19th International Conference on Environmental Science and Technology

Kos, Greece, 3 to 6 September 2025

Innovative Energy Projects and Policies for the Energy Transition of Small Greek Islands

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Abstract Many islands around the world, particularly Non-Interconnected Islands (NIIs), use oil products to meet their electricity needs. Several of these islands enjoy excellent renewable energy potential. This potential of NIIs encourages actions to maximize the integration of Renewable Energy Sources (RES) as part of the energy transition (ET) process. Furthermore, community-based renewable energy projects and equitable access to energy for citizens are critical issues on the global political agenda to support ET, especially at the local level. Sustainable ET for NIIs is a challenging task. Technological, economic, social, regulatory and environmental issues arise during the process. The issues of respecting the cultural heritage and natural beauty of the islands, addressing insularity and national security problems create a complex field. In addition, the decentralization of the electricity system constitutes the greatest technical challenge for islands' energy supply. The current research work examines innovative projects related to the ET of Greek small NIIs. A framework according to energy transition indicators is developed, in order to study the results at the local level. Using the experience obtained by the analysis presented, one may schedule and implement socially acceptable and successful ET projects in the context of the GR-eco islands initiative.

Keywords: Climate Change, Green House Gases, Social Acceptance, Renewable Energy Sources

1. Introduction

The decentralization of the electricity system constitutes the greatest technical challenge for small NIIs' energy supply (Kaldellis, 2008). Decentralization of the electricity system is an umbrella term referring to an increasingly demand-responsive, bi-directional, and equally-distributed power system (Kapsali et al., 2016). The results of all case studies examined validate the argument that financial and regulatory support enhance resilience only if they create value for the local economy. The acceptance by the local community and its participation in the operation of the projects creates added value for both the projects and the local community (Kaldellis and Boulogiorgou, 2022).

2. The Innovative Islands Projects Case Studies forming NIIs Energy Transition Indicators

In order to answer ET issues, it is essential to integrate solutions at all societal and institutional levels. Knowledge transfer, synergies and innovation, as part of Quadruple Helix (QH) model implementation, have a key role in the current ET of NIIs (Boulogiorgou and Ktenidis, 2019).

2.1 TILOS Project

Tilos is a small island (area 61.5 km^2), which geographically belongs to the Dodecanese island group with permanent population of 746 residents. Tilos has an annual energy demand of approximately 3000-3500 MWh with an annual average energy production cost of €1,000,000 (operating cost of the Kos-Kalymnos power plant) and a maximum power demand of 1 MW. The case of Tilos, a HORIZON 2020 project, examined as it is a characteristic and perhaps unique domestic example of a real green ET project on a small isolated island, where the planned energy solution implemented a series of innovative applications with significant technological success, while the project was completed exactly within the planned timeframe (2015-2019) (Kaldellis, 2021).

2.2 Chalki Energy Community

The island of Chalki is located in the SE Aegean Sea, SE of Tilos. The island's surface area is 28 km^2 and it has 475 permanent residents. The annual energy demand of Chalki for 2023 was approximately 2000 MWh with an annual average energy production cost of €573,000 and an average power demand of 1.2 MW (connected with Rhodos island power grid). The CHALKI – GREEN SMART ISLAND project was carried out within the framework of the GR-eco Island initiative. On 05/11/2021, Chalki became the first GR-eco island in Greece. In the summer of 2021, the energy community "ChalkiON" was created. The time of the establishment of "ChalkiON", (~6 months) indicates the importance of the projects synergy.

2.3 Agios Efstratios Project

Agios Efstratios is an island in the NE Aegean. The island has an area of 43.3 km^2 and 257 permanent residents. The island's autonomous electricity system is based on a conventional oil-based power plant with a total capacity of 0.84 MW. The island's annual electricity demand is 1200

MWh and the peak load is 0.35 MW. The island of Agios Efstratios was chosen to be studied because it is in fact completely isolated, on the one hand in terms of energy, since it is not connected to any other energy network, but also physically as it is located at a great distance from the other nearby islands and much larger than any major port. The second reason is that the project on the island of Agios Efstratios is characterized by successive delays and changes in the technical solution. An important and challengin part of the positive results of the project is that the management of the Hybrid Power Station is foreseen to be the responsibility of the Local Municipality.

2.4 Responsible Innovation through Quadruple Helix Model

From the study and evaluation of the innovative projects of the three (3) islands, it was recorded that the levels of CO_2 emissions reduction for each island range from 1200 to 1800 tons CO_2 / year. In order to categorize the results of the projects, eight indicators were developed by processing the data from the selected case studies. Table 1 presents a summary of the processing outcomes. The evaluation of the selected case studies aids in assessing the development of the ET in isolated areas.

Table 1. *Innovative small NIIs' Projects Case Studies*

ISLAND / INDICATOR	TILOS	CHALKI	AGIOS EFTRATIOS
FRAMEWORK	HORIZON	GR eco islands	National
FINANCE	European Research	Private Grants	National
INNOVATION INDEX	CEII INDEX	NO	NO
INNOVATION	Technological	Social	Procedural
STACKEHOLDERS	Government Academy, Industry, Society	Government, Industry, Society	Government, Industry
REGULATORY FRAMEWORK	Creation of new regulation	Regulatory problems identification	Delays in implementation
IMPLEMENTATION TIME	On time	Extremely Fast	Long delays - postponed
ELECTRIFICATION COVERAGE	>50%	>70%	>70%

The need for a holistic approach to energy transition issues and the need to adapt the legislative framework to local needs became evident. It was also observed that the framework for implementing projects plays a decisive role in their timely and successful implementation. Another important issue that emerged is the importance of the innovation process and the number of stakeholders involved in it (Boulogiorgou and Kaldellis, 2023). The projects implemented in a European framework have been completed on time (Tilos and Chalki). The funding, combined with research projects, helps to collect data and draw valid conclusions for the correct design and implementation of energy transition projects on small NIIs. The creation of QH synergies helps in the timely implementation, sustainability and development of the projects, with innovation playing an important role in this success. A typical example is the TILOS project.

Changing the attitude of the local community and accepting the precepts of the Just and Fair ET can be achieved mainly with examples that developed at the local level and projects that follow specific and defined procedures. QH synergies are the appropriate model for managing the interdisciplinarity required by the design and implementation of the innovative small NIIs' projects. In the development of interdisciplinary synergies, a new culture of cooperation is formed and the creation of a common code of communication between the sciences is facilitated (learning by doing). This process ensures the utilization of the potential of interdisciplinary teams, reducing delays caused by poor communication.

3. Conclusions

The current ET must actively involve citizens. Changing both the beliefs/attitude and the daily behavior of citizens in relation to energy production and consumption is crucial. It is important to also consider the way in which the innovative ET projects carried out on the NIIs. Policies should ensure knowledge transfer and establish innovative paradigms. This ensures the implementation of the innovative projects, mobilizing and motivating other NIIs to choose to implement such a project on their community. This approach will be very useful for the successful implementation of the GR-eco Islands initiative.

In any case, it is essential to analyze the way in which the projects are implemented as paradigms and to examine their adaptation to the local reality. In this way, reliable policy change suggestions are also produced for the successful implementation of the ET for small NIIs.

The research work was supported by the Hellenic Foundation for Research and Innovation (HFRI) under the 3rd Call for HFRI PhD Fellowships (Fellowship Number:6824).

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