Journal of Business and Economics, ISSN 2155-7950, USA
April 2020, Volume 11, No. 4, pp. 410-419
DOI: 10.15341/jbe(2155-7950)/04.11.2020/003

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Public Policies in the Development of Renewable Energies in Spain in the XXI Century

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Abstract: It has been noted that in recent decades, society has become increasingly convinced of the anthropogenic ingredient in environmental problems on the planet. This awareness has guided public policies to protect the environment, such as those for the promotion of renewable energies. The objective of this study is to analyze the influence that a country's public policies can have on the development of renewable energies technologies. For this purpose, Spain was selected, due to the important development of these technologies in the first decade of this century. The method is based on empirical documents from databases of national and international recognized institutions. The analysis strategy consisted of the selection of variables corresponding to the elements of the proposed model: (i) public renewable energies spending policies; (ii) development of renewable energies technologies; and (iii) participation of these sources in primary energy production. Significant positive correlations were found between these three elements, however the regression analysis shows that it is actually the expenditure on subsidies and R&D (Research and Development) that determines the development of that industry and its participation in primary energy generation in the country.

Key words: ublic policies; renewable energy; Spain
JEL codes: O380

1. Introduction

Although environmental problems have always existed to some extent, it has not been until the last few decades that awareness has been aroused by the aggravation of them and their effects at the planetary level such as global warming, climate change and pollution of the atmosphere in large cities, etc. (Krugman, 2016).

Environmental problems caused by the abuse of natural resources, mainly non-renewable resources such as fossil fuels, have contributed to the new paradigm of economic growth called sustainable development that has influenced importantly in public policy, mainly in industrialized countries (Thomas, 2011).

The official recognition of the global environmental problem was in 1972, in Stockholm, during the United Nations Conference on the Human Environment, when it came to concepts relating to environmental issues, of their education and importance in changing the development model. At this Conference, the United Nations Environment Programme (UNEP) was established, with the aim of coordinating at the international level actions for the protection of the environment.

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From that moment on, there have been different events on this subject, which make up what we call the environmental debate, among which we can highlight, the United Nations Conference on Environment and Development, Rio de Janeiro, 1992, which it brought important international agreements, and relevant documents, such as Agenda 21, in parallel to the Earth Summit, was held at the Rio 92 Global Citizen Forum, in which 33 treaties were approved (Alea-García, 2008).

In the same year, the United Nations Framework Convention on Climate Change was formed, convening the Kyoto Protocol adopted in 1997, followed by the World Summit on Sustainable Development (Rio + 10), held in 2002, in Johannesburg, South Africa. Finally, within this same framework convention, all countries were called up to the Paris Agreements in 2015 to establish greenhouse gas emission mitigation measures.

One of the first and best-known definitions of the concept of sustainable development is the Brundtland report[1] at the UN World Commission on Environment and Development in 1987 (Moros & Sanchez, 2012), such as:

> "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

This report, which was originally called Our Common Future, makes a critique of economic development for not considering the damage it caused to the environment. In order to solve this, it proposes a rethink of economic development policies at the global level that will have to take ecological sustainability into account in an economic and social framework of development.

In this way sustainable development can be regarded as a new interdisciplinary space between the social sciences and the natural sciences, especially between economics and ecology, as well as an operational field for public policies economic and environmental development (King & Alvarez-Campana, 2007).

As climate change is the most well-known problem facing sustainable development, it has become a major concern around the world. In Europe, the 2013 Eurobarometer surveys indicate that at least two-thirds of the population considers global warming to be one of the most serious problems facing humanity today (Kosenius & Ollikainen, 2013).

This awareness of the population, which has led to greater participation of citizens in environmental issues has given rise to the theory of Ecological Modernization, developed by sociologists Janicke and Huber, as an alternative to the concept of sustainable development, considering it somewhat limited to integrate the ecological problem with economic growth. This theory provides elements for analyzing the relationship between the modernization process and environmental degradation, particularly in the context of industrialized societies (Mol & Spargaaren, 2000).

This theory posits that environmental problems require, in industrial societies, a modernization of institutions towards ecology in order to make the relationship between economics and ecology more interdependent, that is, aimed at internalizing external costs and developing technologies that are less harmful to the environment. The heart of this theory is the integration of ecological rationality into economic rationality (Ibid).

According to this theory, the main features that characterize Ecological Modernization in industrialized countries are: 1) Science and technology have become increasingly important elements; 2) Emerging economic and market dynamics are important; 3) New role of the state towards increasingly decentralized and participatory

[1] The report was prepared by various nations in 1987 for the UN, by a commission headed by Dr. Gro Harlem Brundtland, then Prime Minister of Norway.

environmental policies; and 4) New role of society, moving from a critical and passive role to an active and participatory role. Relative to this last point, concerning the participation of society in matters of interest, is what Giddens (1990), called reformist-class social movements.

The role of consumer citizens as active actors in the cycle of production and consumption of goods and services is incorporated as an additional element in this theory. From this perspective, the so-called circular economy (or cradle to cradle) has been generated, closely related to the concept of industrial ecology (Geng & Doberstein, 2008).

At the 2005 World Summit of the United Nations (UN, 2005), on social development, they identified the goals of sustainable development, economic development, social development and environmental protection, which are and in the long run there cannot be one without the others. Hence sustainability can be outlined that it is at the intersection of three areas that are: environmental; social; and the economical (Farinós, 2008), as shown in the Venn diagram in Figure 1.

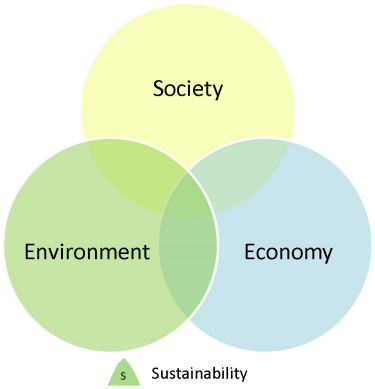

Figure 1 Sustainability Is at the Confluence of the Environmental, Social and Economic Fields

More recently, in the last decade in line with UN Agenda 21, a fourth element has been added, unfolding the social field in political and cultural, generating the Model of the Sustainability Circles containing the four domains: Ecological, Cultural, Political, and Economical. This last model is the one that has been used in the programs of the Cities and Metropolises of this same organization (UN, 2003; Deyna, 2008).

Some of the elements that make up sustainability are research and innovation activities, which give rise to the European Union's environmental policies in these activities, oriented towards a more "green" and therefore sustainable economy and society, 2020 Horizon program, which funds research and innovation in different areas, including the themes of sustainable development (European Commission, 2014).

Climate changes that have been presenting prominently in recent decades due to global warming, which are the subject of dialogue in most of the world's population, have resulted in both government administrations and businesses, establishing sustainability policies or actively participating in support of this issue.

One of the pillars of this sustainable development is trends in the field of clean energy generation from environmentally friendly renewable sources, such as solar, wind, hydraulic, geothermal, biomass and all oriented towards the so-called low-carbon economies (Clark, Duttz & Kronberg, 1993).

According to REN21 (Renewable Energy policy Network for the 21st century), by the end of 2015, 173 countries had established targets in renewable energy and estimated that 146 countries had policies to support renewable energy. In Eurobarometer surveys, 70% of the European population believes that alternative sources to fossil fuels are required in energy production, for which they are willing to pay an extra price on their bill

(Hanemann, Labandeira & Loureiro, 2010).

According to the International Energy Agency (IEA, 2007), the expected growth trends of the main energy sources for the period 2005-2030 in the world, considering the APS[2] (Advanced Planning Scheduling) scenario, are those shown in the Table 1.

Table 1 Expected Growth in Energy Production in the World for the Period 2005-2030 According to the APS (Advanced Planning Scheduling) Scenario

Conventional		New renewable energies	
Oil	39%	Wind	18 times
Gas	63%	Electric solar power	60 times
Coal	54%	Thermic solar power	10 times
Nuclear	19%	Biofuels	10 times
Hydraulic	63%	Oceanic energies	46 times

As can be seen there are spectacular growths in new renewable energies, whose increases in absolute terms are: wind from 82 to 1,440 TWh[3]; on the electric solar from 4 to 238 TWh; solar thermal from 6.6 to 64 Mtoe; biofuels from 15 to 147 Mtoe and oceans from 0.54 to 25 TWh. The projections made for the year 2050, renewable energies will generate in the order of 3,620 TWh, of which wind will do so in half and the rest equally geothermal and electric solar, with a small contribution of the oceans.

In the case of the European Union, the White Paper (IEA, 2007), which establishes a Common Strategy and an Action Plan for Renewable Energy, published in 1997 by the European Commission, is considered as the foundation of renewable energy development. This document set ambitious goals; renewable energy sources should contribute 12% in the primary energy demanded in the European Union by 2010 and 20% by 2020.

Within this strategy, in Spain the main factor that has contributed to the growth of the renewable energy sector is the Renewable Energy Development Plan 2005-2010, published in 1998, which is part of the European Union White Paper mentioned above. The main motivation for this plan was the high energy dependence of this country, which at the time imported 80% of the energy it consumed, mainly from politically unstable countries.

In addition to the environmental advantages, from an economic point of view, renewable energies offer the following four great advantages, which support this plan:

1) They are labour-intensive, creating more jobs for each Euro invested, compared to traditional energies.
2) The use of own energy sources makes the investments remain in the place where the facilities are located.
3) They contribute to the progress of the domestic industry, increasing the competitiveness and opening up export markets for high value-added products.
4) Stimulates the creation of enterprises and employment in rural areas, particularly for the production of the raw material for biomass and biofuels.

These advantages mean that in Spain the implementation of renewable energies has a broad base of social, political and trade union support. Typically, the public perceives these technologies as new and beneficial, particularly in the context of combating global warming. For a large part of the population, wind and solar

[2] APS is the scenario that believes that most countries will promote renewable energy for strategic, economic and environmental reasons.

[3] TWh are Terawatt-hour, which is equivalent to 10^{12} watt-hours.

photovoltaic energy have a clear environmental connotation, which relates to the "clean", "healthy", "green" or "sustainable" meanings (Frolova & Pérez, 2008).

Of the total energy consumed by a country or primary energy, renewable energies participate in Spain in three forms of production of this energy: (i) electricity, in its different modalities; (ii) thermal, mainly for heating systems; and (iii) in transport with the production of biofuels. There is sustained growth in the share of renewable energy, particularly in electricity and thermal energy, which highlights the public policy pursued in the energy sector, particularly in the first decade of this century (Montoya, Aguilera & Manzano, 2014).

It is noted that it is in the production of electricity, where renewable energies have a greater participation (Seville, Golf & Driha, 2013). Below is shown in Figure 2, the participation of the four main renewable energies in the production of electric energy is observed. It should be noted that hydraulics are excluded as an alternative emerging technology and nuclear as it is not considered renewable.

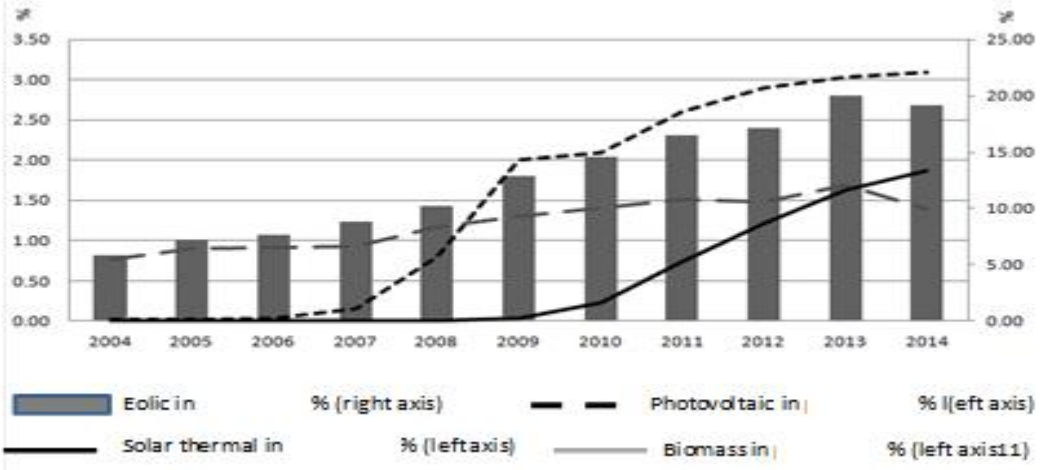

Figure 2 Evolution of the Share of Renewable Energies, Wind, Solar Photovoltaic, Solar Thermal and Biomass, in the Production of Electricity in Spain 2004 to 2014

On the right axis of Figure 2, you can see that wind energy contributes the most to electricity generation, about 20%, with sustained growth, except last year, which had a slight decrease, as did biomass that in 2014 had a decrease. However, solar, both photovoltaic and thermal, has been the renewable energy that had the greatest growth in the period analyzed (Martínez-Paz, Almansa-Saéz & Perni-Llorente, 2011).

Given the above, the overall objective of this study is to analyze the importance of public policies in the development of renewable energy technologies. For this purpose, Spain was selected as a case study, due to the important development of these technologies in this 21st century, particularly in its first decade. This objective is aimed at achieving a better understanding of the relationship between public policies and their effect on the development of technologies in a population-sensitive field such as environmental protection.

The justification is to highlight, through the case of renewable energy technologies, the influence that public policies can have on the development of renewable energy technologies in a country.

The general hypothesis that was formulated was essentially H1: the influence that public policies exerted on spending on renewable energy, was an important factor in the development and implementation of these technologies in Spain in the first decade of the present Century.

2. Method

The proposed type of study is of type applied in its purposes, however its development implies the proposal of a theoretical model of analysis, with a quantitative, non-experimental approach. Information sources are essentially documents based on empirical data, as well as national and international databases on environmental issues and the development of renewable energy technologies in Spain, from 2000 to 2014.

The subjects or unit of analysis of the study were the Spanish renewable energy industry and its economic impact at the country level. The variables analyzed are those corresponding to renewable energy technologies, both technological and economic in the industry. Below are the variables, the queried sources, or databases from which they were taken.

- From the National Institute of Statistics (INE),
  - Government spending on renewable energy subsidies
  - Government spending on Research &Development on renewable energy
- From the International Energy Agency (IEA),
  - Patents in renewable energy technologies
  - Scientific articles on renewable energies
- From the Spanish Electricity Network (REE),
  - Percentage of renewable energy in the generation of total, electricity, thermal and biofuels
- From the Institute for Energy Diversification and Savings (IDEA),
- From the Association of Renewable Energy Producers (APPA)

The analysis strategy of the study is to present first a descriptive part that presents the values of the main variables, both technological and economic, followed by an inferential analysis, which identifies the associations between the these variables through correlation coefficients, a regression analysis (using the SPSS package), and finally a discussion and the conclusions of the study.

3. Results

3.1 Spending on R&D in General, on Renewable Energy and Subsidies

In order to promote renewable energy, from 2000 ones subsidies began to be granted, in order to reduce their cost to the consumer, which was increasing until 2013, when they began to decline from this year until 2016. Table 2 shows spending on these subsidies (thousands of millions Euros, M€), the general Research &Development spending on renewable energy technologies (in millions of Euros, M€), and the Gross Domestic Expenditure on Research & Development (GERD), as percentage of Gross Domestic Product.

Table 2 Evolution of Spending on R&D for Renewable Energies, Research and Development Spending (GERD) in the Country as a Percentage of GDP, and Subsidies in the Renewable Energy Industry from 2000 to 2013

Indicator	2000	2004	2008	2012	2013
Spending on R&D in the renewable energy (M€)	21.7	25.2	37.2	77.6	37.9
Country R&D spending (% of GDP)	0.91	1.06	1.35	1.3	1.26
Renewable energy subsidies (thousands of M€)	1.5	2.5	3.3	8.5	8.9

Source: From the author with data from IEA Spain 2015 and INE 2016.

Due to public policies in this area, the growth of government spending on R&D in the renewable energy industry increased by more than three times from 2000 to 2011, pointing to the importance of the technological development of this industry in this period, however, from 2012 begins to decrease due to new public policies in the energy sector. Similarly, spend in research and development (GERD), as a percentage of GDP begins to decline from 2010, a decrease that has continued until 2017 (Gil, 2013).

Regarding the evolution of government spending in the R&D&I (input) process in renewable energy industry technologies and their results in innovations, such as the patents (outputs) of this process, Figure 3 shows the evolution in this expenditure and the registration of patents in Spain by residents of renewable energy technologies (OECD/IEA, 2009).

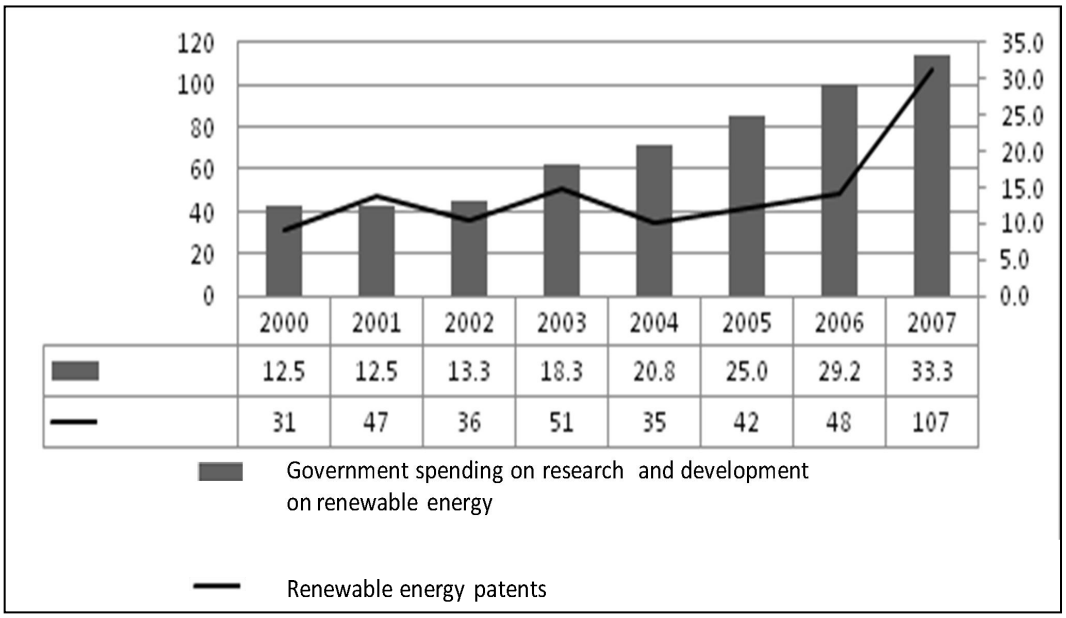

Figure 3 Evolution of Government Spending on R&D (M€) on Renewable Energy Technologies (REs) on the Right Axis and Patents on These Technologies in Spain by Residents, 2000 to 2007 on the Left Axis

Source: Elaboration of authors with OECD/IEA data, 2009

There is a virtually parallel evolution between R&D government spending and patent registration in Spain by residents of renewable energy technologies from 2000 to 2007. Regarding the publication of scientific articles on these technologies, considerable progress was also made, from 47 in 2003 to 206 in 2009. These results show significant growth in R&D efforts and in their results in innovations through patents and scientific publications in these technologies in that period (Romo, Guerrero & Moya, 2013).

With regard to employment in this renewable energy industry, there is a growth in direct employment until 2008, which reaches 78,924 direct workers and 136,160 considering indirect, starting to decline from this year (Nieto, 2008).

3.2 Relationship Between the Main Variables

In order to identify the weight that public policies can have on the development of renewable energy technologies, then Figure 4 presents the proposed model of analysis that shows the sequence of the main elements of the process that starts from public policies that determine government's spending on R&D and subsidies in this field, which in turn influence the development of technologies and finally in the presence of these technologies in

energy production in the country.

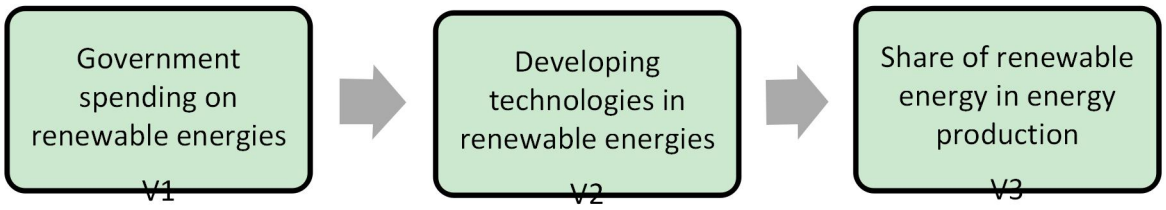

Figure 4 Analysis Model Proposed with the Process Sequence Showing the Influence of Public Policies on the Development of the Renewable Energy Industry

In order to show the relationships between these three elements, the correlation coefficients between representative variables of each of them are calculated, shown below.

- Public policies on government spending on renewable energy, a variable consisting of the sum of subsidies and R&D expenditure, expressed in millions of Euros per year, V1.
- From the development of technologies in renewable energies, "Number of patents registered on renewable energies in Europe by Spanish residents per year" was selected, V2.
- From the participation of renewable energies in energy production, this same variable, expressed in the percentage of power generation in primary energy, V3.

Table 3 shows the Pearson correlation coefficients between these three variables, particularly the relationship between the V1-V2-V3 sequence of the model in Figure 4, which highlights the influence of government spending on renewable energy on the other two variables.

Table 3 Positive and significant Pearson Correlation Coefficients Between the Three Variables of the Proposed Model

Variable	V1	V2	V3
V1	1	0.931**	0.947**
V2		1	0.933**

Note: ** denotes significance P< 0.01

It is noted that the correlations of V1 (government expenditure in renewable energies) with V2 (European Union patents) and V2 with V3 (% of renewable energies share), are high, however to detect and avoid collinearity, the following two linear regression models are calculated using the backward method.

Model 1: $V3 = 5.847 + 0.036.V2 + 0.001.V1^*$ $R^2 = 0.916$

It is noted that the variable V2 in model 1 is not significant at p level<0.05 due to its collinearity, so it is removed in model 2, obtaining:

Model 2: $V3 = 4.972 + 0.001.V1^{**}$, $R^2 = 0.896$

This model 2 shows that both the constant and the V1 variable are significant at a P level < 0.01, so it is considered more appropriate. The standardized beta coefficient of the V1 variable corresponds to the correlation coefficient of 0.947.

The interpretation of this regression analysis is that in reality the variable that explains and allows to predict the participation of renewable energies in primary energy production (variable V3), is the economic variable V1, which corresponds to the sum of the subsidies and R&D spending on renewable energy. The variable related to technological development and Patents V2, can be considered as a result of the variable V1, with which it has a

high correlation coefficient, which explains its collinearity and elimination of the final Model 2.

3.3 Hypothesis Test

Below is the verification of the hypothesis raised, H1: the influence that public policies exerted on renewable energy spending, was an important factor in the development and implementation of renewable energy technologies in this country, in the first decade of this century.

The Pearson correlation coefficient between these two variables V1 and V3, shown in Table 3, is 0.947 ($P < 0.01$), which rejects the null hypothesis with a probability greater than 99% and tests the alternative hypothesis H1. This result is proven with the calculated regression model 2.

4. Conclusions

From the above results, the following conclusions can be drawn based on the objective set out, which is to analyze the influence that public policies can have on the development of renewable energy technologies, for which the case was taken Spain in the present century.

1) It was found, an important positive correlation between public policies on subsidies and R&D spending in the renewable energy sector and the development of renewable energy industry technologies, as measured in terms of renewable energy innovations in patents and scientific articles.
2) Similarly, an important positive correlation was observed between the development of renewable energy technologies and the increase in the participation of renewable energy technologies in power generation in the country.
3) It was found that the most important relationship was between public policies concerning expenditure on subsidies and R&D in the renewable energy sector and the participation of these technologies in primary power generation in the country, with a coefficient of Pearson correlation of 0.947 and an R^2 coefficient of 0.896.

These results show important relationships that suggest the existence of causal relationships, which would point in the sense of confirming the calculated model that proposes the alignment of public policies with the development of technologies sensitive to the population, such as environmental protection through renewable energies.

As noted in the case of Spain, this alignment occurs particularly in the first decade of the century, during which there is a sustained growth of the participation of technologies in renewable energies in primary energy production. It was noted that from 2011, the decrease in government budgets, both to R&D spending and to renewable energy subsidies, results in a decrease in the development of these technologies and in the growth of their participation in the energy "mix" (Serrano & Ruiz, 2006).

As a general conclusion it can be noted that the above results allow a better understanding of the weight that public policy decisions can have on issues sensitive to society, such as environmental protection through development and the implementation of renewable energy technologies, within the framework of sustainable economic development.

References

Alea-García A. (2008). "Breve historia de la educación ambiental: del conservacionismo hacia el desarrollo sostenible", *Revista Futuros*, Vol. 12, pp. 1-10

APPA (2015). "Estudio del impacto macroeconómico de las energías renovables 2014", Madrid. Asociación de empresas de energías

renovables de España.

Clarke H. D., Dutt N. and Kornberg A. (1993). "The political economy of attitudes toward polity and society in Western European democracies", *The Journal of Politics*, Vol. 55, No. 4, pp. 998-1021.

DEYNA (2008). *La agenda 21 local. Una institución tergiversada*, Madrid: Fundación Desarrollo y Naturaleza.

European Commission (2014). "Guidelines on open access to scientific publications and research data in horizon 2020", European Commission.

Farinós J. (2008). "Gobernanza territorial para el desarrollo sostenible: estado de la cuestión y agenda", *Boletín de la A.G.E.N.*, No. 46, pp. 11-32.

Frolova M. and Pérez B. (2008). "El desarrollo de las energías renovables y el paisaje: algunas bases para la implementación de la convención europea del paisaje en la política energética española", *Cuadernos Geográficos*, Vol. 43, No. 2, pp. 289-309.

Gil F. (2013). "Energías Renovables en España", *Revista de obras públicas*, Vol. 160, No. 3548, pp. 43-52.

Hanemann M., Labandeira X. and Loureiro M. L. (2011). "Climate change, energy and social preferences on policies: Exploratory evidence for Spain", *Climate Research*, Vol. 48, No. 2-3, pp. 343-348.

IEA (2007). "Renewables in global energy supply an IEA fact sheet", International Energy Agency (IEA), OCDE, Paris.

IEA (2015). "Statistics renewables trends 2015", Paris: International Energy Agency, OCDE.

INE (2016). *Estadísticas en Ciencia y Tecnología 2015*, Madrid. Instituto Nacional de Estadísticas.

Kosenius A. K. and Ollikainen M. (2013). "Valuation of environmental and societal trade-offs of renewable energy sources", *Energy Policy*, Vol. 62, pp. 1148-1156.

Krugman P. (2016). El ello que devoró el planeta. Laboratorio de ideas. Madrid: Diario El País, 20.

Martínez-Paz J., Almansa-Saéz C. and Perni-Llorente Á. (2011). "Energía eléctrica procedente de fuentes renovables: Percepción social y disposición al pago", *Estudios de Economía Aplicada*, Vol. 29, No. 2, pp. 539-560.

Mol A. P. and Spaargaren G. (2000). "Ecological modernisation theory in debate: A review", *Environmental Politics*, Vol. 9, No. 1, pp. 17-49.

Montoya F., Aguilera M. and Manzano F. (2014). "Renewable energy production in Spain: A review", *Renewable & Sustainable Energy Reviews*, Vol. 33, pp. 509-531.

Moros J. and Sánchez F. (2012). "Modelo de Gestión Ambiental basado en Valores Conservacionistas que Contribuya a la Integración Universidad – Comunidad. DAENA", *International Journal of Good Consciencie*, Vol. 7, No. 1, pp. 13-24.

Nieto J. (2008). "Estimación del empleo en energías renovables 2007", Instituto Sindical del Trabajo, Ambiente y Salud, ISTAS, CCOO, España.

OCDE/IEA (2009). "Renewables in Global Energy Supply an IEA fact sheet", Paris: International Energy Agency, OCDE, Paris.

ONU (2005). "Documento final de la Cumbre Mundial 2005", Resolución aprobada por la Asamblea General de la ONU, Octubre 2005.

Pnuma R. M. (2012). "Eficiencia en el uso de los recursos en América Latina: Perspectivas e implicancias económicas 2011", Programa de Naciones Unidas para el Medio Ambiente.

Rey A. and Álvarez Campana J. (2007). *Evaluación ambiental y desarrollo sostenible*, Madrid: Ediciones Pirámide.

Romo L. M., Guerrero V. and Moya F. (2013). "Análisis de la producción científica española en energías renovables, sostenibilidad y medio ambiente (Scopus, 2003-2009) en el contexto mundial", *Investigación Bibliotecológica*, Vol. 27, No. 60, pp. 125-151.

Serrano M. L. T. and Ruiz J. M. (2006). "La percepción social de las energías renovables a través de una encuesta de opinión: Un caso práctico en localidades del noroeste murciano", *Papeles de geografía*, No. 44, pp. 141-152.

Sevilla M., Golf E. and Driha O. (2013). "Las energías renovables en España", *Estudios de Economía Aplicada*, Vol. 31, No. 1, pp. 35-80.

SCSC (2016). "Spanih corpus of scientific culture", Recuperado 10 de Julio 2016 en la página, available online at: http://abejaruco.rec.usal.es/awfullform.

Thomas H. (2011). "Tecnologías sociales y ciudadanía socio-técnica. Notas para la construcción de la matriz material de un futuro viable: Revist@ do Observatorio do Movimento pela Tecnologia Social da America Latina", *Ciencia & Tecnologia Social*, Vol. 1, No. 1, pp. 1-22.

UN (2003). "Agenda 21", Department of Economic and Social Affairs, Division for Sustainable Development, UN 2003.