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Renewable energy policy and landscape management in Andalusia, Spain: The facts

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ABSTRACT

Renewable energy has developed spectacularly in Spain since the European Union started a process of energy policy reform. A review of Spanish State legislation on renewable energies confirms that the success in installing renewable energy is attributable to public aid. Andalusia is one of the autonomous communities, which has simultaneously developed the legal framework and very successfully implemented the introduction of renewable power. When implementing the central government's policy, the Andalusian regional government prioritised increases in both surface cover by wind and solar plants (thermal and photovoltaic energy) and in the number of companies involved. However, this development of renewable energies took place without any proper integration into regional spatial and landscape planning. This paper explores renewable power implementation in Andalusia through regulatory measures put in place over the last decade to develop renewable energy systems and the way they can be managed alongside planning issues. The location of large-scale renewable plants has had consequences for territory in the socio-political context of renewable energy promotion. The main findings focus on renewable energy plant sprawl throughout rural areas in Andalusia with no clear effect on landscape management and no firm backing from the local population.

1. Introduction

The development of renewable energy has been spectacular since the European Union first initiated the process of energy policy reform. Spain has very successfully implemented the introduction of renewable power by virtue of major resources and instruments. These major resources are, primarily, the number of sunlight hours per annum and the power of the wind in large areas of the country and also the wide expanses of territory that can be used to grow energy crops. The wind used to traditionally be used for grinding grain and extracting water from the subsoil (as testified by the windmills in La Mancha and those that can still be found scattered around rural areas in Majorca), whilst the sun was used to heat water. Like the windmills in the timeless Spanish masterwork, 'Don Quixote', the number of sunlight hours is a national symbol when compared to other European countries. The promotion of Spanish coastal tourism from the nineteen-sixties onwards was based on the slogan of 'sun-and-sand'. Wide-ranging and hugely productive agriculture is also sustained by the long hours of sun, moderate temperatures and the use of water to irrigate the fields. In contrast to what has gone before, new methods for exploiting the hours of sunshine and the force of the wind as energy resources are connected with technical and political instruments. The technical instruments in question are, basically, those that allow an optimum use to be made of the speed of the air and sunlight for the production of energy. Spain plays a leading role on the world stage in wind energy production systems, whilst at the same time it also has technological developments for the production of solar thermal energy and has made big strides in the installation of photovoltaic systems (APREAN, 2009). As far as legal instruments are concerned, over the last decade important new regulations have been added to the legal framework for energy production and supply. To be specific, the domestic energy system has prioritised the granting of direct aid for the production of renewable energies and this has jump-started the sector spectacularly. Major energy companies have been heavily involved since the start and this has all occurred around the same time that the energy market was liberalised in Spain, in 2003 (Ruiz, 2003).

All this means that Spain is preparing to respond to energy challenges with an energy mix resting on solid foundations that comply with international agreements. These challenges are compulsory reductions in greenhouse gases and sustainable energy consumption; secondly, an ability to improve supply security in the face of imports, and, thirdly, technological developments to generate energy using renewable systems. It must be highlighted that all this has been possible by virtue of the direct involvement of successive governments throughout the last

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decade. In 1997, the Kyoto Protocol, which was signed by the European Union countries (United Nations, 1998), included a commitment to reduce CO_2 emissions in the Fight against climate change. From 1997 on, Spain enacted legislation for the production of electricity using renewable resources, waste and cogeneration and supported this with a favourable funding scheme (Law 54/1997, Electric Sector). The scheme was interrupted in 2009 when the goals had been met and also due to the economic crisis and cutbacks in funding for renewable energy installations. Presently, business culture put greater faith in the implementation of new technological developments for the production of renewable energies and the building of new renewable energy plants in certain areas of the country. For this to be done, a new framework of economic intervention based on the granting of incentives for kW/h of production had to be put in place. This step gave rise to a certain degree of euphoria in the Spanish energy sector up to the introduction of the 2009 cutbacks. Spain has been one of the first countries to base energy development on wind power and solar photovoltaic power (the second largest solar power market after Germany) with its own technological developments exported and implemented all over the world (APREAN, 2009).

1.1. Siting decisions of renewable power and landscape concern

Despite the interesting economic results and higher suitability of energy consumption being evident, renewable energy has major impacts on the landscape. The development of power plants increases the number of siting decisions that have to be taken and their impact on the territory tends to be greater than for conventional power plants. As renewable energy plants are decentralised and widely scattered, the landscapes that are affected are peripheral areas both economically and spatially speaking. The huge majority have been installed in rural areas, either on the coast or inland, where conditions favour them being brought into operation quickly and cheaply. Underlying these siting patterns is the fact that the rural environment is regarded as an unproductive and not very profitable wilderness. These siting patterns have also included protected areas and their surroundings, where the installation of renewable energy plants is understood to be in keeping with the aims of environmental conservation. European rural and natural areas are being turned into the preferred sites for the construction of the renewable energy facilities needed to combat global warming and climate change (Nadai and Labussière, 2007; Hinkelbein, 2010). Notwithstanding, renewable energy technologies do impact on the conditions of the environment and the territory where they are introduced. Resource consumption, changes in the landscape, bird mortality, noise and sight pollution are just some of the arguments that question the merit of renewable energy technologies on a daily basis (de Lucas et al., 2007a). Renewable energy technologies make use of resources such as land and water, and involve changes in land cover and the uses of agricultural land and pastures as a result of infrastructure and pylons being constructed for power generation, transformation and delivery. All these actions bring new driving forces of change to rural areas that affect current traditional economic activities in the areas and also impact on the way nature behaves. The European Commission has warned that unwanted side-effects would include changes in biodiversity and landscape in rural areas due to marginalization and even the abandonment of agriculture in some of the most vulnerable areas. And, in general terms, changes resulting from the implementation of renewable energy plants in the territory will change the way the landscape is perceived as a symbol of the natural and cultural heritage of a large part of the European homeland (Council of Europe, 2000).

This paper focuses on an Andalusian case study. Public aid, together with major resources and instruments, has been central to the development of renewable energy in Andalusia. From 2003 to 2009 the Andalusian government strove to increase surface cover by wind and solar plants without any landscape and spatial planning concerns. During that time there was an unfinished dialogue between the implementation of legislative measures to promote renewable energies on the one hand, and the sprawl of solar power plants, on the other. The complexity of the interrelations associated with these renewable energies has to be brought to the table and scientific arguments used in the debate on the harmless impact that they have on agricultural land and the landscape.

2. The success of the installation of renewable energy technologies in Spain is dependent on public aid

Until 2009, the success of the implementation of renewable energies in Spain could only be understood as a result of public aid. Renewable energy plant installation was supported by a policy of incentives and inducements per kW/h made to electricity companies, which is the main reason why Spain achieved European targets. In Spain, the objectives of combating climate change and reducing greenhouse gases were first adopted with the Kyoto Protocol in 1998. But it was not until the international agreements on the protection of the environment and on energy efficiency were adopted by the European Union that decisive steps were taken in the direction of Kyoto. Actions such as the launching of the ALTENER Renewable Energy Programme (1998–2002), the 'Towards a European strategy for the security of energy supply' Green Paper and the White Paper that sets out the EU strategy and plan of action are all key (European Commission, 1997). These documents set out a blueprint for doubling renewable energies' 6% share of the European Union's gross total internal energy consumption. The target set by the White Paper is to reach 12% of energy from renewable sources. Spain has enacted abundant legislation to include the indications on sustainable energy production, energy security and efficiency in these documents, and to promote the technological developments required to implement them.

The implementation of renewable energies in Spain has to be examined on two fronts. The first of these relates to applicable legislation in the energy sector in general and, more specifically, legislation on renewable energy. The second is spatial planning and urban development legislation for the construction of power plants. The planning and siting of new plants is connected with both of these (Nadai, 2007). And both have to be taken into account on the State and the Autonomous Community levels. The Spanish State is responsible for endorsing international and European Union agreements, as well as legislating for these to be put into due effect. The Autonomous Communities legislate on measures regulating the installation of renewable energy technologies and devise their own models of land implementation within this legislation. Legal and planning aspects are therefore bound by a broad framework of legislation and competences.

There has indeed been legislation and planning on both of the fronts mentioned earlier: the general circumstances surrounding energy production and regulation on a State level, and its application on a regional level through legislation put in place by the Autonomous Communities. Decisions adopted in connection with energy security provide for aspects both relating to the environment and to energy security, industrial development and the creation of employment. They also stress the use of own resources for the production of energy and its release to the energy market without any financial conditions being imposed.

None of this would have been possible without the hefty public investment approved by European action plans included in State legislation up to 2009.

2.1. 1997/2004: the renewable power boom

Table 1 lists State provisions to promote energy production using renewable sources. The general framework was laid down in 1997 with Law 54/1997 on the general regulation of the energy sector. This is a basic Law inasmuch as it exhaustively defines technologies for the production of energy using renewable sources, generating capacity, etc., and because it also distinguishes these from traditional production systems in legal terms. What is most striking about this Law is that it considered State intervention not to be necessary and facilitated the involvement of different operators. It also established conditions for production with a special funding scheme for cogeneration and renewable energy systems. It must be repeated that this special funding scheme was, without doubt, the most advantageous feature in the promotion of renewable energies. It comprised a range of incentives that were added to general energy supply tariffs. To be more specific, incentives were made available to renewable energy facilities for installed power capacity and the type of energy in question.

A year later, a Royal Decree 2818/1998, on the production of electrical energy in facilities supplied by renewable energy resources or sources, waste and cogeneration, specified the aims laid down in the 1997 White Paper on Renewable Energies (European Commission, 1997). It outlined the special arrangements for the production of electricity in renewable energy facilities, and also established a system of incentives to supplement general tariffs in facilities of over 50 MW, as well as some additional amounts for brackets of power production for lower levels of output. This system of compensatory incentives was substantiated post 2004 with the establishment of a special economic scheme that, with four-yearly modifications to the amount, became consolidated as the financial support mechanism for the construction of renewable energy plants (RD 436/2004). Basically, the price of renewable electric power under the special regime was established according to the reference average rate. The renewables sector was developing dramatically due to the participation of large engineering firms and energy companies.

There has been a spectacular rise in installed power capacity for three main reasons:

- the existence of development companies;
- the very favourable incentives for renewable power-based energy production;
- the absence of restrictions for the setting up of renewable power farms.

This first stage has meant the emergence of development companies in the installation of renewable power plants. Tax benefits and the compliance of land owners (mostly farmers) greatly boosted the growth of installed power capacity up to 2006. The favourable reception given to renewable energy installations by land owners could be explained by diminishing agricultural production and prices. The 2003 CAP reform led to a decline in production and a fall in farmers' average income while at the same time the cost of inputs continued to rise up to 2008 (Gallardo, 2002; Urbano, 2010). There was, therefore, no alternative but to seek income from other sources. And this coincided with the public subsidies for the renewable energy sector and the interest of developers in setting up photovoltaic plants. The consequence of this rapid response by companies and the sharp rise in applications to install renewable energy plants was a cutback in the incentives. It could be said that renewable energy companies were the victims of their own success in meeting government targets.

2.2. Cutbacks in state aid for renewable power, 2007/2009

The conditions imposed on generated power and the age of facilities has led to cutbacks in incentives for installed power capacity. Successive cutbacks were first introduced in 2006 and further cutbacks came in the 2007 and 2008 Royal Decrees, bringing sharp responses from installers and major environmental organisations (see Table 2). Yet, the cutbacks did not manage to halt the process but, rather, made it go in a new direction. The successful expansion of wind turbines and the public debate that sprang up around the siting of new offshore wind farms led State planning to decide to compensate solar energies. The upward trend in the installation of renewable energy plants continues, with wind energy giving way to solar energy, which has been less affected by the cutbacks. But this growth has also become swept up in affairs of speculation, and the strong upward trend in the installation of renewable energy plants has been linked with the real estate bubble (Fig. 1).

Royal Decree 661/2007 established a new legal and economic framework. From then on the price of energy would not depend on the reference average rate. The higher premiums were for renewable plants with installed capacity for higher targets. When the goal of 85% was reached, the new facility would not benefit from these conditions. This scheme would benefit the photovoltaic power plants in widespread areas and thanks to them the objectives were soon reached. The Decree also established the legal power of the Autonomous Communities to authorise the installation of renewable energy plants for the first time. A year later, RD 1578/2008 would regulate new tariffs for electric energy production using photovoltaic technology for installations after the RD 661/2007 deadline. The government was forced to approve new tariffs that benefitted not only large facilities. And that would also establish greater control over the new renewable power projects.

New regulations in 2009 again made cutbacks in the funding of new renewable energy installations. Royal Decree-Law 6/2009 on

Table 1
Legislation to promote renewable energies in Spain 1997/2004.

Legislation	Regulatory area	Aim	Jurisdiction
Law 54/1997, **on the electricity sector**	Electricity sector	To reach 12% renewable energies by 2010	General regulations
(Royal Decree) RD 2818/1998, **on the production of electrical energy by facilities supplied by renewable energy resources, sources, waste or cogeneration**	Renewable energies	Regulation of installations and incentives for installations > 50 MW	Installations > 50 MW offshore wind farms
RD 436/2004, **which sets out the methodology for updating and systematising the legal and economic systems to provide for a special scheme for energy production**	Renewable energies	Settlement of tariffs, incentives, inducements and supplements	Funding scheme for receipt of public aid

Table 2
Legislation to promote renewable energies in Spain 2006/2009.

Legislation	Regulatory Area	Aim	Jurisdiction
RD-L 7/2006, **on emergency measures in the energy sector**	Energy sector	Payments made for cogenerated electricity whatever the size of the facility Flexibilisation of incentives and inducements	Installations > 50 MW Offshore wind farms
RD 661/2007, **regulation of a special scheme for electrical energy production**	Electricity sector	Promotion and economic incentives	Autonomous communities authorise renewable energy projects
RD 1578/2008, **pay for electrical energy production through solar photovoltaic technology for installations after the deadline of RD 661/2007**	Solar photovoltaic	Promotion and economic incentives	Specific regulations of solar photovoltaic technology
RD-L 6/2009, **adoption of certain measures in the energy sector and approval of 'social bond'**	Electricity sector	Creation of 'social bond'. Creation of state register with preallocation of new installations	State authorizes renewable energy installation projects

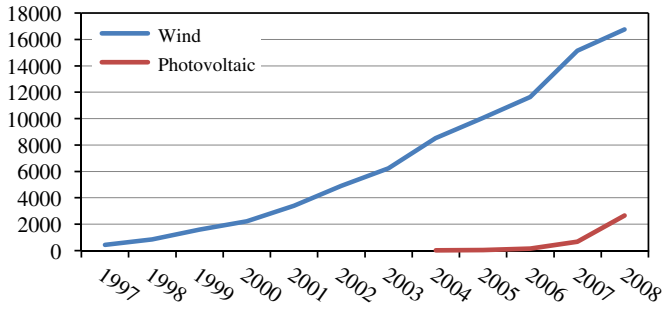

Fig. 1. Evolution of installed wind and photovoltaic energy power capacity in Spain (MW) 1997–2008.

the adoption of specific measures in the energy sector and the approval of the social bond meant a reduction in incentives to promote renewable energies. The central administration was afraid that the policy in effect for the promotion of renewable energies might put up the cost of the electricity bill and make the absorption of electricity by the grid difficult. And it was admitted that the great success of the incentives policy was due to speculation by the larger development companies. As a result of this, the State administration created the so-called "centralised remuneration pre-allocation register", the aim of which was to regain the legal power to authorise new renewable energy plants that had been granted to the Autonomous Communities in 2007. The main action taken was a review of the payment of incentives in Royal Legislative Decree 6/2009, which also established control mechanisms for the approval and processing of plans for new plants. From 2009 on the State only authorised new installations if they met the commitment requirements for the effective installation of new plants in the agreed time period, and only registered installations would be able to receive the economic incentives approved in 2007.

Two goals were being pursued. The first, to ensure the greater commitment of new renewable installation plans to the energy savings strategy and the second, to disassociate any new plans from the receipt of incentives and favourable tariffs. In the same line, the new 2011–2020 Renewable Energies Plan set binding and compulsory minimum targets regarding the share of total energy consumption to be covered by renewable sources. The Plan also established that the socio-economic benefits derived from the new production and consumption patterns should benefit not only the electricity development companies, but the population as a whole through the generation of employment and environmental outcomes. The main business associations have shown their opposition to this cutback in aid. Far from bringing their expansion to a halt, they have determined to optimise new installations with the technologies that most benefit from the inducements policy on a State level and from planning in each of the Autonomous Communities. An increase in solar energy plants is anticipated in coming years and they are expected to be sited in the areas of most sunshine: in the south of the Iberian Peninsula, especially on the coast and in the inland plains and valleys. However, the new 2009 regulations will doubtlessly lead to a slow-down of new projects and new plants in favour of greater control.

3. Renewable power policy implementation in Andalusia: the search for spatial planning rules

There are differences in the competences that each of the Autonomous Communities holds within the Spanish State. Some Autonomous Communities have passed legislation with measures to regulate the installation of renewable energy plants and establish their own models of territorial implementation. Andalusia is an Autonomous Community with a wide margin of self-government and has full competences in the areas of planning, developing and installing renewable energy sources.

Andalusia has implemented the introduction of renewable power by virtue of major legal instruments and resources. The resources are the number of sunlight hours per annum, the power of the wind in large areas of the countryside, and also the wide expanses of territory that can be used to grow energy crops. As far as the legal instruments are concerned, in Andalusia new regulations have been added to the State legal framework for energy production and supply. In Andalusia, the model chooses:

- to address State measures on energy issues;
- to plan its own incentives programme;
- to authorise the siting and construction of renewable energy plants.

The application of State legislation as a whole is based on the Andalusian government setting its own targets and incentives. This incentives policy has been well received by companies. Three rafts of actions have to date been approved regarding specific plans and land planning. In particular, actions have been carried out on two fronts: the design of policies to promote renewable energies, and spatial planning and urban development for new installations.

3.1. Regional policy to promote renewable energies

Broadly speaking, the Andalusian policy for promoting renewable energies applies European Union and Spanish State policies. The main action taken was the formulation of regional energy plans, the first of which was the 1995–2000 Andalusian Regional Energy Plan. A second Plan was passed in 2003: the 2003–2006 Andalusian Energy Plan set its own targets for energy promotion while at the same time introducing positions on the preferred siting of installations. One of the targets of the Plan is for 15% of the regional demand for electricity to be supplied from renewable energies by 2013. For this ambitious demand to be met, the regional administration has announced annual economic incentives charged against European funds for regional development (see Table 3) in which State and European measures for developing renewable energies and energy savings and efficiency are specified. And without them, the success of renewable energy implementation in Andalusia could not be envisaged. The Plan also launches the Andalusian Energy Agency as its main tool. Apart from compliance with international agreements, the Agency is also responsible for coordinating sector policies and policies to promote renewable technologies.

The results were successful. The Andalusian Energy Agency confirms that the targets that were set had been reached in 2007. The rate of installation had been high and renewable energy plants were widespread throughout the whole of the Autonomous Community. In 2007, total power from renewables stood at 2141.3 MW (www.agenciaandaluzadelaenergia.es). Wind energy was mainly responsible for this large share, with solar energy and other renewable energy technologies trailing a long way behind. Total installed power capacity for wind energy stood at 1291.7 MW, which meant it delivered 12% of electrical power to the Autonomous Community and constituted 60% of all renewable energy sources. Solar energy was a distant second despite a sharp increase. In 2008, installed power capacity for photovoltaic energy stood at 656 MW, with the majority of installations on agricultural land (see Fig. 2). Finally, the other great white hope of renewable technologies is solar thermal energy, which in 2008 commanded an installed power capacity of 60.93 MW (APREAN, 2009). The remainder corresponds to other systems, including biomass and energy crops.

To conclude, Andalusia's response to the State's incentives policy for the implementation of renewable energy has been very positive. As is the case in the country as a whole, wind technology stands out as far as installed power capacity is concerned. Nevertheless, despite the smaller contribution it makes, solar power undoubtedly plays a prominent role in Andalusia due to the amount of sunlight and the availability of water and land, and future expansion is anticipated. Solar plant siting patterns show a clear preference for installations on agricultural land. Large agricultural properties, such as latifundia, and also smaller farmsteads with smaller surface areas throughout the Guadalquivir valley are the preferred sites for installing new photovoltaic and thermal plants. And there can be absolutely no doubt that energy companies and installation companies, and research in new technological developments, will consolidate Andalusia as the driving force behind some unique projects in the world, especially in the field of solar energy.

3.2. Spatial planning and renewable energies plans: an unfinished dialogue

The most innovative actions on this twin front of energy and land planning were taken in 2007 by virtue of the competences that RD 661/2007 granted the Autonomous Communities. In the same year Law 2/2007 on energy efficiency and the 2007–2013 Andalusian Sustainable Energy Plan were passed in Andalusia. Both documents confirmed the target of achieving 15% of demand for primary energy from renewable power in 2013 (Dept. of Innovation, Science and Enterprise (Consejería de Innovación, Ciencia y Empresa), 2007). Both stressed the opportunity for research, technological development and innovation in a bid to consolidate leading edge companies in the Andalusian renewable

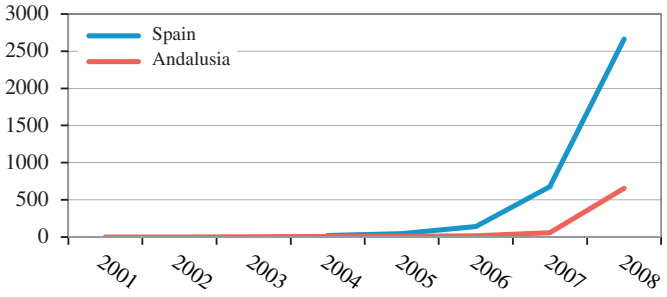

Fig. 2. Evolution of installed photovoltaic energy power capacity in Spain and Andalusia (MW) 2001–2008.

Table 3
Legislation to promote renewable energies in Andalusia 1995/2009.

Legislation	Regulatory Area	Aim	Jurisdiction
1995–2000 Andalusian Energy Plan	Energy sector	To increase amount of renewable energy in energy supply	Regional Energy Plan
Decree 86/2003, **approving the 2003–2006 Andalusian Energy Plan**	Energy sector	To cover 15% of energy demand with renewables by 2010	Regional Energy Plan
Law 4/2003, **for the creation of the Andalusian Energy Agency**	Energy sector	Creation of Andalusian Energy Agency	Compliance with 2003–2006 Andalusian Energy Plan
Order 18/2005, **regulating the requirements for incentives for the development of sustainable energy in Andalusia**	Renewable energies	Announcement of economic incentives	Simplified regulations for applications for incentives
Order 19/2006, **regulating the requirements for incentives for the development of sustainable energy in Andalusia**	Renewable energies	Announcement of economic incentives	2006
Order 11/2007, **regulating the requirements for incentives for the development of sustainable energy in Andalusia**	Renewable energies	Announcement of economic incentives	2007
Order 4/2009, **regulating the requirements for incentives for the development of sustainable energy in Andalusia, and his called is maded for years 2009–2014**	Renewable energies	Announcement of economic incentives	Simplified regulations for applications for incentives Period 2009–2014

energy sector. This explains the interest shown by engineering and major infrastructure companies in becoming part of this new model as they position themselves as energy installers and producers. Companies thus take advantage of the public economic incentives, which are decisive factors in renewable energies being favourably received. A second aspect which is highly significant because of its originality is connected with the process of installing renewable energy plants. This Law includes a number of articles concerning renewable energy sources and land planning, and also argues the need for energy planning and land policy to be coordinated on the town, environmental and cultural levels. The Law also proposes that renewable energy land programmes be drawn up for the installation of plants and infrastructure. Finally, it details urban development procedures for installations of this type. Both municipalities and regional administrations are involved and must coordinate their work to ensure that urban development plans are complied with (Table 4).

The 2007–2013 Andalusian Sustainable Energy Plan, or PASENER, contains a large number of the new provisions in Law 2/2007. The Plan relates the various plans and programmes that have a bearing on energy planning to one another, emphasising their cross-links with other public policies. Secondly, the beneficial effects of renewable sources over conventional sources for the environment are highlighted. From this point on, the favourable environmental effects of renewable energies must be incorporated into energy planning, and also into urban development and environmental planning (Consejería de Innovación, Ciencia y Empresa, 2007).

The 'PASENER' includes a specific section on the environmental effects of renewable energy plants. This section recognises that there are some negatives linked to the implementation of certain technologies, with specific mention being made of the bird mortality associated with wind power and the effect of wind turbines on natural and cultural heritage (Consejería de Innovación, Ciencia y Empresa, 2007).

Although power lines for the transport of energy have been mentioned in this paper, bird mortality due to collisions with the propeller blades of wind turbines has been identified as the most important area of contention. Some studies have been conducted on wind farms in the Straits of Gibraltar as a key area on birds' migratory routes. The findings point to the height of the turbines and their height over sea level as the cause of mortality among griffon vultures (*Gyps fulvus*) (de Lucas et al., 2007b). The PASENER includes some contradictory statements with respect to the effects of renewable energies on the natural and cultural heritage. Regarding natural heritage, it refers to the impact of renewable energy plants on non-built-up land caused by changes in land relief and in vegetation. Yet, at the same time, agricultural land is considered to be the preferred area for their siting: "where associated impacts are not usually significant" (Consejería de Innovación, Ciencia y Empresa, 2007: 139). Installations on agricultural land do not require any environmental impact statements, but these are required for forest land. The effects of renewable energy plants on cultural heritage allude to reductions in CO_2 emissions and impacts on the conservation of buildings of architectural, artistic or historic value. Finally, the relationship between renewable energies and cultural heritage is made subject to the need for specific studies and integrated policies (Feria, 2005).

The PASENER also refers to the large swathes of land required for the installation of photovoltaic energy and the huge amounts of water consumed by solar thermal plants, but it does not mention the amount of water consumed by thermo-solar plants. A photovoltaic energy plant requires a surface area of 2 ha (approx. 5 acres) per megawatt of installed power, whereas 1 MW of thermo solar energy requires 1.2 ha (approx. 3 acres) and 0.02 hm^3 (approx. 4,400,000 imp. gallons) of water (Prados, 2009). The Plan states that, should these negatives exist, they would not stand in the way of renewable energies development; on the contrary, they are the lesser of two evils compared with the undoubted advantages that renewable energies provide for the environment. Given heightened sensitivity to these drawbacks, it therefore plays down any possible impact renewable energies might have, also stating that any impacts are minimised by the fact that these installations are sited on flat agricultural land.

The document on the environmental effects of renewable energy plants makes no reference to the impact of new installations on the landscape despite the fact that renewable energy projects have been undertaken willy-nilly the length of valleys and all over the Andalusian countryside. The absence of regulatory plans and the expansion brought about from 2007 on have led to adverse effects on the environment and the landscape. This has resulted in installations sprawling over large expanses of land, polluting the area visually.

As far as regional spatial planning is concerned, the PASENER refers to the provisions of the Andalusian Spatial Plan. As Andalusia does not have any landscape protection legislation in place, the Andalusian Spatial Plan is the main legal point of reference for this matter. The Plan makes it compulsory to include measures for the protection and improvement of landscapes in regional spatial planning (Dept. of Public Works and Transport (Consejería de Obras Públicas y Transportes), 2007). According to Council of Europe dictates, landscape planning is defined as "strong forward-looking action to enhance, restore or create landscapes" (Council of Europe 2000, art. 1). And landscape planning is underpinned by the landscape being regarded as an integral part of Andalusia's natural and cultural heritage. This three-pronged joint identification of landscape, heritage and

Table 4
Andalusian Energy Plan and Spatial Planning.

Legislation	Regulatory area	Aim	Jurisdiction
Law 2/2007, **on the development of renewable energies and promotion of energy savings and efficiency**	Renewable energies and energy savings and efficiency measures	To achieve a quality sustainable energy system and development of competences in drawing up of plans and programmes	Compliance with EU and Spanish plans, programmes concerning energy savings and efficiency and the development of renewable energies Sustainable Energy Plan
Decree 279/2007, **approving the 2007–2013 Andalusian Sustainable Energy Plan (PASENER)**	Energy infrastructure and the development of renewable energies	• To prioritise the use of renewable sources • Management plan for a system of energy infrastructure • To promote the energy technology business fabric	

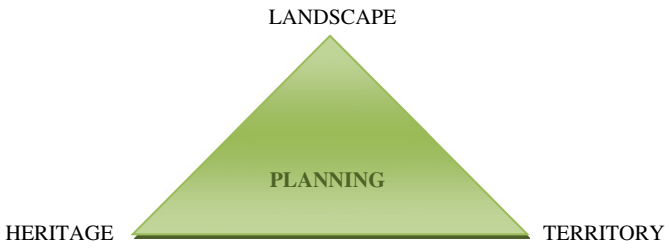

Fig. 3. The landscape in the 2006 Andalusian Spatial Plan.

territory pursues the integrated management of all three of these mutually supporting elements, including specific policies for landscape development and advancement (Fig. 3).

One of the new elements that the regional Spatial Plan introduces is a series of recommendations for spatial planning and territorial development for new renewable energy installations. These are specifically as follows:

- the inclusion of the energy system in the Andalusian land use model;
- establishing landscape protection measures in energy planning and in plans for infrastructure;
- setting aside the coast and lesser urbanised inland areas as preferred sites for both wind and solar systems, as well as agricultural land for energy crops.

The Andalusian Spatial Plan does not specify how the landscape is to be protected in the planning of energy installations. The option of siting facilities on the coast comes into *de facto* conflict with the protection of the Andalusian coastal landscape, which has been greatly degraded by both past and more recent urban developments. On the other hand, the siting of renewable energy plants inland jeopardises the conservation of the cultural heritage. The preferred siting of photovoltaic and solar thermal plants on agricultural land brings a new twist to an already fragile rural environment, which has been greatly weakened by the agricultural sector's loss of economic importance. Neither do the Plan's competences over landscape development properly provide for the integration of renewable energy plants on the level of the effects of old plants and their inclusion in landscape planning.

In short, what is missing is a criterion that links energy policy and landscape development together in a mutual relationship, and the two remain detached from each other. This therefore creates a major contradiction, as the PASENER expressly includes a reference to the Andalusian Spatial Plan in the ambit of regional spatial planning for renewable energy plants.

4. The sprawl of renewable energies and landscape management

4.1. Wind energy

To date, public aid has received a better response from wind energy than solar energy in Andalusia. The policy of subsidising new renewable energy installations has resulted in the growth of technology, with greater capacity. This high level implementation of wind energy has been felt all over the country. Wind farms have spread over inland rural land and all along the coast taking advantage of strategic areas. This has drawn greater public and political attention to the significance of their presence for power supply, the environment, local development and the landscape. In practice, the degree to which these initiatives are accepted is connected with two elements: the proximity of residential areas to the installations, and the time when they are installed. As a rule of thumb, public opinion accepts these installations if they have been present on the landscape for a certain length of time and the people do not live in the vicinity (Prados, 2009). In contrast, local populations do not respond so positively. Demonstrations against the installation of new plants usually take place in areas where the unwanted effects of wind turbines are already well-known. The negative aspects noted in the PASENER have led to open protest from local residents and businesspeople on the coast in the past and continue to do so, as installations have been in existence there for longer (www.diarioelpais.com).

There is no doubt that these protests have sparked a movement for effects on the environment and on the landscape to be included in energy plans. The latest initiative to install offshore wind farms along the whole of the Spanish coastline has triggered widespread public debate. In 2007, the Ministry of the Environment and Marine and Rural Affairs announced the results of a Strategic Environmental Study of the Spanish coast for the installation of offshore wind farms (Spanish Government (Gobierno de España), 2007). The purpose was to plot the route for the installation of wind turbines in the sea on the basis of a map of sea winds. The proposed installation of offshore wind farms has been well received by companies, but not by the public. The opposition shown *en bloc* by businesspeople, fishers and town mayors has been instrumental in this change of attitude as they forced the Andalusian Government to demand that said zone be excluded from the national offshore wind farm map (Spanish Government (Gobierno de España), 2007) (Fig. 4).

And yet, other mayors on the edge of this exclusion zone are trying to attract installations to their towns with support from environmental groups and residents' associations and opposition from everybody else. The regional government hopes that the various parties involved will reach an agreement so that a decision can be taken that favours the municipalities' interests. This attests to the Andalusian Government's lack of criteria for the planning of energy installations, as it means that the regulations governing the development and protection of the landscape in the Andalusian Spatial Plan are not worth the paper they are written on.

4.2. Solar power

Cutbacks in the financial incentives policy for renewable energies have led to new developments in solar energy. As Andalusia is blessed with a large number of sun hours per year, this resource would seem to be easy to optimise. The average annual sunlight shows the coast and the south-western sector to be highly favourable areas for exploiting the sun as an energy source (Andalusian Energy Agency (Agencia Andaluza), 2010). Average sunshine is over 3000 h in these areas, more than 125 days per year. These favourable circumstances mean that advantage is being taken of the region for the expansion of photovoltaic solar energy. Not only solar farms, but even solar latifundia spread over erstwhile agricultural lands. The main reason for this is that large areas of flat agricultural land are preferred for photovoltaic plants so that they can capture sunlight (Prados, 2008).

There are a number of prerequisites that this land must meet: it must be exposed, it must be accessible and it must be near electricity substations (Prados, 2008). If the land is flat, installation costs are cheaper, as is the subsequent maintenance. Agricultural land meets all these needs, but installation would not be possible without support from farmers. The loss of earnings from agriculture is a prime factor in the expansion of solar energy in Andalusia. Falling prices for agricultural produce, changes in

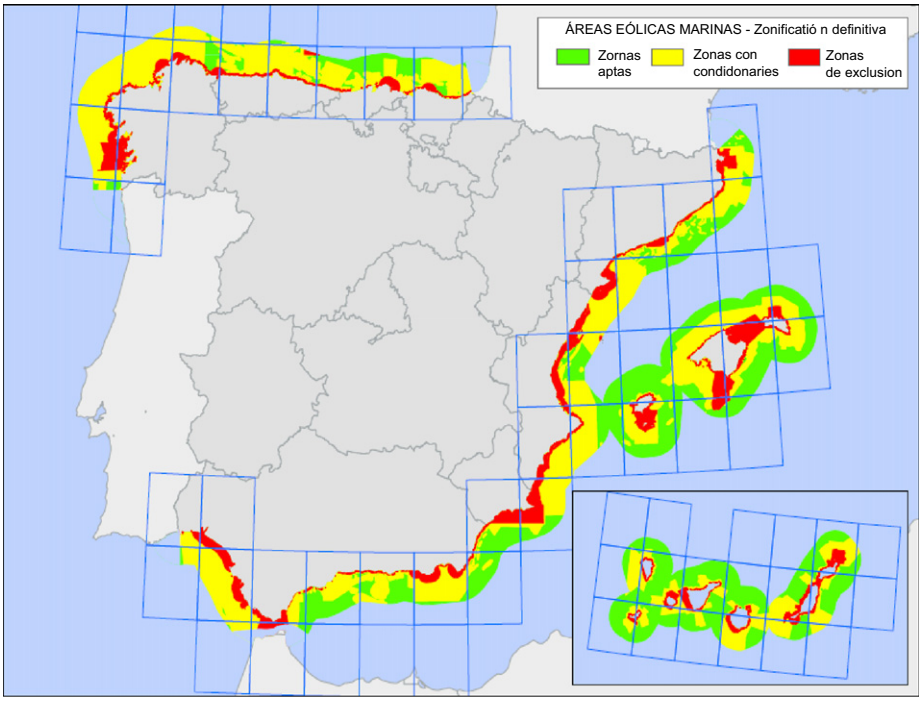

Fig. 4. Map of proposed areas for wind farm developments in Spain with extended exclusion zones.

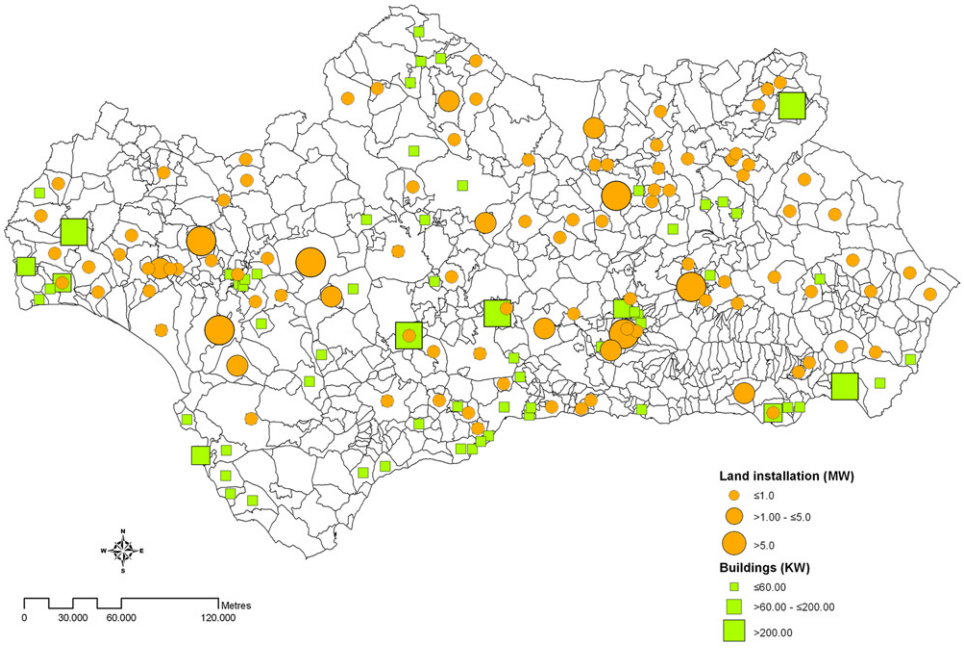

Fig. 5. Map of installed photovoltaic solar energy capacity in Andalusia, 2008.

the region's agricultural policy and restrictions to the agro-foodstuff sector have been decisive in the expansion (Prados, 2009). Owners of small-holdings consider that the renting out of their land for the installation of solar panels represents a steady income to supplement fluctuations in prices for agricultural produce (Prados, 2009; Espejo, 2010). As the PASENER itself states, no environmental impact study is required for photovoltaic plants on agricultural land (Consejería de Innovación, Ciencia y Empresa, 2007). Mayors in these municipalities grant licences for these small installations and thus switch the type of land use from rural to industrial. The result has been the proliferation of small-scale plants, with the consequent chaos at the levels of spatial planning and the uploading of energy generated at solar farms.

Fig. 5 presents the sites of photovoltaic energy plants installed on agricultural land and on buildings by municipality for 2008. According to data supplied by the Andalusian Energy Agency, photovoltaic plants have 128.10 MW installed power and occupy a surface area of 250.34 ha (approx. 618 acres). The amount of power authorised for 2008 was 823.80 MW.

The renewable energy installations with a greater capacity are considered small plants (under 1 MW capacity, and between 1 and 5 MW), along with those of a larger size that exceed 5 MW. The former are medium-size and large-size plants on land

surfaces previously used for agriculture, whereas the latter are isolated panels installed on buildings. They are distributed far and wide throughout the territory, as the large number of municipalities that have at least one of these small plants shows. At the same time installations on buildings are widespread and in the majority of cases in the same municipalities where plants already exist on the ground. This duplication attests to the chaotic implementation of solar energy plants in Andalusia, where there seems to be an inability to respond with a rationality plan for renewable energy production.

The map of installed photovoltaic installations shows the areas that they covered were spread throughout the region in 2008. Solar energy over agricultural land requires large expanses of land where solar panels can be laid. As they occupy a large surface area, they tend to be sited away from populated areas. For the technology to be exploited on an industrial scale, cheap land that is also agricultural land is required. And all this with a technology that is low capacity as far as energy per unit of surface area is concerned and which does not guarantee the continuity of the power supply. Any photovoltaic plant covers a wide area, and this means that a 1 MW installation of photovoltaic power requires an average of some 2 ha (5 acres) of rural land. The returns on land usage for this type of energy are also highly questionable, and the fact that these plants are scattered far and wide extends their impact to cultural landscapes, which makes their planning and management difficult (Prados, 2009).

In 2008, the 250 ha occupied by photovoltaic energy plants in Andalusia were spread over a large expanse of the territory. There were 208 plants installed located in 198 municipalities. As previously mentioned, installed power in 2008 was 128.10 MW while 823.80 MW of power was authorised. A year later, installed power had risen to 658.65 MW, which means that new photovoltaic plants had been installed at a high rate, but it had still not reached the figure that had been authorised in 2008. The cutbacks introduced by RD-L 6/2009 led to a significant slowdown in the growth rate of installations. The most recent data available for 2010 estimates power connected to the grid to stand at 672.47 MW. The rise in installed power logically goes hand-in-hand with a rise in the surface area occupied by photovoltaic plants, which is currently (2010) estimated at 1350 ha (approx. 3336 acres). The repercussions on the territory are, however, even greater if the number of municipalities where at least one photovoltaic plant is located are taken into account. In 2009, there were 519 municipalities with photovoltaic plants, i.e., two thirds of the sum total. There are 822 municipalities in Andalusia, which means that between 2008 and 2009 there was an 80% rise in municipalities with photovoltaic plants. The new installations also resulted in the growth of surface area occupied and the number of municipalities with photovoltaic plants. Their presence in the territory at the current time is even greater than two years ago.

Solar energy is hugely extensive in its exploitation, demanding large open spaces, which are usually agricultural areas. It was the smaller energy returns from photovoltaic plants that led companies to change track. Southern Spain meets all these conditions and this is the reason why Spanish companies are doing research into innovative technologies to ensure that the process is optimised and to guarantee the continuity of the energy supply. Technologies with greater capacity, such as thermo-solar energy and solar thermal energy, have been developed on the basis of photovoltaic solar energy. Whatever the type of installation, this process ensures a continuous and stable power supply, which is not the case with photovoltaic energy. But, the expansion of major thermoelectric installations might eventually externalise the problems of solar energy plant concentration as the technology competes with agriculture for land use and water consumption. For the time-being, public opinion regards them as an innovative phenomenon, as milestones in sustainability and symbols of the construction of new landscapes (Prados, 2009).

This opinion is based on a lack of scientific debate on the implications of this technology for sustainable development, the rural economy and the preservation on cultural landscapes. It is therefore necessary to analyse the consequences of the expansion of these energies and investigate the implications for land and landscape in greater detail. It is evident that thermo-solar energy is supported by the conversion of agricultural land and farms into industrial areas for energy production. Once more, large expanses of relatively flat agricultural land are required, that is, 1.2 ha (3 acres) of land are required for each megawatt of thermo-solar energy power. The overexploitation of water resources is a new element to add to the environmental and landscape implications of renewable energies. Thermo-solar energy plants have to be sited on irrigable agricultural land as they make use of the irrigation water for energy production. It is estimated that a 50 MW plant requires some 220 million imp. gallons of water (Prados, 2009). It is no trivial matter that energy that is supposed to be sustainable is reliant on such a scarce resource. And, it confirms the view that sun-based renewable energy is a major consumer of large expanses of land resources and landscapes.

More and more agricultural land will be taken over, and the plants will be further scattered around more municipalities in the region, and other resources will be increasingly consumed. Notwithstanding, no estimations have been made on just how much land can or will be used for the targets of sun-based renewable energy production to be reached. The disappearance of agricultural land converted into areas for energy production will also have other consequences: the survival of agriculture, the development of multipurpose agriculture, the disappearance of the plant cover associated with crop growing, its ability to act as a CO_2 sink, etc. And, of course, the conservation of that part of heritage associated with agriculture and the survival of cultural landscapes. This whole process comes under the competences of spatial planning and landscape management, although there are no clear ideas about how the differences between these competences can be settled. As far as new renewable energies are concerned, the planning of installations and the keeping in check of the impacts they have are matters that still have to be resolved.

5. Conclusions—renewable energies: a panacea for energy challenges?

Renewable energies are at the core of proposals included in international commitments to a reduction in emissions and the greater sustainability of energy consumption, which augurs well for further installations. This paper analyses the renewable energy implementation process in Spain and in Andalusia. The legislative measures driven by the central government and the Andalusian autonomous government's energy plans together explain the success of renewable energy installation. The article details the results regarding technology implementation for sun-based energy generation. Very broad progress has been made at a great rate in the case of photovoltaic technology: to 2010, 672.47 MW had been connected to the grid out of the 823.80 MW total authorised in 2008.

The renewable energy boom should also be assessed with respect to the surface area occupied by the new installations in general, and their spread over agricultural land in particular. Progress in the numbers and power of installations has been driven by hefty incentives from public subsidies in the energy

field. However, energy planning and the on-the-ground planning of renewable energy plants are clearly out-of-step. Measures aimed at subsidising the rapid growth of energy generated by renewable energy technologies have not been accompanied by any planning of the installations in the territory. This would seem to undervalue the implications of the process for the territory and the landscape, although it has been clearly demonstrated that neither should be regarded in this way. This article has exposed a number of shortcomings that question the safe and beneficial image that solar energy has in particular. The technology that produces energy from the sun uses a renewable resource, but that does not mean that the installations are harmless for the environment. The article also analyses the environmental and territorial implications that renewable energy plants have, especially photovoltaic plants sited on agricultural land. Meeting sustainable energy targets through the use of renewable energy technologies will have other collateral effects that are difficult to forecast. Some of these side-effects have been revealed in this article, including changes in land cover and use, the disappearance of crops, the need for water to keep solar thermal technology plants up and running, and the expansion of photovoltaic plants on agricultural land in a greater number of municipalities.

It is evident that a balanced appraisal of the environmental effects of solar energy plants should include all the aspects relating to the installation of plants for energy production. Renewable energies cannot be regarded exclusively as a much sought-after panacea for energy challenges. The complexity of the interrelations associated with these new energies has to be brought to the table and scientific arguments used in the debate on the harmless and beneficial image that they have for the global environment. Renewable energies cannot be proclaimed as torchbearers of sustainability if they jeopardise the future of the territory and the landscape. Changes in land use contribute to the transformation of cultural landscapes as a focal part of heritage. And they lead to the creation of new landscape structures, which must be modelled to minimise the impact of renewable power plants. Landscape change is at the nub of the spread of renewable energy production and as such should be considered as part of spatial and energy planning. The credibility of landscape protection policies and the sustainability of renewable energies itself is rooted in this.

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