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Time Evolution of Renewable Energy Applications Social Acceptability. The Wind Energy Case in Decarbonization Areas

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Abstract: Energy transition policy towards zero carbon electricity generation by 2030/2050 in European as well in national level is based on increased exploitation of Renewable Energy Sources (RES) giving great importance to public opinion and public participation. Considering the above, it is important to analyze in detail the society's current view regarding the installation of additional RES applications in local level. Wind energy is one of the most mature technologies applied in order to decarbonize the electricity sector, while due to the size of the contemporary wind turbines they are always a subject for intense debate.

Moreover, social acceptability of wind parks has always been characterized by a dynamic relationship between local society and the corresponding applications. Actually, the general broad acceptance of RES varies widely when one considers public opinion locally in areas where RES projects have been or are going to be installed. In order to investigate the wind-based applications acceptance on an "objective" basis the Soft Energy Applications and Environmental Protection Laboratory of the University of West Attica recorded the time evolution of the public attitude during the last twenty years, since the first commercial wind energy applications are dated at late 90's. The results of the recent research have been statistically processed. At present, the resulting conclusions are not as positive as in the previous decade and highlight the need for additional information concerning the benefits arising from the operation of similar installations.

Keywords: Energy Transition, National Energy and Climate Plan, Wind Energy, Public Attitude.

1. Introduction

EU is implementing an ambitious energy transition policy towards zero carbon electricity generation by 2030/2050 based on increased exploitation of Renewable Energy Sources (RES) giving great importance to public opinion and public participation. The decarbonization pathways to a net-zero Europe are countless, but not all options are cost optimal. Despite the pathway adopted, EU emissions should be reduced by 55% by 2030. Taking into consideration that during the last five years the EU-27 countries emitted annually 3.4 to 3.9 Gt CO_2 (almost 7% of global greenhouse gas (GHG) emissions) the EU achieving climate neutrality will have a big impact on the global climate challenge. (D'Aprile P., et al, 2020) More precisely, in 2021, global emissions bounced back almost to the level of 2019 (the year before the COVID pandemic), reaching 37.9 Gt (0.36% lower than in 2019), while Europe reached almost 3.4 Gt. (International Energy Agency, 2023) Across sectors, fossil fuel combustion is the biggest source of GHGs, accounting for 80% of emissions.

Accordingly, in Greece GHG emissions decreased to 53.4 Mt in 2021 from 55.6Mt in 2020. (Trading Economics, 2023) The majority of GHG emissions (47.5%) in 2020 derived from energy industries, while the contribution of transport, manufacturing industries and construction and other sectors is estimated at 29.8%, 8.6% and 12.8% respectively. (Ministry of Environment and Energy, 2022)

The exploitation of RES potential is assumed as one of the main weapons against the forthcoming climate change. The policies and measures concerning the installation targets of RES according to the National Energy and Climate Plan (NECP) take into account social parameters in addition to technological and environmental ones. Considering the revised NECP targets, planning greater participation of RES in the national energy mix, it is important to analyze in detail the society's current view regarding the installation of additional RES applications.

Table 1. Initial and updated NECP targets: Net capacities in GW per energy form

NECP 2030 GW	Updated NECP 2030 GW	Updated NECP 2050 GW	Energy Form
7.7	14.1	34.5	Solar
7	2.7	17.3	Wind offshore
	7	10	Wind onshore
0.5	0.8	2.8	Other RES
3.9	4	4.7	Hydro
6.9	6.9	5.1	Gas Fired
0.3	0.7	0.2	Oil Fired
0.0	0.0	0.0	Solid Fuels

According to the statements of the Greek Minister of Environment and Energy in April 2023, the new Hellenic NECP will be available for public consultation after the preliminary notification has been made to the Commission. Actually, the presentation of the new NECP was officially made by the Minister of Energy and Environment in January 2023. In Table 1 we present the capacity (installed power) targets in GW per energy source of the aforementioned NECP (Hellenic Ministry of Environment and Energy, 2023)

2. Future Targets for Wind Energy Applications and their Land Requirements

During the last decade, Greece has shifted its electricity generation policy towards cleaner energy solutions, in view of the EU decision for electricity sector complete decarbonization by 2050. In view of this significant effort, during 2020 wind energy and photovoltaic contribution exceeds 30% of the national electricity consumption.

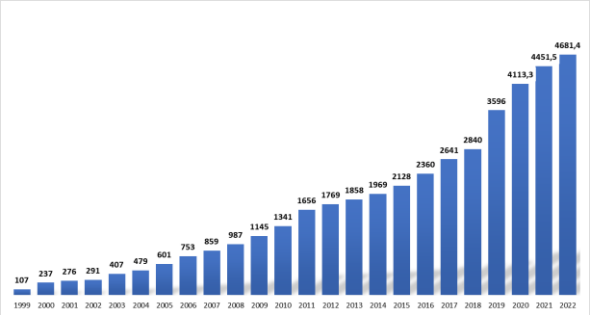

Figure 1. Installed (MW) Wind Power time evolution in Greece. Source HWEA, 2023

More specifically, in Figure (1) one may find the time evolution of the installed wind power since 1999, hence at the end of 2022 almost 4700 MW have been installed in mainland Greece and in the Greek islands. Using the most recent available official data the estimated green electricity contribution to the local economy annual consumption is slightly above 42%. This figure should be directly compared with the national target by the original NECP (2019) where minimum 61% RES participation in the annual national electricity consumption of 2030 has been scheduled, while according to the revised NECP more ambitious options have been planned, i.e. the expected RES contribution to approach 80%. At this point it is important to note that even for the implementation of the initial NECP the necessary wind power for 2030 should be higher than 7000 MW, while the corresponding total installed PV power should exceed 7600 MW. Based on the available expertise (Kaldellis J.K., 2022) the addition of 2.5 GW of new wind parks requires approximately 700 to 750 contemporary wind turbines (WTs) of 3 to 5 MW, to be added to the already existing 2800 commercial WTs installed in Greece during the last twenty years. Taking into account the typical dimensions of similar commercial machines, the minimum area required in order to create the necessary wind parks will be 100 km^2 at the minimum, i.e. almost the 0.8% of the total land of Greece. Moreover, taking into account the area occupied by the already existing 2800 (relatively smaller) WTs the total area affected by the implementation of the 7000 MW wind parks by 2030 will represent almost 1.8% of the total land of Greece, in case that all the wind capacity is going to be installed onshore. Adding the corresponding figures (including all the RES technologies) concerning the necessary land in order to implement the national targets of the initial NEPC, it is obvious that almost the 3% of our country land is required; hence a considerable part of local population, especially in the rural areas, will be affected by the forthcoming green transition. The situation will be much more challenging in case that the revised NECP will be realized.

Using the above preliminary estimations, one may clearly understand that during the next years the existence of wind parks will be dominant in rural and sub-urban Greece in comparison with the minimum existence twenty years ago. Actually, nowadays wind and PV installations are no more an alternative solution but they will be the mainstream of electricity generation. In this context, the public/social attitude of local citizens towards similar investments is going to play a dominant role for their successful implementation. Taking into consideration the dynamic relationship between local society and the corresponding electricity generation installations a systematic analysis of several public surveys concerning the public attitude towards similar applications has been carried out in the course of time, including long-term data by studies provided by the SEA & ENVIPRO Lab of UNIWA.

3. Presentation of Historical Data

Social acceptability of RES applications has always been characterized as a crucial issue strongly affecting the applicability of a real world application. Actually, on the basis of several published results, the general broad acceptance of RES varies widely when one considers public opinion locally in areas where RES projects have been or are going to be installed. In order to investigate the wind-based applications acceptance on an "objective" basis, a systematic analysis of several public surveys concerning the public attitude towards similar applications is carried out in the course of time. In this context, the same questionnaire is used by the researchers of SEA & ENVIPRO Lab, in order to investigate the time evolution of the public attitude during the last twenty years. Emphasis is given, on capturing the opinion towards the new wind farms. Actually, relative data have been collected from the late 1990s to the recent questionnaires of 2022, reaching a number of more than 2000 questionnaires. The relative questions to the subject investigated are summarized in Table 2, along with the possible answers, for the wind energy sector. Table 2 does not include the first two questions that were asked to ensure that respondents were familiar with the topic under consideration. (Kaldellis J.K., 2005)

One of the most important topics of the present study is the selection of the areas where the public survey should be realized. We prioritize our study in islands and decarbonization areas, as well as in areas where wind parks have been already installed. Our aim is to study the

public opinion over time as well as the impact of the legal framework changes on the installation procedure of new wind power projects. Moreover, we also analyze how the public information and the familiarity with these projects ultimately interact with the public opinion.

Table 2. Demonstration of the questionnaire used in the present public opinion survey

Questions	Possible Answers
Question 3 Do you actually agree with the installation of wind turbines in your territory?	A. YES, I do B. NO, I don't C. I would agree if only I had proof of their usefulness D. I am not interested in this matter E. I have no formed opinion
Question 4 In case of a new wind park installation in your territory:	A. I would not care B. I would react on this installation C. I might agree, after examining all available data D. I have no formed opinion E. I would happily agree, being aware of their effectiveness
Question 5 In case of a new wind park installation in your territory:	A. I would not wish to participate, even when it is financially profitable B. I would not wish to participate, as I hear it is financially unprofitable C. I would ask for further financial data regarding this project D. I would wish to participate at any rate, realizing all financial benefits E. I am not interested in this matter

As already mentioned, we have been systematically studying the social attitude towards RES (mainly wind energy applications) since the late 90s (Marouli Chr., Kaldellis J.K., 2001) (Kaldellis J.K., 2001). The areas that the present analysis is concentrated include the prefecture of Peloponnese and the one of West Macedonia as well as the islands of Greece, where the main decarbonization activities will be implemented.

4.1. Geographical distribution of public reaction towards Wind project (focus on decarbonization areas)

More precisely, for the prefecture of Peloponnese during the period September 2009 to June 2010, almost 400 questionnaires were collected. Accordingly, during the years 2017-2019, almost 40 questionnaires were also collected, belonging to a sample of 700 questionnaires concerning the decarbonization areas. For the prefecture of West Macedonia 380 questionnaires were collected, during the period September 2020 to June 2021. Finally, for the Greek islands more than 400 questionnaires collected during 2001-2004 may be compared with the almost 330 ones gathered fifteen years later.

Comparing the public opinion between 2010 and 2019 for the prefecture of Peloponnese, one should mention that the high positive attitude (61% positive & 23% positive under conditions) for the existing wind parks of 2010 has been substantial reduced recently to 32% positive and 35% positive under conditions. Note that during 2010 the existing wind parks in Peloponnese are less than 100 MW in comparison with almost 560 MW of 2019. For the question concerning the public acceptance of new wind farms one can see the increased with tine percentage of participants who need more information about the wind energy applications from 28% to 45%. For both questions (3) and (4) the negative opinion has remarkably increased. Finally, the percentage of local citizens who need more financial data in order to consider participating in new wind projects increased by 14% (60% in 2010 vs. 74% in 2019).

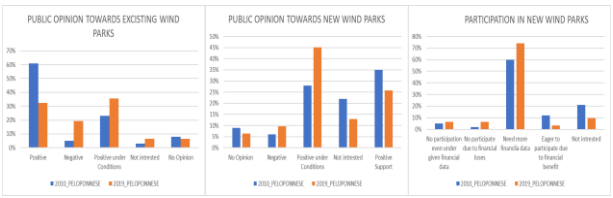

Figure 2. Public opinion towards wind parks in Peloponnese prefecture (2010 vs. 2019).

The case of West Macedonia prefecture is quite different than the one of Peloponnese, although both face the problem of fast decarbonization and the abandonment of the local lignite extraction. Actually, West Macedonia wind potential is quite lower than the one of Peloponnese, hence in the past the interest of building wind parks in the area was minimum. This is the main reason that one cannot find public surveys concerning the wind energy applications in the area before 2020. Currently the existing wind parks exceed the 450 MW.

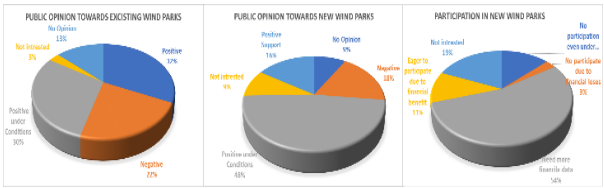

Figure 3. Public opinion towards wind parks in decarbonization prefecture of West Macedonia in 2021.

Using the first available data (2021) for the prefecture of West Macedonia, one can say that the acceptance percentage of existing wind farms (62%, i.e. 32% positive & 30% positive under conditions) is similar to the one of Peloponnese, Figure (3). For the development of new wind farms 64% of local people had a positive view (16% positive and 48% positive under conditions), while 54% of participants need more information to make a decision to participate in wind farms. Although in West Macedonia local population is more skeptical for the creation and the participation in new wind parks than

in Peloponnese, the general attitude is more or less similar. Finally, there is a remarkable minority not interested in participating to new wind parks, i.e. 32% for West Macedonia (19% not interested and 13% not even after getting new information about the projects) and 26% for Peloponnese (21% and 5% respectively).

The third case analyzed concerns the Greek islands, participating also in the EU decarbonization process. The more recent (2017) island sample consists of almost 150 citizens vs. more than 400 people during 2001-2004. Note that the first wind parks of Greece have been developed on Greek islands since late 80's, while during the last decade the installed wind power has been stagnated due to zero electrical space to develop new wind parks in the weak autonomous electrical networks (Kaldellis J.K., 2008). Despite the continuous positive attitude towards existing and new wind farms in most islands (between 2000 and 2017), the installed wind power in the islands is almost constant during the last ten years. One also may observe the respondents' need to learn more about the financial data (51% vs. 39% of responses) in order to decide for their participation in wind projects (Kaldellis J.K., Boulogiorgou D., 2022).

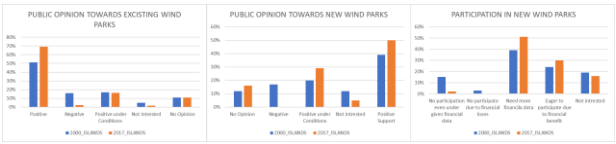

Figure 3. Public opinion towards wind parks in Greek islands between 2000 and 2017.

Using the current quantitative data, one may support that in the decarbonization areas the positive attitude towards wind energy applications is still alive. However, nowadays people are less eager (than in the past) and need more detailed information in order to welcome or even to participate in new wind projects in their area, despite their standard of living deterioration due to the shrinkage of fossil fuels-based economic activities.

4. Conclusions and Proposals

From the results of the questionnaires and comparisons selected and according to the data analyzed, the following conclusions arise:

• The results of the public opinion studies are not eternal and the conclusions drawn must be reviewed and measured at regular time intervals, taking into account the possible changes in the local society.

• Financial incentives alone are not sufficient to guarantee the participation of local society in the energy transition.

• The participation and familiarization of the local people with RES projects for the benefit of the local society must start immediately if we want to achieve the ever-increasing European and National goal.

• The time evolution of the wide acceptability of wind energy, even in the decarbonization areas, is gradually reduced and may hinder future efforts to substantial increase the RES (wind) share in the EU (and Greece) fuel mix.

Summarizing, the modern energy transition is a complex process that involves society more than any other transition. The acceptance of innovative technologies is not enough. Citizens' participation plays an important role with the main objective of changing their behavior and adopting standards of respect for the environment and behaviors related to the consumption and production of energy. Today, more than any other time, we have the opportunity as societies to actively participate in a just and clean energy transition.

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