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Method for the identification of regulatory barriers to the integration of renewables in electricity systems. A case study.

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Abstract. The European Union (EU) has set up a regulatory framework aimed at maximizing the integration of renewables in the energy systems of its member countries for the purpose of decarbonisation, establishing a series of specific targets and time horizons. The regulatory framework that is established for the energy sector of each country will have a major influence on whether the targets set are attained within the scheduled time horizon. An analytical method based on 5 stages is developed in this paper. In the different stages an analysis is made of the historical energy plans, their subsequent outcomes and the binding regulatory framework with the aim of identifying the possible regulatory barriers that might affect the large-scale integration of renewables in electricity systems and, hence, their decarbonisation. The method is applied to a case study of the electricity systems of the Canary Islands (Spain). It is concluded from the results of the study that the regulatory framework and its governance, especially in relation to remuneration schemes, have a decisive influence on the successful attainment of the targets that are set. It is also concluded that the negative impact on target achievement is drastically reduced when the regulatory framework is attractive, secure and flexible for investors.

Keywords: Energy planning, regulatory barriers, renewable energies, decarbonisation of electricity systems.

1. Introduction

The European Union (EU) has established a regulatory framework [1] that incorporates strategies that aim to maximise the integration of renewable energy sources into the energy systems of member countries and their regions. To this end, member countries are obliged to establish national plans in this area that contribute to this strategic objective. In this regard, the Spanish government has drawn up its integrated National Energy and Climate Plan (PNIEC by its initials in Spanish) [2], in which the strategic objective for the year 2030 is for renewable energies to contribute 81% of electricity demand. Environmental and urban planning regulations make decisive contributions to the protection and management of land and landscapes, but they can also hinder and slow down rational and sustainable development of the territory, especially with respect to the implementation of electricity generation facilities based on renewable sources [3]. Sim and Young [4] studied a case in the Arab Gulf states which showed that the regulatory regime (planning and enforcement) has played an important role in the low development of solar energy in the Gulf. Bessin et al. [5] developed a method for the integration of wind and PV in the EU. They concluded that the effective deployment of such installations was being limited by challenges such as territorial conflicts, aesthetic issues and regulatory barriers.

Compared to continental electricity systems, those deployed on islands present a series of unique characteristics due to their isolation and small size. These characteristics make such systems especially vulnerable, with a systemic risk of loss of guarantee and quality of the electricity supply, which is aggravated by the incorporation of non-dispatchable renewable energies, mainly wind and photovoltaic, into the generation mix.

In [6] and [7], the authors analysed barriers, other than those of a regulatory nature, such as territorial or technical ones, to the integration of floating offshore wind energy in isolated electricity systems.

In general, all the research papers analyzed employ the same methodology: identification of barriers, classification into groups and measurement of the relative importance of each barrier, based on the subjective opinions of experts. However, these articles do not measure the effects of these barriers on the quantitative objectives established by energy planning. The island electricity systems in Spain are subject to a unique sectoral regulatory framework [8], which has the dual objective of guaranteeing the supply of electricity and its quality, at the lowest possible cost, and maximising the penetration of renewable energies through a specific remuneration system. The Canary archipelago, one of the EU's nine outermost regions, has 7 main islands with isolated electricity systems that are neither connected to the continental system of the Spanish mainland nor to each other (with the exception of two of the islands). The islands are a fragmented and fragile territory, with a high degree of environmental protection. The Canary Islands Government, following the energy policy guidelines dictated by the European Union and Spain, has drawn up and approved successive energy plans over the years in which, among many other aspects, a series of objectives and deadlines have been set for the integration of renewable energies in the different electricity systems of the islands. At the end of 2024, the average contribution of renewable energies to the archipelago's electricity demand was 22.4% [9], considerably short of the targets established in national planning. Practically all the renewable energy generated in the islands comes from wind (77%) and solar photovoltaic technology (21%) [10], with the remaining 2% corresponding to other renewable energies. It is important to review the successive energy plans historically drawn up in the Canary Islands and try to identify the regulatory barriers that may have prevented the effective deployment of renewable energies in the archipelago.

This paper proposes an analytical method, based on ratios, for the analysis of energy plans and their subsequent outcomes, and more specifically with respect to the large-scale integration of renewable energies in electricity systems. The aim is to identify the regulatory barriers that may have negatively affected the attainment of the strategic objectives established in the plans and to quantify their influence, all within the framework of the sustainability and decarbonisation of electricity systems. A case study is undertaken of the different electricity systems of the Canary Islands. The method is intended to be of help in the preparation of future planning and regulatory documents for the electricity sector, with the goal of minimizing deviations from the objectives and deadlines established for the decarbonisation of the electricity systems.

2. Materials and method

To carry out this research, the necessary data were taken from the energy plans [11] and the Energy Yearbooks [12] published by the Canary Islands Government. The first approved energy plan, specifically oriented towards energy transition, was the PECAN 2006-2015. This plan set specific targets for the Canary Islands in terms of installed capacity from renewable sources (1,308.1 MW), integration percentage (31.5%) and a time horizon for their attainment (10 years). The PECAN 2006-2015 is the only energy plan to date, which was approved and executed by the Canary Islands Government, whose performance can be fully verified. The other energy planning documents drafted by the Canary Islands Government, EECan 2015-2025 and PTECan 2020-2040, which set more ambitious targets for the integration of renewables in the electricity systems (see Table II), have not reached their time horizon. Every year, the last one in 2022, the Canary Islands Government publishes its Energy Yearbooks with the aim of showing the evolution of the energy situation in the archipelago.

The research method developed, which was applied to a case study, consists of the following stages:

Stage I. The data on the actual installed capacity of renewable electricity generation (P_{rj}), in MW, for each year j of the plan, for all technologies and for the whole of the Canary Islands, were extracted from the Energy Yearbooks. These data were obtained for the years 2005, the year prior to the entry into force of PECAN 2006-2015, to 2022, the latest available Energy Yearbook. These data, together with the percentage contribution of renewables to electricity demand, are shown in Table I.

Stage II. The only two energy plans approved in the Canary Islands (PECAN 2006-2015 and EECan 2015-2025) were reviewed, extracting from them the targets set for renewable energies: target installed power in the final year, tf, of planning, P_{pf} (MW), and time horizon, N_p (years), for all technologies and for the Canary Islands as a whole. Although not yet approved, the same has also been done with PTECan 2020-2040, since the objectives set out in this energy plan continue to form part of the current energy policy of the Canary Islands Government. These data are shown in Table II, together with the percentage contribution of renewables to electricity demand established as a target for each of the energy plans considered.

Stage III. The annual growth rates of installed capacity in electricity generation from renewable sources were calculated for the whole of the Canary Islands, which, on average, should be maintained to guarantee compliance with the planning objectives set out successively in PECAN 2006-2015, EECan 2015-2025 and PTECan 2020-2040. These data are shown in Table III. The average annual growth rate of installed renewable electricity generation capacity required for a planning P, in a period of time tf-ti, would be given by the following expression, Eq.(1):

$$\boldsymbol{K_{p(tf-ti)} = \frac{(P_{pf} - P_{ri})}{N_p}} \quad (\mathbf{1})$$

where:

$K_{p(tf-ti)}$: Growth rate, on average per year, expressed in MW/year, required by planning P in the period tf-ti.

P_{pf}: Installed capacity of renewable electricity generation required by the planning P, to be installed in the final year tf of the planning, expressed in MW. Includes all renewable technologies foreseen in the energy planning.

P_{ri}: Actual installed renewable electricity generation capacity installed in source year ti of planning P, expressed in MW. Includes all renewable technologies foreseen in the energy planning.

N_p: Planning time horizon, expressed in years; final year tf minus initial year ti (tf-ti).

Stage IV. The average year-on-year growth rates of installed capacity in electricity generation from renewable sources actually obtained were calculated for the whole of the Canary Islands, both those obtained year by year (t_{j+1}-t_j) and those obtained for the total period relating to each plan (t_{j+k}-t_j), namely 2015-2005 and 2022-2015 and also for the total period 2022-2005. These data are shown in Table IV. The average year-on-year growth rate of installed capacity in electricity generation from renewable sources actually obtained, in a period of time t_{j+k}-t_j, would be given by the following expression, Eq.(2):

$$\boldsymbol{K_{r(t_{j+k}-t_j)} = \frac{(P_{r_{(j+k)}} - P_{r_j})}{(t_{(j+k)} - t_j)}} \quad (\mathbf{2})$$

where:

$K_{r(tj+k-tj)}$: Average annual growth rate actually obtained, expressed in MW/year, in the period $t_{(j+k)}-t_j$, where t_j is the start year and t_{j+k} is the final year.
$P_{r(j+k)}$: Actual installed capacity in electricity generation from renewable sources in planning year $t_{(j+k)}$, expressed in MW.
P_{rj}: Actual installed capacity of renewable electricity generation installed in planning year t_j, expressed in MW.
$(t_{j+k}-t_j)$: Interannual calculation period, expressed in years.

The values that k can take are: k=1 for calculation of the actual annual average growth rate between two consecutive planning years; k=Np for calculation of the actual annual average growth rate between the final and initial planning year; or any other intermediate value ranging between 1 and Np, for calculation of the actual annual average growth rate between any two non-consecutive planning years.
The rate $K_{p(tf-ti)}$ is the minimum admissible annual growth rate for strict compliance with planning. If, in some of the years t_j of the planning period, the actual growth rate $K_{r(tj+1-tj)}$ is lower than the average rate $K_{p(tf-ti)}$ ($K_{r(tj+1-tj)} < K_{p(tf-ti)}$), this deficit must be compensated for in subsequent years with actual growth rates $K_{r(tj+1-tj)} > K_{p(tf-ti)}$. This is so for the average actual growth rate of the planning period $K_{r(tj+k-tj)}$, for k=Np, to be equal to or higher than $K_{p(tf-ti)}$. Otherwise, the planning target for installed capacity will never be reached.

Stage V. A search was carried out in the Official Gazette of the Canary Islands (BOC) and the Official State Gazette (BOE) to identify, chronologically, the regulatory actions carried out by both the Canary Islands Government and the Spanish Government, respectively, over the period 2005-2022. This was done with the aim of verifying the existence or otherwise of a correlation between the year-on-year growth rates actually observed and the regulatory actions carried out by these governments over the study period and, subsequently, of measuring the possible influence of such actions and identifying any potential regulatory barriers.

3. Results and discussion

The results of the calculations made in accordance with the methodology set out in section 2 are shown below and discussed. As can be seen in Table I, the installed capacity of renewable electricity generation in the Canary Islands followed a continuously upward trend from 2005 to 2022, as was the case with the percentages of integration into the electricity systems.

Table I.- Evolution of installed renewable power in the Canary Islands (P_{rj}, in MW), for each year “j”, and average relative contribution of renewables to electricity demand (%).

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Prj(MW)(%)	139.2(3.6%)	147.9(3.7%)	167.7(4.0%)	247.4(4.7%)	254.0(5.5%)	285.5(5.7%)	300.7(6.4%)	328.0(6.7%)	336.5(7.3%)
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Prj(MW)(%)	359.3(7.6%)	360.4(7.7%)	367.2 (7.8%)	422.8(7.9%)	612.1(10.3%)	636.4(15.9%)	697.9 (17%)	768.5(19.5%)	922.0(19.8%)

However, it can be seen in Table I that the increase in installed capacity in the most recent years (2021 and 2022) was not accompanied by a significant increase in the percentage penetration of renewable energy in the electricity systems. The explanation for this could be due to the ‘curtailments’ experienced by renewable plants, as demand in the Canary Islands has remained practically stagnant since 2005. In fact, demand in that year was 9,097 GWh [12], while in 2022 it was 8,991 GWh [12]. The demand forecast for 2040 estimated in PTECan 2020-2040 is 8,187 GWh [11]. In this regard, although it is true that demand for electricity is expected to increase due to the incorporation of electric vehicles and the electrification of other production processes and sectors, the application of energy efficiency policies would offset this growth. On the other hand, as can be seen in Table II, the installed capacity of renewable electricity generation in the Canary Islands and the percentages of integration to satisfy demand imposed in each of the plans drawn up have been increasingly ambitious.

Table II.- Targets established in the different energy plans for renewable power (Ppf, in MW) and for the average contribution of renewable energies to electricity demand (%). Np (years): Time horizon of the plan.

Plan	Pp2015 PECAN 06-15	Pp2025 EECan 15-25	Pp2040 PTECan 20-40
Ppf (MW)	1,308.1 (31.5%)	1,660.1 (47%)	11,774.6 (100%)
Np	10	10	20

As a result, as shown in Table III, the plans drawn up to date have set increasingly demanding average annual growth rates for installed capacity in renewable electricity generation.

Table III.- Average annual growth rates (in MW/year) of planned renewable capacity (see Eq.(1)).

	Kp(15-05) PECAN	Kp(25-15) EECan	Kp(40-20) PTECan
Kp(tf-ti)	116.9	129.9	553.8

As can be seen in Table IV, in no year in the period 2006-2015 (which correspond to the scope of application of the PECAN 2006-2015) was it possible to grow installed capacity at the minimum average rate required by the planning (116.9 MW/year). Consequently, in 2015, with an average growth of 22.1 MW/year during the 2005-2015 period, the installed capacity was 360.4 MW, and the integration percentage was 7.7%, far below the capacity to be installed (1,308.1 MW) and the integration percentage (31.5%) required by this planning.

Table IV.- Evolution of the actual annual growth rate of installed renewable capacity (see Eq. (2)).

PECAN 06-15	Kr (06-05)	Kr (07-06)	Kr (08-07)	Kr (09-08)	Kr (10-09)	Kr (11-10)	Kr (12-11)	Kr (13-12)	Kr (14-13)	Kr (15-14)
MW/year	8.8	19.7	79.7	6.6	31.5	15.2	27.3	8.5	22.8	1.0

EECan 15-25	Kr (16-15)	Kr (17-16)	Kr (18-17)	Kr (19-18)	Kr (20-19)	Kr (21-20)	Kr (22-21)
MW/year	6.8	55.6	189.3	24.4	61.5	70.5	153.6

Annual average values	Kr (15-05)	Kr (22-15)	Kr (22-05)
MW/year	22.1	80.2	46.1

On the other hand, as can also be seen in Table IV, in the period corresponding to the scope of application of EECAN 2015-2025, in two non-consecutive periods (2017-2018, 189.3 MW) and (2021-2022, 153.6 MW) installed capacity grew at a rate higher than the minimum average required by the planning for that period (129.9 MW/year). In the other years, the average growth was much lower than the minimum rate required by this planning. Consequently, in 2022, with an average growth of 80.2 MW/year during the period 2015-2022, the installed capacity was 922.0 MW, and the integration percentage was 19.8%, far below the capacity to be installed (1,660.1 MW) and the integration percentage (47%) required by this planning. In view of the results shown in Table IV, it can be concluded that the average annual growth rates of renewable installed capacity in the Canary Islands are irregular, are generally well below the minimum growth rates required by the plans, and could not be sustained consistently over time. At this point, it is necessary to explain the reasons for this behaviour of the growth rates and their relationship over the period 2005-2022 with the regulatory actions carried out by the Spanish and Canary Islands Governments. In the period 2005-2008 the only renewable power installed in the Canary Islands was photovoltaic [12]. The installation of new wind farms destined to feed all their energy into the grid was not permitted since, as will be explained below, it was subject to a quota system. The Spanish Government, through Royal Decree 661/2007, established a very attractive remuneration framework for renewable energy installations, especially for photovoltaic solar energy, to the extent that the growth in installed capacity experienced by this technology throughout Spain was much higher than expected, rising in the Canary Islands from 8.8 MW/year in the 2005-2006 period to 19.7 MW/year in the 2006-2007 period. This led the Spanish Government to decide to downgrade its remuneration scheme by approving Royal Decree 1578/2008, which came into force on 26 September 2008. In consequence, a maximum installed photovoltaic capacity in the Canary Islands of 79.7 MW can be observed in the period 2007-2008, motivated by the desire of investors not to lose the previous, more attractive, remuneration scheme. The new remuneration scheme of Royal Decree 1578/2008, revised downwards, explains the sharp drop in the annual rate of installed photovoltaic capacity, which went from the aforementioned maximum of 79.7 MW in the period 2007-2008 to 6.6 MW in the period 2008-2009. In the period 2008-2015, the renewable power installed in the Canary Islands was predominantly photovoltaic (>85%) [12], with the exception of the period 2013-2014 when the 22 MW of the Gorona del Viento hydro-wind power plant on the island of El Hierro was installed [12]. Installed wind power capacity was residual, corresponding to the repowering of some onshore wind farms, the only ones not subject to the quota system. In order to safeguard the security and quality of the electricity supply in the system, as well as to minimise production restrictions for those technologies considered non-dispatchable, mainly wind and photovoltaic, reference installed capacity targets were established. Thus, the Canary Islands Government, by means of Decree 53/2003, established a system of power allocation by means of a public tender procedure. The first tender for the allocation of wind power capacity was called by the Canary Islands Government in 2004 for a maximum of 344 MW. However, this tender was annulled for legal reasons in 2006 and was re-launched in 2007 for a maximum of 440 MW of wind power. This last tender in 2007 was also annulled by court rulings between 2014 and 2016. This period 2005-2015 is known in the Canary Islands as the ‘Wind Standstill’. In the period 2012-2013 the rate of installed renewable power, only photovoltaic, fell again to 8.5 MW/year. This was because, in 2012, the Spanish Government, arguing that the growth of wind and solar photovoltaic technologies had produced a significant increase in the additional cost to the system in terms of premiums which had caused the tariff deficit of the electricity system to grow, proceeded, through Royal Decree-Law 1/2012, to remove the incentives for the construction of these facilities. This led to a lack of investor interest in undertaking this type of project in the Canary Islands, and in 2015 the growth rate reached an all-time low of 1.0 MW/year. The failure of the two previous tenders resulted in the publication by the Canary Islands Government of Decree 6/2015, which eliminated the power allocation tender systems and opted for free establishment. At the same time, in 2014, the Spanish Government, by means of Order IET/1459/2014, issued a call for the assignment of the right to receive a new specific remuneration scheme for wind technology facilities located in the Canary Islands, for a maximum of 450 MW, and with no restrictions in the case of photovoltaic technology. This call established two deadlines: 31 December 2015 and 31 December 2018. The first deadline required, among other administrative requirements, a favourable Environmental Impact Statement, and the second the full completion and commissioning of the facilities. In view of this situation, the Canary Islands Government exceptionally excluded certain projects from the environmental impact assessment process, as the ordinary completion of these procedures would not be possible before 31 December 2015. The wind farms excluded from the environmental impact procedure had a total capacity of 157.15 MW. Therefore, the combination of the requirement of a deadline for commissioning, set for 31 December 2018, and the administrative simplification, materialised in the exemption of these farms from the environmental assessment procedure, explain why the installed capacity rate grew from 6.8 MW/year in the 2015-2016 period to 55.6 MW/year in the 2016-2017 period, culminating in the historical maximum of 189.3 MW at the end of 2018. After this historical maximum of 189.3 MW, the installed capacity rate fell again to 24.4 MW/year in the period 2018-2019 and then increased again in the following two successive periods to 61.5 MW/year (2019-2020) and 70.5 MW/year (2020-2021). These growth rates culminated in the second historical maximum of installed renewable capacity in the Canary Islands at the end of 2022, when the annual installed capacity ratio reached 153.6 MW/year. The explanation for this can be found in the publication of Order TEC/1380/2018, which established aid for investment in electricity production facilities with wind and photovoltaic technologies co-financed with ERDF Community Funds, setting 30 December 2022 as the deadline for the completion of investments. However, as in the previous period 2015-2018, in the period 2018-2022 the Canary Islands Government had to resort to exceptional regulatory instruments, this time to exempt both wind and photovoltaic installations from compliance with urban planning regulations. Thus, during the period 2018-2022, the Canary Islands Government published a total of 45 decrees in which it exempted 31 wind and 14 photovoltaic installations, with a total capacity of 318 MW (269 MW wind and 49 MW photovoltaic), which was slightly more than the total installed capacity during the period 2018-2022 (310 MW), from the urban planning regulations, obliging the competent administrations to modify the current planning which prohibited the construction of these installations. As a summary of the above, Figure 1 shows that the actual growth rates for the Canary Islands as a whole are considerably below the values foreseen in the energy plans, both past and future.

Based on the input data used, incorporated throughout the work, and the results obtained in the case study, it can be deduced that the applicable regulatory framework acts as a barrier to the effective integration of renewable energies and the decarbonisation of the electricity systems within the foreseen time horizons.

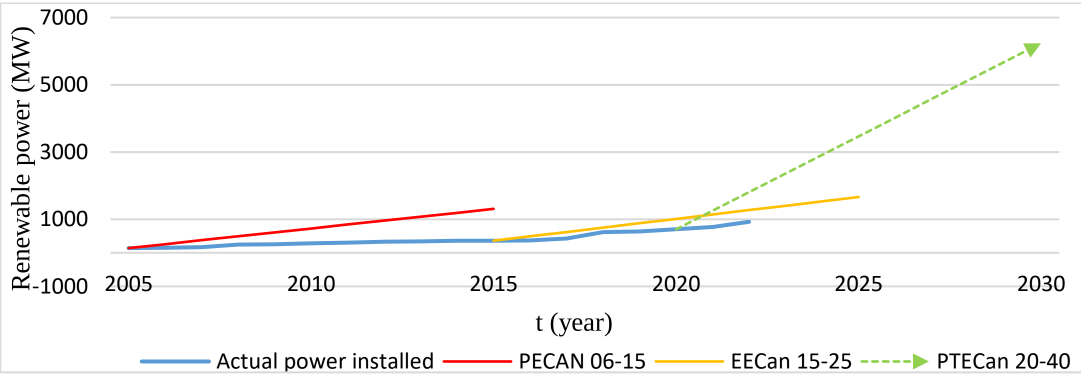

Fig. 1. Evolution of actual installed renewable power vs. planned power according to the established plans (PECAN 06-15; EECan 15-25 and PTECan 20-40)

4. Conclusions

A method is developed in this paper for the analysis of energy planning and its results, specifically in relation to the large-scale integration of renewable energies in electricity systems. The aim is to identify the possible regulatory barriers that may have influenced deviations from the established objectives and, therefore, the decarbonisation process of electricity systems. In this study, the method is applied to the case of the Canary Islands electricity systems. It is clear that there is a clear deviation between the planning and the energy reality of the islands' electricity systems. Despite the favourable conditions of the renewable resources existing in the Canary Islands, in general the objectives and deadlines set out in the successive energy plans drawn up to date have not been met with regard to the integration of renewable energies into the electricity systems. The root cause is the existence of regulatory barriers that slow down the attainment of the proposed objectives before the deadlines proposed in the energy plans. These regulatory barriers, especially those related to remuneration and governance in general, have a decisive influence on achieving the targets, drastically reducing the negative impact on them when the established regulatory framework is attractive and secure for investors and when exceptions are agreed for renewable installations to comply with environmental and urban planning regulations. For the case study, the decarbonisation objectives established in the planning for the year 2040 impose highly demanding rates of installation of renewable electric power, considerably above the current rates of growth. The method developed aims to be useful for the realization of more flexible and realistic energy planning, by the competent administrations, for any region or country, as well as for the design of an adequate regulatory framework, understood as one that is flexible, simple and secure and in which such planning can be developed without limitations. In future research work we intend to quantify, in a differentiated manner, the particular effect of each of the barriers, those related to land use planning, economic barriers, and those linked to logistics in the development and execution of projects, with the strategic objective of maximising the integration of renewable energies in electricity systems.

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References

[1] European Union, "Directive (EU) 2018/2001 of the European Parliament and of the Council, of 11 December 2018, on the promotion of the use of energy from renewable sources (recast)", Off J Eur Union 2018; 2018:82–209

[2] Spanish Government, "Plan Nacional Integrado de Energía y Clima 2023-2030 (PNIEC)", https://www.miteco.gob.es/es/energia/estrategia-normativa/pniec-23-30.html (accessed January 31, 2025).

[3] B. Shao, L Zhang and SAA. Shah, "Barriers and Opportunities in Implementing Carbon Neutrality Goals in China's Heavy Industries", Sustainability (Switzerland) (2025), 17 (2), art. no. 674, doi: 10.3390/su17020674

[4] L.C. Sim, K.E. Young, "What impedes solar energy deployment? New evidence from power developers in the Arab Gulf states", Energy for Sustainable Development (2025), 84, art. no. 101597, doi: 10.1016/j.esd.2024.101597

[5] A. Bessin, J. Serra-Adroer, N. Debonne and J. van Vliet, "Location determinants of industrial solar photovoltaics and onshore wind turbines in the EU", Renewable and Sustainable Energy Reviews (2025), 210, art. no. 115257, doi: 10.1016/j.rser.2024.115257

[6] M. Martín-Betancor, J. Osorio, A. Ruiz-García and I. Nuez "Evaluation of maritime spatial planning for offshore wind energy in the Canary Islands: A comparative analysis", Marine Policy (2024), 161, art. no. 106046, doi: 10.1016/j.marpol.2024.106046

[7] M. Martín-Betancor, J. Osorio, A. Ruíz-García and I. Nuez, "Technical-economic limitations of floating offshore wind energy generation in small isolated island power systems without energy storage: Case study in the Canary Islands" Energy Policy (2024), 188, art. no. 114056, doi: 10.1016/j.enpol.2024.114056

[8] Spanish Government, "Ley 17/2013 para la garantía del suministro e incremento de la competencia en los sistemas eléctricos insulares y extrapeninsulares", BOE núm. 260, de 30 de octubre de 2013, pp 87569- 87580, https://www.boe.es/eli/es/l/2013/10/29/17 (accessed January 30, 2025).

[9] Spanish electricity system operator (REE, by its initials in Spanish), "Evolución de la generación renovable y no renovable. Comunidad autónoma: Islas Canarias", https://www.ree.es/es/datos/generacion/evolucion renovable-no-renovable?start_date=2023-01-01T00:00&end_date=2024-12-31T23:59&time_trunc=year&geo_ids=8742&geo_trunc=electric_system&geo_limit=ccaa, (accessed January 30, 2025).

[10] Spanish electricity system operator (REE, by its initials in Spanish), "Generación renovable por tecnología (MWh). Comunidad autónoma: Islas Canarias", https://www.ree.es/es/datos/generacion/estructura-renovables?start_date=2023-01-01T00:00&end_date=2024-12-31T23:59&time_trunc=year&geo_ids=8742&geo_trunc=electric_system&geo_limit=ccaa, (accessed January 30, 2025).

[11] Canary Islands Government, "Observatorio energético de Canarias-planificación", https://www.gobiernodecanarias.org/energia/oecan/es/publicaciones/planificacion/, (accessed January 30, 2025).

[12] Canary Islands Government, "Observatorio energético de Canarias-anuarios", https://www.gobiernodecanarias.org/energia/oecan/es/publicaciones/anuarios/, (accessed January 30, 2025).