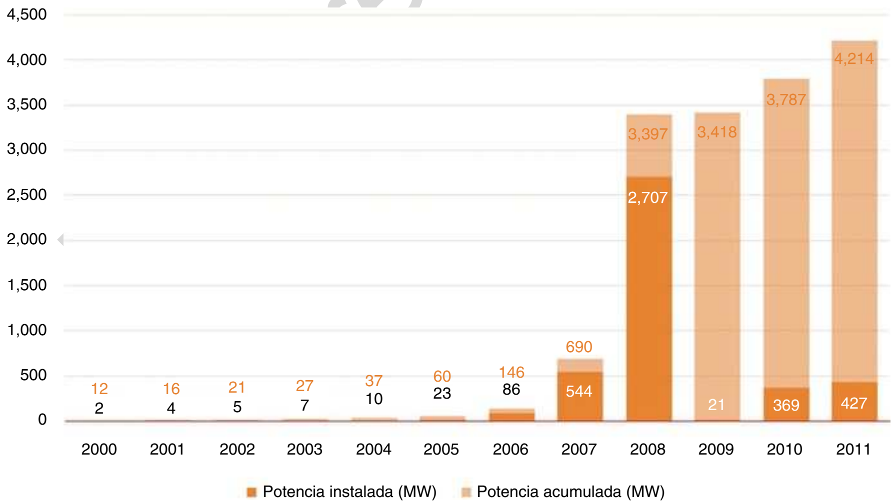

Fig. 4.2 Evolution of the total PV power installed in Spain (2000–2011) (Source: IDAE 2005, 2007, 2011a, b)

so far offered the best solution. While in the domestic market, the only alternative is to develop what is known as 'self-consumption with a net balance', in other words, the option of consuming the energy you produce yourself with the possibility of depositing any excess in the grid and taking it back later when required. This form of production is, however, pending specific regulation. In any case, the cutbacks and the general recession in the sector must be seen as a product of the current economic situation in Spain and of the regulatory and economic mistakes made during its expansion, as in other countries in Europe and indeed throughout the world, the photovoltaic sector is expanding very fast. The reduction in costs and the increased efficiency of photovoltaic systems may help the sector reach grid parity (when a renewable energy source can generate electricity at a levelised cost that is less than or equal to the price of purchasing it from the grid), so enabling it to operate profitably without government subsidies and help the country reduce its dependence on imported energy (IDAE 2011a). Apart from their effects on energy supply in Spain, government spending cuts have had serious effects on a business sector hitherto renowned for its innovative nature and its international projection and one of the few industrial sectors in which Spain has achieved some degree of international leadership.

4.4 Impact on Landscape and Emerging Landscapes

The varied Spanish countryside has witnessed a generalised installation of photovoltaic systems in practically all kinds of landscape. Although the best solar radiation conditions are in the south and west of the Iberian Peninsula, in northern Spain, altitude and exposure factors can be exploited to ensure that acceptable performance levels are achieved (Baraja and Herrero 2010). The transformations that have taken place in rural areas due to the deployment of photovoltaic installations have happened rapidly and spontaneously, independently of territorial planning. This has prevented any analysis of these transformations and any discussion or debate as to possible alternatives for the integration of photovoltaic installations into the rural landscape (Mérida et al. 2012). On the other hand, landscape protection policy has not been a significant obstacle for the deployment of PV on-floor installations, as a study in the region of Catalonia has shown (de la Hoz et al. 2013).

In general, the ideal sites for ground-mounted photovoltaic systems are flat areas or areas with a gentle incline, connected to the main electricity grid. In conceptual terms, this model has been associated with the idea of energy as a crop, in its initial phases in relatively small-scale plants (hence the name *huertos solares* which can be translated as 'solar farms'), a model that is very different from the dominant system in other countries such as Germany, in which there are many more roof-mounted installations. In more rugged, mountainous areas in which access and energy distribution are complicated, small isolated installations predominate, often in association with old traditional buildings in the area.

4.4.1 *Photovoltaic Plants (*Solar Farms*)*

The large number of photovoltaic plants installed has had important effects on the landscape in the areas concerned and has led to the appearance of new landscapes, especially in those areas in which the plants are more densely deployed or in those in which they are combined with other renewables, especially wind power, giving rise to the appearance of what have been dubbed *landscapes of renewable energy* (Mérida et al. 2009). Depending on aspects such as the suitability of their location and the quality and integration in the landscape of their design, these plants can either cause severe negative impacts on the landscape or on the contrary contribute to the recovery of the landscape in certain areas through the improvement of the composition and scenic values.

Although there had been experiments with solar thermal power plants in the province of Almería (south-east Spain) in the 1980s (Espejo 2004), it was not until the following decade that the first ground-mounted solar PV plants appeared in Spain, with pioneering examples such as the plant at La Puebla de Montalbán (Toledo, 1 MWp) (European Commission 2000). In just a few years, these plants became a business success story to which many landowners and investors turned as an investment for the future, encouraged by the incentive system in place at the time, as mentioned earlier.

This type of installation had numerous effects on country landscapes in particular as a result of their unusual (especially in rural areas) design, the large areas that they occupy (Mérida et al. 2010) and the reflective material used in the panels. Government territorial planning instruments have so far proved unable to keep up with the rapid rate of expansion, and no firm criteria have been established that take the impact on the landscape into account. On agricultural land, for example, it has not been necessary to make environmental impact studies when building solar farms, but this has been required in forested areas (Prados 2010a). Many solar farms have a high impact on the territory, as according to studies in Andalusia (Mérida et al. 2010), they are normally situated on flat sites or on hillsides, from which large viewsheds are produced.

The result of all this is a serious, uncontrolled transformation of the traditional rural landscape, in which some agricultural fields have been replaced with large groups of panels, of all the different types on the market, which both in continuous rows and in free-standing, solar trackers are in stark contrast with the area around them. This said, these installations have the advantage of being reversible, in that they can easily be taken down and removed.

The visual impact of solar plants or farms has been studied in detail in recent research (Mérida et al. 2012), and a number of design criteria have been put forward to ensure their improved integration into the landscape. These involve first and foremost carefully selecting the site and minimising the impact of the different component parts of the plant, such as modules, structures, panels, roads, ground, auxiliary buildings, etc. At a more general level, the European project Enerscapes analyses the repercussions of renewable energies, including solar power, on the landscape in different regions of Mediterranean Europe, one of which is Andalusia (ENERSCAPES 2013).

In terms of photovoltaic energy in particular, the main objective of territorial planning must be to correct the situation that arose in recent years in which almost any site and any layout were considered suitable for the installation of a photovoltaic plant, without a thought being given to possible repercussions on the landscape. Another positive step would be to understand the introduction of these installations not only as an impact but also as an opportunity for the rural landscape, as something which with the right measures could even enhance its value. It is therefore important to be aware of the positive social attitude towards these plants which we will be analysing later.

4.4.2 Isolated Photovoltaic Installations in Rural Areas

As has happened in many other countries (Lorenzo 1997), in Spain, photovoltaic solar energy has proved an excellent solution for the electrification of isolated buildings in areas that are far away from power lines. On many occasions, this is done by installing solar panels on the roofs of traditional rural buildings. A good example, due to their size and scope, is the programmes carried out in the region of Catalonia. In one of these programmes, 35 isolated *masías* (traditional Catalonian farmhouses) in the Solsonès area were electrified (Institut Catalá d'Energía 1990). Similar programmes were carried out in the Garrotxa area, in which 65 sites were electrified with a total of 51 kWp (Fig. 4.3).

Isolated systems of this kind have also been constructed in other areas (European Commission 2000), such as the natural parks in Catalonia and in archipelagos such as the Cies Islands off the coast of Galicia. They have also been used as additional electric support for farms, for example, in Jaen (Andalusia). Although there are quite a few cases in the different parts of the country, little research has been done on the landscape impacts of these new installations. In general they look strange and out of place, in a similar way to solar farms, because the materials with which pan-

Fig. 4.3 Solar farm located in the Province of Malaga (Andalusia) (Source: The authors)

els are normally constructed do not usually blend as well with traditional architecture (built of stone, slate, etc.) as with modern buildings. In addition, these houses, normally designed for one family, are small in volume, so heightening the impact on the landscape of the solar panels and complicating their integration still more. The possibilities of using photovoltaic materials that blend in with the building in terms of shape and colour have hardly been explored due to the higher costs they would involve, although this is clearly a field in which more work should be done.

4.4.3 Solar PV Power in Urban Areas

The increase in the area of photovoltaic energy capture on the roofs of buildings has also been important in Spain's cities in recent years. With the most recent changes in legislation, forecasts suggest that the negative trend of the last few years will be reversed, and the solar roof market will be significantly larger than that of ground-mounted installations (ASIF 2011), so bringing the Spanish model into line with that of most of its neighbours.

The introduction of the TBC (Boletín Oficial del Estado 2006), which sets out the criteria that all buildings in Spain must meet, provided a new impetus to the installation of both thermal and solar PV power on the roofs of buildings. It introduced the obligation to install PV power systems on buildings that were above a certain size, as set out in Table 4.1.

The TBC divides the country up into five climate areas on the basis of the average solar radiation they receive. These classifications are used together with the intended use of the building and the floor area to calculate the minimum power that must be installed. The Code also establishes a maintenance plan and maximum loss limits compared to a theoretical optimum system.

The estimated increase in annual production as a result of compliance with the TBC has been calculated. It is estimated that in 2020 this will be around 80 GWh (IDAE 2011b). For their part, the association of manufacturers and installers expects the new European Directive on energy efficiency in buildings to provide a significant boost to the market, as photovoltaic power generation is versatile and can easily be adapted to meet the requirements of this Directive (ASIF 2011).

Table 4.1 Limits set out in the Technical Building Code (TBC) for the installation of photovoltaic panels in buildings in Spain

Type of use	Application limit
Hypermarket	5,000 m^2 floor area
Shopping and leisure centres	3,000 m^2 floor area
Warehouse	10,000 m^2 floor area
Office buildings	4,000 m^2 floor area
Hotels and hostels	100 spaces
Hospitals and private clinics	100 beds
Pavilions in trade fairgrounds	10,000 m^2 floor area

4.4.3.1 City-Level Projects and Ordinances

In addition to the regulations set out in the TBC and those set out in state and regional legislation about energy, each local council has the power to propose its own conditions. In their municipal ordinances, many of them have included the obligation to install solar energy systems. In 2005, a year before the TBC came into force, there were 30 such ordinances referring to solar technology, principally aimed at obtaining hot water and heating (PV UPSCALE 2007).

More recently, some councils have issued ordinances specifically aimed at regulating the construction of photovoltaic installations. Various councils in the island of Gran Canaria, for example, have made it obligatory to install photovoltaic systems in all new buildings, extensions, renovations, refurbishments and changes of use (Ayuntamiento de Las Palmas de Gran Canaria 2009). These regulations also stipulate the minimum power capacity that must be installed for each use and floor area, the maintenance plan and maximum loss limits in a more detailed way than the TBC itself.

Some Spanish cities have taken part in international projects charting the progress of photovoltaic energy in cities. One example is Vitoria, in the Basque Country, which took part in the POLIS (Identification and Mobilisation of Solar Potentials via Local Strategies) project. The aim of this initiative was to encourage the development of solar energy (thermal and photovoltaic) by making it an integral part of town planning strategies (POLIS 2012a). Vitoria has carried out three pilot schemes, aimed at evaluating the solar potential of the city by using digital elevation models (POLIS 2012b). A similar project was executed in the city of Malaga in Andalusia (Ayuntamiento de Malaga 2013). These strategies, which require huge technological input, are fundamental when trying to find the best places to locate urban photovoltaic plants and as a source of detailed information for plant developers and installers.

Another city that has taken an active role in this kind of initiative is Barcelona. The Catalan capital was studied in the PV UPSCALE programme, a European project about city-scale photovoltaic systems, which focuses on areas in which a significant quantity of these plants have already been installed or are planned (PV UPSCALE 2012). Barcelona was praised amongst other things, for its pioneering role in strategies promoting photovoltaic systems, the large number of demonstration installations and the conditions set out in the city's ordinance on solar power, which were stricter than those in the TBC (Caamaño 2009).

4.4.3.2 The Development of Photovoltaic Energy in Buildings and Urban Furniture

In recent years, there has been a great deal of research in this field encouraged to a large extent by the main research centres specialising in this subject (Caamaño et al. 2009). As a result, a number of technical guides have been published, aimed mainly at promoting and improving the integration of photovoltaic systems into buildings

(Martín and Fernández 2007; Martín 2011). The regional governments of Madrid and Andalusia have also produced handbooks of this kind (Comunidad de Madrid 2009; Agencia Andaluza de la Energía 2009). Solar PV power has been integrated into the office buildings of the companies specialising in this market and into numerous recently constructed buildings in which bioclimatic criteria have been taken into account. In 2012, Madrid hosted the Solar Decathlon Europe, an event that seeks to promote the design of efficient buildings by making prototypes (SDEurope 2012).

The truth is that in spite of this research and experimentation, PV power still has a long way to go to become an integrated part of the urban landscape of most Spanish cities. Despite this, Spain already has a long architectural tradition in this field. Specialised bibliography often cites the case of the Pompeu Fabra Library in Mataró (Catalonia), built in 1996, which was one of the first examples of modular facades with photovoltaic panels (Lloret et al. 1999; Martín and Fernández 2007; Roberts and Guariento 2009). In industrial areas, photovoltaic energy is progressively occupying a large number of roofs of industrial units, which often have large exposed surfaces (Martín 2008), although these are normally out of sight of the general public (Fig. 4.4).

In the case of urban furniture, a whole array of different formats have been tried. The most interesting includes the so-called photovoltaic trees and the photovoltaic systems that can be installed on top of pergolas (IDAE 2007). Perhaps the best-known

Fig. 4.4 PV pergola in the venue of Barcelona Forum 2004 (Source: The authors)

example was built on top of the huge pergola structure under which the Barcelona Forum was held in 2004, which had a panel area of 3,410 m^2 that generated 1.3 MWp of electricity, making it the biggest urban photovoltaic plant in Europe (Espejo 2004). The avant-garde design of this pergola gave its solar electricity generation facility an almost monumental character, and it has become one of the icons of the city. It can also be considered a symbol of the current state of urban photovoltaic energy in Spain, which is typically installed in new buildings, often with a symbolic message, while generalised installation in our cities is still a long way off.

4.4.4 Social Perception

Until very recently, there was no tradition in Spain of encouraging public participation in the process of installing renewable energies in its territory. As a result, public opinion has had a very limited role or input into decision making (Frolova and Pérez Pérez 2008). This trend however has gradually been changing due to the concerns of the population regarding the social, ecological and landscape impact of renewable energy installations. Today, public perception of renewable energies is an increasing concern, above all for manufacturers, developers, conservationists and defenders of the landscape and finally for local councils, residents, farmers and landowners, who in general perceive this kind of installation as a positive step to boost economic development in the area (Tudela and Serrano 2006). In general, this sector has a positive public image. For many people, wind and photovoltaic solar energy are considered environmentally friendly and are often associated with concepts such as 'clean', 'healthy', 'green' and 'sustainable' (Frolova and Pérez Pérez 2008). According to the results of the most recent Eurobarometer, 70 % of Europeans and 81 % of Spaniards consider renewable energies to be the best energy option to promote today (European Commission 2013).

As regards the specific case of photovoltaic plants, the assessment of their landscape impacts was until recently plagued by the absence of specific studies on their social perception (Mérida et al. 2012), due to a large extent to the fact that these installations are relatively new and are still continuing to emerge. For this reason, there is a lack of information about the attitudes and opinions, positive or negative, of the population regarding the undeniable mark these plants leave on the landscape. Some tests and studies have been conducted, however, which enable us to make an initial approach to the analysis of the social perception of these installations.

A case in point was the research conducted by the University of Murcia in the north-east of the region (Tudela and Serrano 2006), during the months of May and June 2006, in which local people's assessment of the photovoltaic plants was studied on the basis of a survey on renewable energy systems. The study revealed that photovoltaic energy was little known (only 9 % of those interviewed said they knew about it) and the general opinion was that it was very expensive, something that applied to renewable energies in general. In this same study, it was also found that this energy was often confused with thermal solar energy and people could not distinguish between the two. Lastly, some of those interviewed shared their concerns about the possible impact of these energy plant installations on the newly emerging rural tourism sector.

Another research paper that explored the perceptions of local people regarding solar photovoltaic and thermoelectric installations was conducted in Andalusia, more specifically in rural areas around the River Guadiamar Protected Landscape (Seville) during the summer of 2009 (Prados 2010b). Based on a sample group of 62 residents of this area, the objective was to assess the transformation of productive agricultural land into large-scale solar plants. Most of those interviewed (78 %) were shown to have an acceptable degree of information about renewable energies. These percentages fell, however, when they were asked to specify the types of renewable energy about which they had information and to list those that were present in their area. Most of those interviewed (60 %) had a positive opinion and thought that the new installations had brought significant changes to the geographical area, environment and landscape.

In another study conducted in Andalusia, social perception of photovoltaic plants was analysed (Mérida et al. 2012). The surveys were performed in 2009, and a sample population was chosen of residents of four villages near photovoltaic installations.

Almost all those interviewed (94 %) said that they had seen the solar farm near their village, while 6 % replied that they had not. A large majority also considered these farms to be positive (63.4 %), while 19.5 % had a negative attitude towards them. Those who viewed the plants positively cited the economic, energy, environmental and employment benefits brought by photovoltaic plants and solar energy. A clear majority (58.5 %) considered that the plants had brought benefits to their areas. Although the concept of photovoltaic energy as something environmentally friendly and associated with values such as progress and innovation undoubtedly has a favourable influence on people's interpretation of the plants' effects on the landscape, in general, those interviewed did not approve of the aesthetics of these installations, which would imply a rejection of their formal contents. Fifty-six percent of those interviewed did not like the sight of solar farms, while 29.2 % considered them attractive (Mérida et al. 2012). Along the same lines, 68.3 % thought that the landscape was more attractive before the installation of the solar farms, and 48 % said that they preferred roof-mounted solar installations, compared to only 29.2 % who thought rural land the best option.

In conclusion, the research done so far in Spain shows a broad public acceptance of renewable energies and in particular of solar PV power due to its positive environmental connotations and the benefits it is perceived to bring to the economic development of the area in which it is located, although concerns were also shown about its high cost. There seems also to be a certain lack of knowledge and wariness regarding photovoltaic energy, largely as a result of its recent arrival on the scene, and a rejection on aesthetic grounds of its formal components (shape, colour) and its industrial nature. A lot of work therefore remains to be done on the design of installations and the selection of suitable sites in order to improve local opinions of these installations (Mérida et al. 2012).

In any case, the aforementioned studies provide specific experiences about particular spaces. It is necessary, therefore, to carry out broader research both in spatial and subject matter terms on the social perception of the development of photovoltaic installations, so as to give us a clearer picture of the degree of acceptance of these installations that will enable us to establish landscape integration parameters for them. Such studies would engage well with the proposed measures for the improvement of the social perception of renewable energies set out in the Renewable Energies Plan 2011–2020 (IDAE 2011a).

4.5 Conclusions

The photovoltaic sector is currently at a crossroads. The existence of favourable natural conditions for its development, generous public subsidies and an important industrial framework combined, until very recently, to give Spain a leading role in the sector at an international level. However, the excessive dependence on public aid and the rapid growth in the number of plants have led, due to their excessive cost in times of crisis, to the sector's current state of paralysis. It is important to emphasise however that the photovoltaic sector makes other significant contributions to Spain's economy, such as reducing its energy dependence, helping it comply with international commitments (climate change, European Union energy strategy) and boosting exports. Its innovative nature (visualised in the development of patents) and even its contribution to the image of Spain as a modern, technologically advanced country must also be borne in mind. In addition, the perspectives for the growth of photovoltaic energy at an international level are excellent, especially amongst emerging countries, which means that if the sector can adapt to this new scenario, ridding itself of all speculative components, it could well have a very promising future.

From the point of view of landscape, the intensity and the speed with which the photovoltaic sector bursts onto the Spanish energy scene explain the almost complete absence of any regulation of its territorial deployment. In general, landscape criteria have played no part either in the choice of sites or in the design of the equipment and installations. It is important to take advantage of the fact that its uncontrolled expansion has now come to a halt to introduce landscape management measures both in rural and urban areas, which will not only lead to the reduction of these impacts but also in certain areas allow plants to be used to enhance the quality of the landscape, so increasing the added value these installations provide. In this sense, the positive social acceptance of photovoltaic energy would be an interesting starting point on which to build. At the same time, the photovoltaic experience should serve as an example on which to reflect about the effects that financial incentives for specific business activities can have on the landscape or territory.

Acknowledgement We are grateful to the Spanish Ministry of the Economy and Competitiveness (Grant Code CSO2011-23670) for funding the translation of this chapter.

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