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Energy Self-Sufficiency in Rural Areas; Case Study: North Euboea, Greece

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Abstract

The modern globalized civilization is sustained by interactions, trade, the transportation of goods, and energy. Energy self-sufficiency is crucial in rural and disaster-prone areas like North Euboea because dependence on external energy supplies can leave regions vulnerable to supply chain disruptions, price volatility, and geopolitical risks. In such isolated regions, energy independence ensures resilience in natural disasters and economic instability. The alternative to self-sufficiency often involves reliance on centralized energy systems, fossil fuels, or external imports, which may not always be reliable or sustainable. Therefore, in this study, we explore the possibility of an area having energy self-sufficiency. As a case study, we chose North Euboea in Greece, explicitly focusing on the Municipality of Mantoudi-Limni-Agia Anna. The analysis combines local land use patterns, energy needs for inhabitants, agriculture and water requirements. It is followed by exploring various renewable energy sources, including hydropower, biomass, solar, and wind. We considered the stochastic nature of renewable energy production and the challenges associated with energy storage. The findings suggest that while wind turbines and solar panels could be installed in the area and contribute significantly to energy needs, achieving complete self-sufficiency requires careful planning, particularly regarding energy storage and the social acceptance of these installations. The results highlight the need for a holistic approach that integrates environmental, landscape, societal, and technical considerations in designing and implementing renewable energy systems. Additionally, it is highlighted that the available renewable energy from forest biomass (before the 2021 megafire event) could reliably and adequately meet the area's energy needs without requiring investments in photovoltaic parks and wind turbines and without competing with the use of agricultural land.

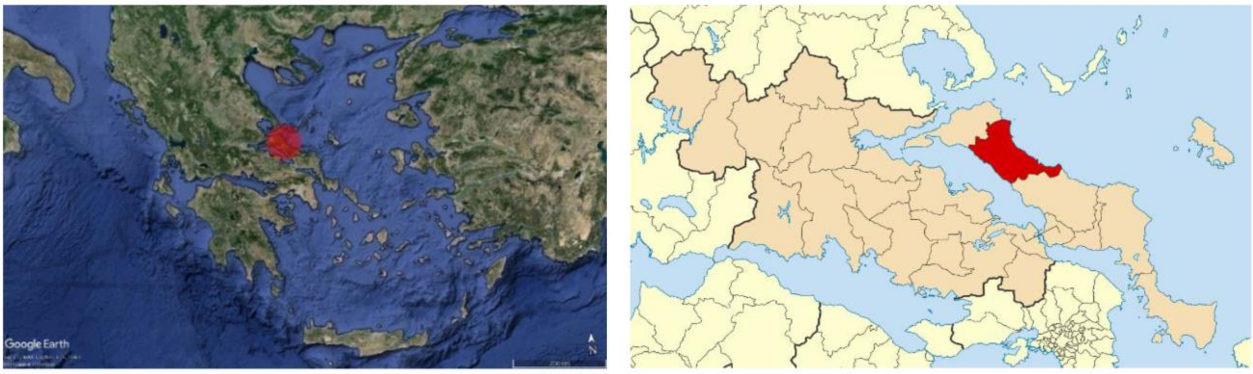
Keywords
Water-energy-food nexus; renewable energy storage; self-sufficiency; social prosperity; human progress

1. Introduction

The balanced function of the water-energy-food nexus is fundamental to societies. Previous studies have argued that the abundance of resources within the nexus is correlated with the life expectancy and quality of life of the inhabitants [1, 2]. Therefore, the social structure becomes destabilized even if one of the nexus elements is limited [3, 4].

Exploring the possibilities of self-sufficiency of energy and water sources we focused on a relevant case study on the region of North Euboea [5], we have collected data that, however, contain uncertainties due their stochasticity and complexity; therefore, the results are presented as an order of magnitude.

The study area is the Municipality of Mantoudi-Limni-Agia Anna (585.39 km^2). It has been chosen since in recent years, it has experienced successive natural disasters such as the expansion of a plane tree disease [6] (2017-present), storm Zorbas (2018), the wildfire of 2021 [7] and lastly the storms Daniel-Elias [8]. The municipality consists of 48 settlements, and according to the 2021 census, it has a population of 12,235 inhabitants. It can be characterized as a typical rural area, and with the highest land coverage being the pine-tree forest (Figure 1).



(a) (b)

Figure 1 (a) North Euboea [9]; (b) Municipality of Mantoudi-Limni-Agia Anna.

2. Methodology

For the study of the area, land uses in the Municipality of Mantoudi-Limni-Agia Anna were first analyzed. These land uses were categorized by detailed observations using Google Earth imagery (Figure 2, Figure 3), and on-site inspections (Figure 4): high-intensity agriculture, low-intensity agriculture, arboriculture (mainly olive trees), forests, and other uses.

Figure 2 Municipality of Mantoudi-Limni-Agia Anna and cultivated land.

(a) (b)

Figure 3 (a) Zoom window of the study area [8]; (b) The view within the zoomed window, used for the inspection of land uses [8].

Figure 4 Land uses in North Euboea. (a) Cultivations, olive trees, and burned forest; (b) pine tree forest unaffected by wildfires.

From the above analysis, Table 1 summarizes the results on the land-use analysis in the Municipality of Mantoudi-Limni-Agia Anna.

Table 1 Distribution of land use and energy needed per hectare cultivation.

	High-intensity agriculture	**Low-intensity agriculture**	**Olive trees**	**Forests**
Area (ha)	2,645	3,821	2,874	48,510
Percentage of land use (%)	4.6	6.6	5.0	83.9
Energy for cultivation (GJ/ha)	45.5	20	10	
Water needs m^3/ha	6000	2000		
Energy for pumping water from 50 m (GJ/ha)	3.9	1.3		
Energy for desalination and pumping to 100 m (GJ/ha)	108 + 7.8 = 115.8	36 + 2.6 = 38.6		

The total cultivated area today is estimated as 9,341.5 ha, and the forest area is estimated as 48,510 ha. The energy needs of high-intensity crops are 45,500 MJ/ha [10], and the estimated energy needs for low-intensity crops are 20,000 MJ/ha and 10,000 MJ/ha for olive trees.

As the primary water source of the area for irrigation is groundwater, additional energy needs arise for the pumping required for its extraction. Considering an average aquifer depth of 50 m, the irrigation needs for high-intensity crops are 6,000 m^3/ha, the estimation for low-intensity crops is 2,000 m^3/ha, and for olive trees, no water needs are considered [11] (Table 1, Figure 5a).

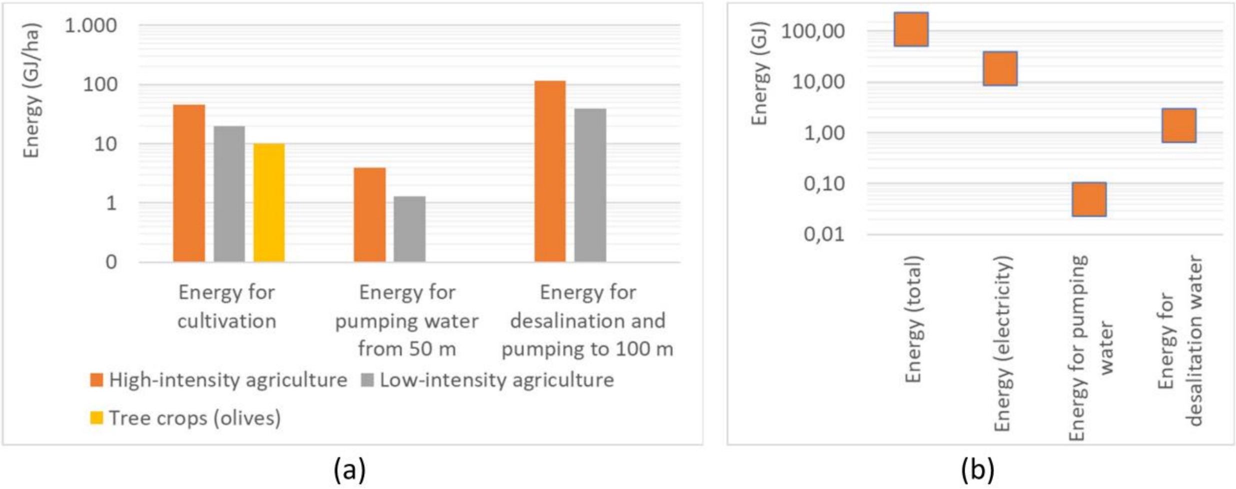


Figure 5 (a) Energy needs for cultivation; (b) Energy needs for inhabitants (per capita).

The energy needs of an average Greek capita are 30,000 kWh/year (108 GJ/year) [12]. The 5,020 kWh/year (1/6 of total energy needs) are estimated as electricity needs [13].

In the context of water resources engineering studies, the average water needs of a Greek citizen are commonly estimated at 200 L/day, or 73 m^3/year [14].

- The energy for pumping 73 m^3 from an aquifer 50 m is 0.05 GJ.
- The energy for desalination (5 kWh/m^3 [15] and pumping to 100 m are 1.41 GJ (Figure 5b).

At present, the energy needs for 12,235 inhabitants and all the arable land are:

- For inhabitants' electricity: 216,000 GJ.
- For inhabitants' electricity, transportation, heat, pumping water: 1,318,210 GJ.
- For inhabitants' electricity, transportation, heat, desalinated water: 1,334,802 GJ.
  - For inhabitants (all the above) and agriculture with pumping water: 2,036,530 GJ.
  - For inhabitants (all the above) and agriculture irrigated with desalinated water: 2,480,400 GJ.

In order to investigate the potential self-sufficiency of the energy needs for the area and to analyze the competition between land uses and energy, we converted the available energy sources of the area to potential energy generation. The available resources include water that can be utilized through various setups of hydropower works, biomass (forest, pruning of olive trees, energy crops for biofuels), solar radiation extracted by Photovoltaic (PV) works, and wind power extracted by turbines. In each case, the calculations were made for the annual energy production in the study area in GJ.

The energy from different renewable sources is calculated using local climate data and established energy conversion factors. Wind and solar power are used as direct electricity generation sources and to charge batteries, while biomass is used for heat and power generation based on the availability of energy demand and store.

Then, we analyzed the stochastic-intermittent dynamics of wind and solar energy sources and addressed the challenge of storing electricity to stabilize energy availability. Furthermore, we presented the energy needs in detail, corresponding to the available energy sources, to investigate the area's potential for energy self-sufficiency and sustainability.

It is also noted that the calculation of energy from different sources can be also related with various uses [16-18]. Some are connected with the direct extraction of energy for the needs of local inhabitants, while others require that electricity is first generated and then utilized. For example, in the case of bioenergy, stoves are used for heating through the direct generation of thermal energy and by consuming biomass. In contrast, energy converters are required to convert biomass into electricity if air conditioners (A/C) are used for heating. However, in order of magnitude, the available resources can indicate whether the existing needs are met.

Additionally, although the energy system is considered self-contained, necessary equipment will be needed, such as wind turbines, PVs, and other advanced technologies and, in order to be created, would require embodied energy. According to different scenarios, if advanced technologies will be imported into the area, energy flows (their embodied energy) will be also imported from other regions and can influence the energy balance and self-sufficiency calculations. These external inputs may lead to a reliance on non-local resources, which contradicts the concept of a closed-loop system and could skew the energy balance. However, these energy technologies, or other future alternatives, seem to be necessary inputs to the system for long-term sustainability.

3. The Energy Sources

3.1 Water

The two rivers, Nileas and Kireas, which flow into Voudouros, have a combined discharge of approximately 1 cubic meter per second during the summer months (July and August), based on in situ measurements. The average discharge of each river is estimated at around 1.5 m^3/s, with a range between 0.5 and 10 m^3/s. In the last 10 km before reaching the sea, the average slope of the rivers is approximately 0.4% for both Nileas and Kireas. Field research indicates that no significant declines of the land relief could be utilized for electricity generation (Figure 6a).

Figure 6 (a) The rivers of the area. Nileas and Kireas; (b) The river Nileas.

Before their confluence with Voudouros, the riverbeds have a depth of approximately 3-4 meters below the surrounding terrain (Figure 6b). In our scenario for energy generation from hydropower, we chose sequential water gates with a height of about 1.5 meters, which would open during flood periods and shut-down when no flood events are expected; these gates would raise the water and direct it to a drop height of 1.5 meters. In case the gates are being closed, the riverbed that would be flooded behind each gate would have a length of approximately 375 meters. Given that the average discharge of the rivers is 1.5 m^3/s, according to the area's topography and along the rivers' flow, ten units could be installed at the mouth of the Nileas (before its confluence with Voudouros). Additionally, another five units could be installed at the mouth of the Kireas (before its confluence with Voudouros).

Estimating the average discharge at 1.5 m^3/s, a small hydroelectric unit of 15 kW [19] could produce 131,400 kWh or 473 GJ per year. The 15 units would generate a total of 7,095 GJ/year, which, however, is very low, out of the needs' scale, and we will not contain it in the evaluation. However, as these infrastructures could protect the riverbed from further erosion by flood events [8], could be analyzed in further research. Hydropower works also benefit from the additional advantage over wind and solar energy works in that the public much more positively perceives their infrastructure in a landscape quality context [20].

3.2 Biomass

3.2.1 Forest and Olive Trees

With the exception of a small portion of biomass used in stoves or fireplaces, the region's biomass is not exploited in any other systematic way for energy.

Today, the available annual biomass from forests older than 20 years is estimated solely from the non-burned forest areas and ranges from 855,000 to 977,000 GJ [21]. Additionally, olive trees, more than 10 years old, could produce approximately 10,000 kg/ha of biomass each year from pruning and olive wastes, meaning that the olive trees in the area could generate 517,381 GJ.

The total available biomass from both the forest and the olive trees is estimated at 1,495,353 GJ and can be converted into electricity with proper scaling machinery units [22, 23].

3.2.2 Biofuels from Energy Crops

There are some energy crops (mainly sunflowers) in the area, but no biofuels are produced. Biofuels are considered a renewable resource that can contribute to regions' energy self-sufficiency [24, 25].

The region's climate is favorable for the cultivation of rapeseed [26], sunflower [27], and winter oats [28] for biofuel production, with their irrigation needs depending on the rainfall and climate of the area, as well as the energy they can produce. Rapeseed primarily relies on rainfall during winter, with minimal irrigation needed in the summer. Sunflower requires more water in the summer, especially during flowering and seed formation. At the same time, winter oats are drought-resistant and can be cultivated with minimal water, mainly during the establishment period.

Energy production ranges from 64 to 140 GJ/ha [29], and for our scenario of energy generation from biomass, we consider an average value of 100 GJ/ha.

3.3 Wind and Sun

3.3.1 Data Source

Figure 7 shows the daily averages of solar insolation (Wh/m^2) extracted from solar radiation (W/m^2) falling annually in the study area and wind speed (m/s) at the height of 8 meters, both acquired from the meteorological station located at the village of Agia Anna (latitude = 38.86 degrees, longitude = 23.40 degrees, altitude = 303 m). The Laboratory of Agricultural Hydraulics, University of Patras, manages the meteorological station.

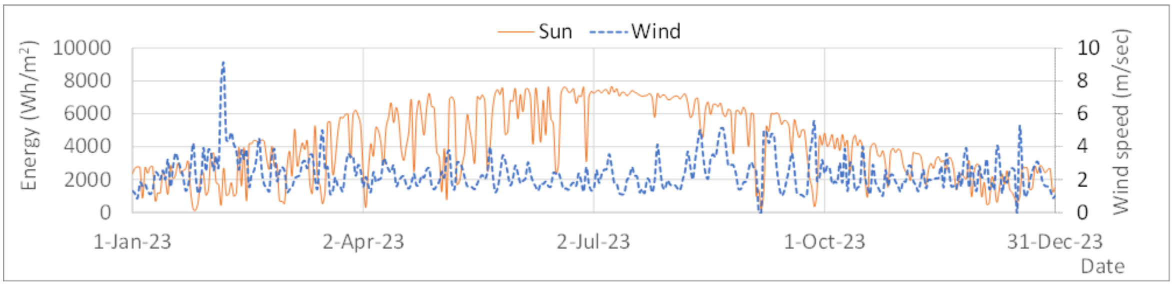
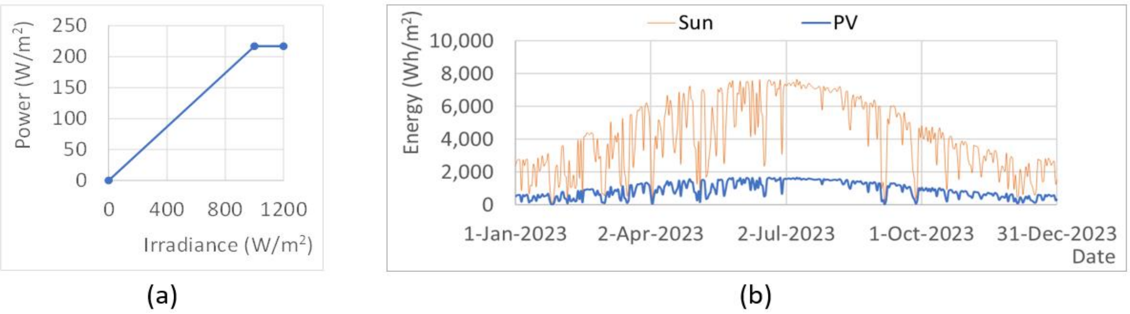


Figure 7 Solar insolation and wind speed (daily average) in the study area in 2023.

3.3.2 Photovoltaic Panels

Total annual energy from the sun (2023) was about 1,534 kWh/m^{2,} 5.52 GJ/m^2.

The efficiency of Photovoltaic panels (PV) also depends on the intensity of sunlight that strikes them [30]. Figure 8a shows a simplified efficiency curve. By correlating it with the climatic data of sunlight, the energy production curves for 2023 are obtained in Figure 8b.



(a) (b)

Figure 8 (a) PV efficiency curve; (b) PV energy production correlated with solar radiation (daily average).

Figure 9 presents the stochastic dynamic and the diurnal periodicity of PVs' energy production, noting the energy production at the sun solstices of the year.

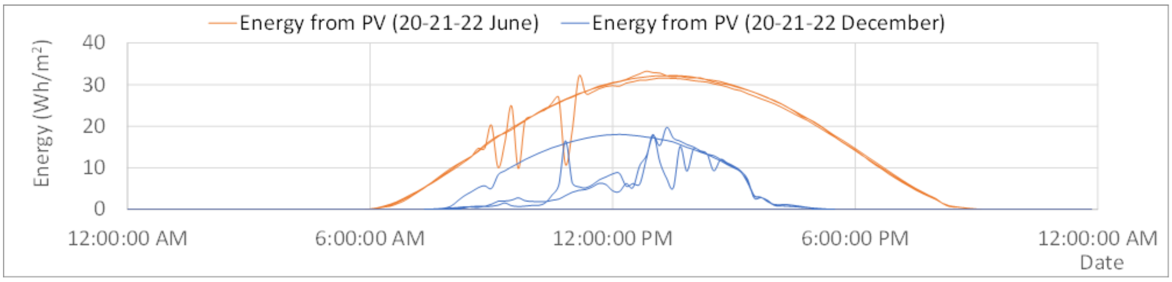


Figure 9 Energy from the sun close to the winter solstice and close to the summer solstice (2023) (ten-minute intervals).

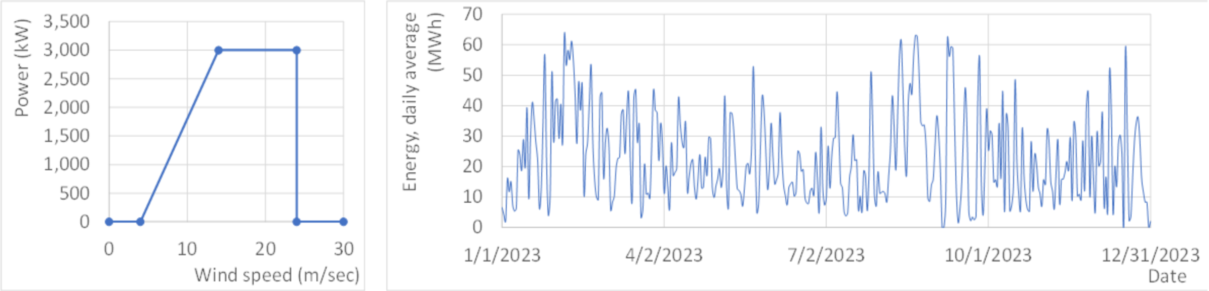
The photovoltaic panels' annual energy (2023) will be 332 kWh/m^2 or 1.19 GJ/m^2, which equals 3,305 MWh/ha or 11,900 GJ/ha. Due to orientation, terrain, and other construction parameters (Figure 10), approximately 50% of the surface area is typically covered with photovoltaic panels. Therefore, one hectare of land would produce annually 1,652 MWh/ha or 5,950 GJ/ha.


(a)
(b)

Figure 10 PV parks in North Euboea.

3.3.3 Wind Turbines

A simplified efficiency curve [31] of a typical wind turbine installed in Greece, with a nominal capacity of 3 MW is presented in Figure 11a. By correlating it with the wind's climatic data, the energy production curve for 2023 is shown in Figure 11b.



(a)
(b)

Figure 11 (a) Wind turbine efficiency curve; (b) Wind turbine energy production correlated with wind speed (daily average).

The stochastic dynamic and diurnal periodicity of wind turbine’s energy production is presented in Figure 12, where we note the wind energy production in the sun solstices of the year.

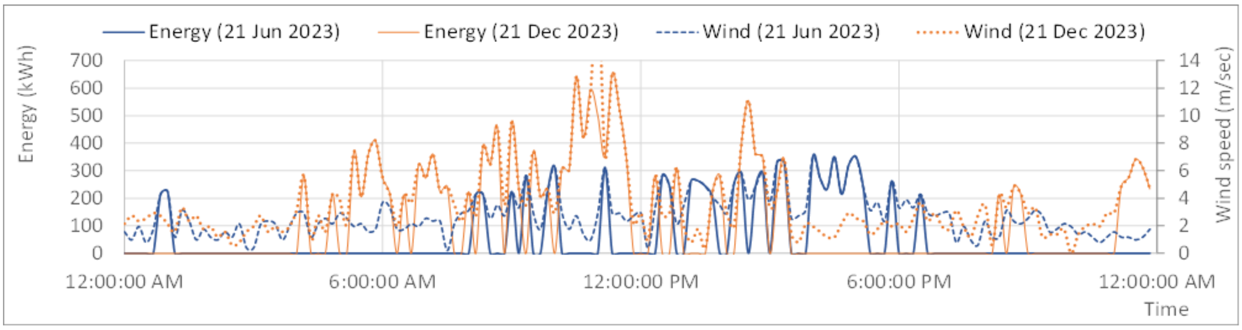


Figure 12 Wind turbine daily energy production in winter solstice and summer solstice (2023) (ten-minute intervals).

The annual stochastic energy (2023) from wind turbine 3 MW will be 8,359 MWh or 30,095 GJ.

3.3.4 Investigating the Stochastic Dynamic of PV and Wind Turbine

Figure 8 and Figure 11 present the potential energy production in 2023 by PV and wind turbines, which, to be useful, must be regulated (e.g., by a set of batteries).

To describe the battery's function, we create a model, considering that we have a battery and that energy consumption is dependent on the availability of the energy storage (even though the consumption is also considered a stochastic process). In this way, the system becomes more stable, increasing its capacity and avoiding collapses. The process is described in equations 1 and 2 [32-35].

$$\underline{S}_T = \max\big(0, \min(K, \underline{S}_{T-1} + \underline{x}_T - \underline{R}_T\big) \tag{1}$$

$$\underline{R}_T = a\underline{S}_{T-1} \tag{2}$$

where T is time; $\underline{S}_T$ is the stock in the battery; $\underline{x}_T$ is the inflow of energy; $\underline{R}_T$ is the discharge considered proportional to the stock; *a* is a constant determining the release; and *K* is the storage capacity.

Given that energy storage is a critical issue, there are generally two technical solutions with varying costs:

1. Lithium-Ion Batteries: The cost typically ranges from €200,000 to €400,000 for 1 MWh.
2. Pumped Hydro Storage: The cost ranges from €150,000 to €300,000 for 1 MWh.

PV produces 1,652 MWh/ha annually or 5,994 GJ per hectare and costs about 500,000 €/ha.

- With a storage capacity of 2 MWh for a daily regulation, the system would provide 751 MWh, and the non-used energy would be 911 MWh (Figure 13).

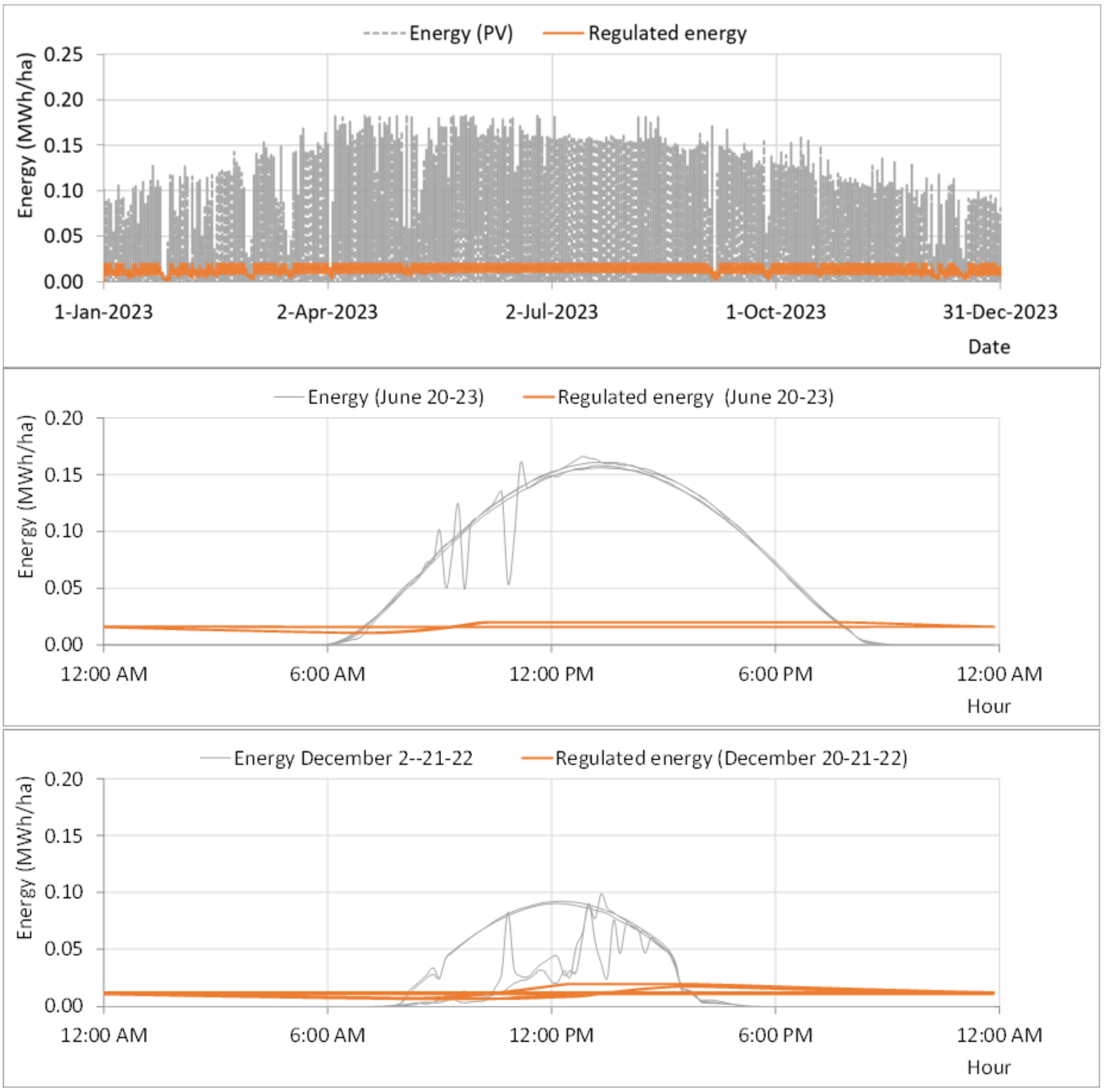


Figure 13 Energy from photovoltaics per hectare, daily regulation with 2 MWh/ha (10 min intervals).

- With a storage capacity of 20 MWh, the system would provide 714 MWh for weekly regulation, and the non-used energy would be 947 MWh (Figure 14).

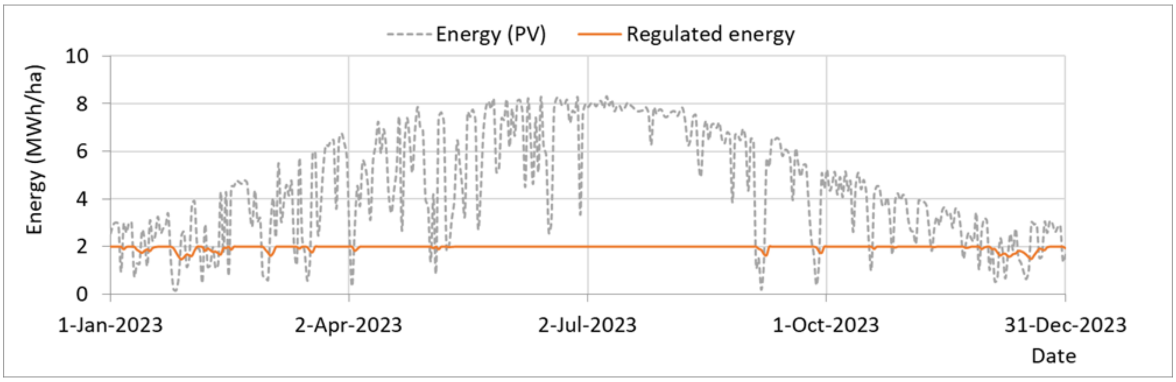


Figure 14 Energy from photovoltaics per hectare, storage system with weekly regulation of 20 MWh/ha (daily intervals).

- With a storage capacity of 200 MWh, the system would provide 1020 MWh for monthly regulation, and the non-used energy would be 667 MWh (Figure 15).

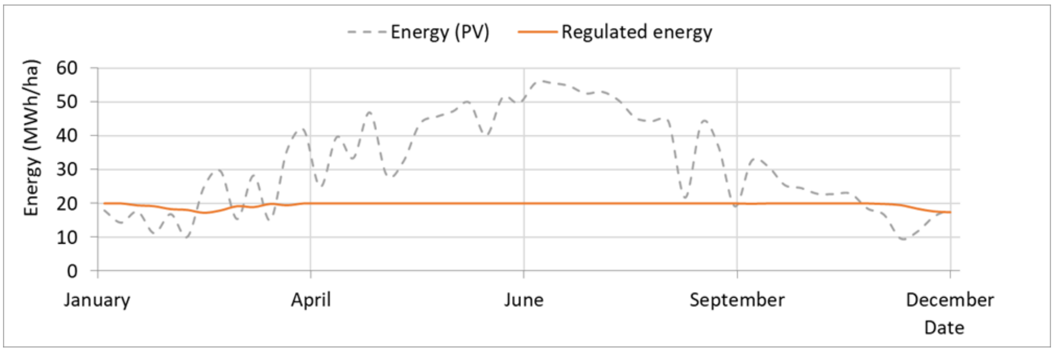


Figure 15 Energy from photovoltaics per hectare, storage system, and weekly regulation with 200 MWh/ha (weekly intervals).

It is noted that 1 wind turbine of 3 MW can produce annually 8,359 MWh and costs about 4-6 million €.

- With a storage capacity of 6 MWh for a daily regulation, one wind turbine would provide 4,581 MWh, and the non-used energy would be 3,775 MWh (Figure 16).

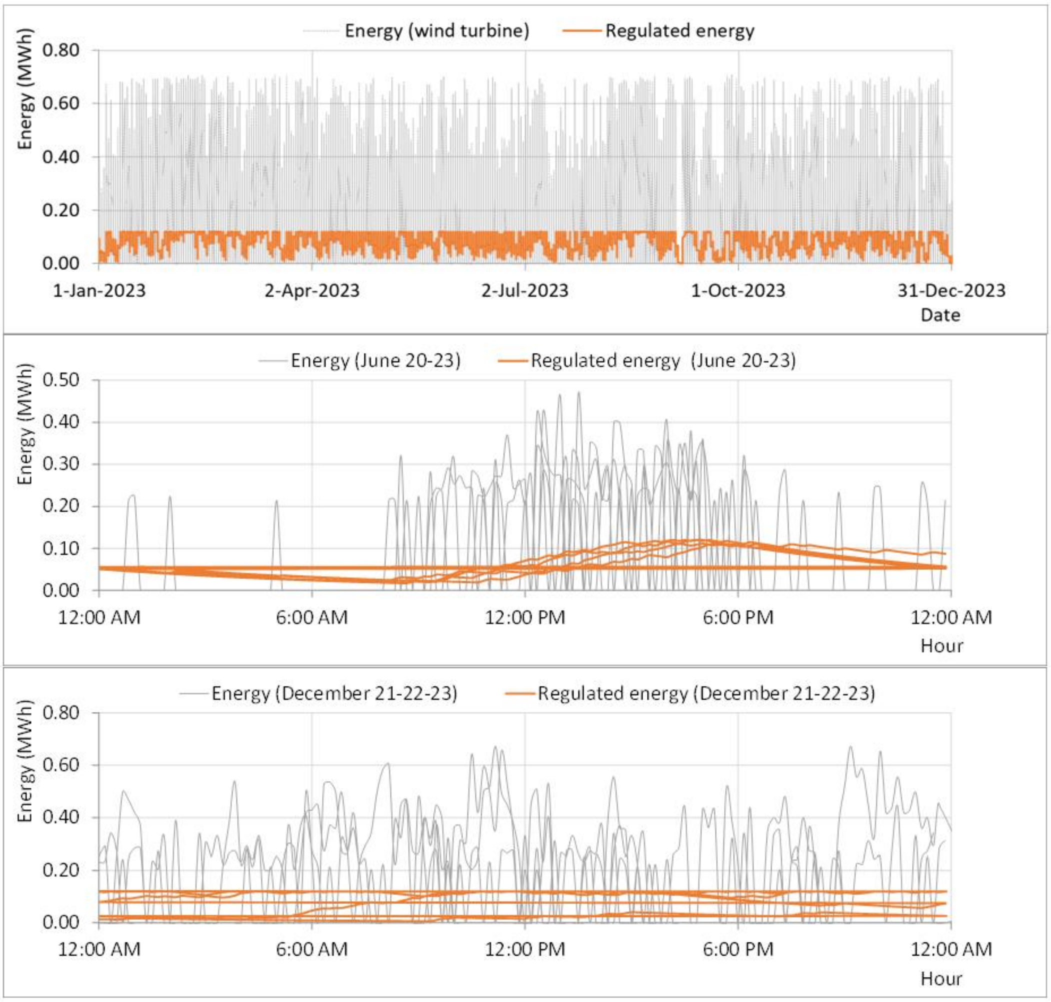


Figure 16 Energy from one wind turbine, daily regulation with 6 MWh (10 min intervals).

- With a storage capacity of 60 MWh, the system would provide 4,205.70 MWh for weekly regulation, and the non-used energy would be 4,138.48 MWh (Figure 17).

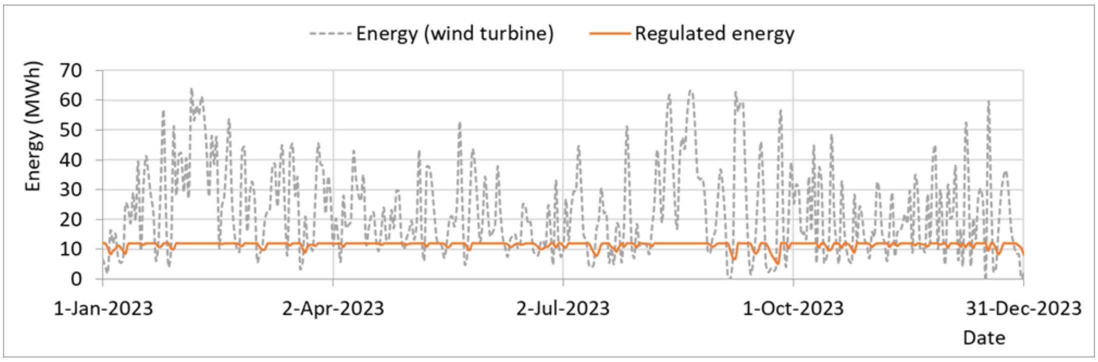


Figure 17 Energy from one wind turbine, weekly regulation with 60 MWh/ha (daily intervals).

- With a storage capacity of 600 MWh, the system would provide 6,185 MWh for weekly regulation, and the non-used energy would be 2,236 MWh (Figure 18).

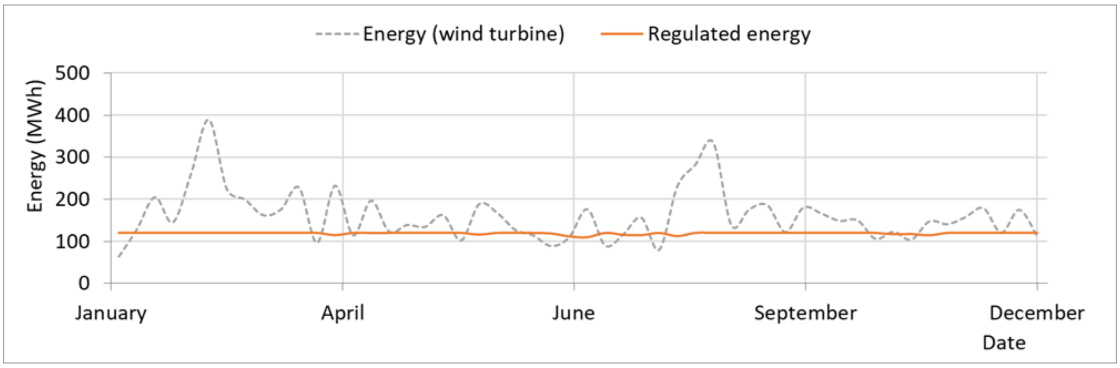


Figure 18 Energy from one wind turbine, monthly regulation with 600 MWh/ha (weekly intervals).

At present, the only economically, affordable energy regulation can be made by the smaller examples of batteries (Figure 13, Figure 16), which would double the investment in renewable energy installations. In this case, we can have a daily regulation, but we cannot remove the stochastic dynamic of energy production. However, we can consider that annually:

- PV can provide useful energy with daily regulation of 751 MWh or 2,705 GJ per hectare.
- One wind turbine (3 MW) can give energy with a daily regulation of 4,580 MWh or 16,500 GJ.
  - per 0.05 hectares (base of wind turbine).
  - per 50 hectares (required space for the spacing of installed wind turbine).

Assuming that 20% of the municipality (57,852 ha) has a suitable area and orientation for the installation of wind turbines (about 11,500 ha), 230 wind turbines could be installed.

Public acceptance of renewable energy installations plays a critical role in the success of such projects. For instance, local opposition to wind turbines [36] or photovoltaic panels [37] often arises from concerns over landscape aesthetics [38, 39]. Presently, there are many voices of social opposition in the case study area for new renewable energy installations.

Therefore, a holistic approach should be pursued for the design of renewable energy systems, including additional environmental, landscape-related and societal considerations. In particular, landscape-impact considerations should be considered primarily for wind turbines but also for solar photovoltaic works, since they have been identified as major origins of opposition movements during the last two decades [40]. Advanced planning methods based on visibility analyses have been developed to mitigate those impacts [41] and the public's participation has also been identified as a critical consideration to advance scientific understandings of public perception of landscapes [42]. Similar approaches should also be followed for other aspects of the design and planning of the proposed energy works to facilitate the multifaceted integration of the projects in the study area.

4. Results

In Figure 19, the energy needs for the inhabitants, agriculture, and desalinated water for irrigation are plotted in red color. Figure 19 also shows the area used for the analyzed energy sources, such as biomass (olive trees, energy crops for biofuels, forest) and PV per hectare. The biomass for non-burned forest is indicated with a green line, and the potential biomass from all the forest is indicated with a green dotted line.

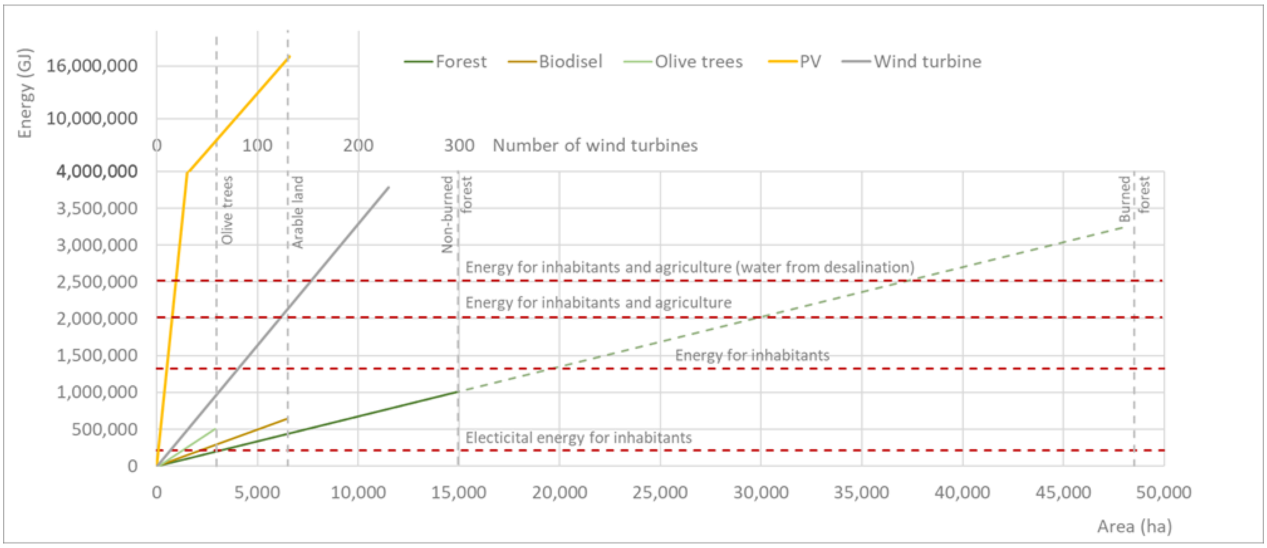


Figure 19 Energy needs and availability of energy sources in the municipality.

The energy produced by wind turbines is considered the sum of the installed wind turbines, which are plotted on the secondary horizontal axis.

Economically, desalination is expensive due to the installation of proper infrastructures and high energy demand. Considering the self-sufficiency of the case study area, where energy needs are already high, desalination would also need the construction of accompanying energy infrastructure projects, highlighting the need for careful investment consideration.

5. Discussion-Conclusions

The implemented research approach, dealing with energy sufficiency as part of the water-energy-food nexus, highlights the importance of integrating environmental, societal, landscape and technical factors in designing resilient energy systems for rural areas.

The analysis of the energy needs of a Greek disaster-struck community on the Island of Euboea supports the investigation of various potential directions to cover the energy needs of approximately 10,000 residents of the study area, which is predominantly rural with around 10,000 ha of land cultivated. The cultivated land is surrounded by a forest of about 50,000 ha, which was extensively burned, in an estimated 72% of the area in 2021.

To conduct the analysis, we surveyed the area, used average energy usage and consumption information from Greece, and incorporated data from previous regional studies.

Although the case study area is a typical rural area, we found that the domestic needs of the usual residents are the primary drivers of energy demand rather than agricultural activities, which are often blamed for high energy consumption.

Assuming all the water is pumped from an underground aquifer approximately 50 meters below the surface, we estimated the energy required for this extraction, which was negligible compared to the total energy needs.

Similarly, we calculated the energy requirements if the water for drinking and irrigation originated from desalination. It turned out that the energy needs for domestic water supply would be very small compared to the total energy consumption of the average resident (about 1%) while using desalinated water for irrigation would increase overall energy needs by 20%.

Biomass from olive tree pruning, olive oil production wastes, and forest residues is a renewable natural resource that could be used for energy production. It is reliable, and if the forest had not been burned, it would have the potential to cover all energy needs. At present, only the energy for the inhabitants can be marginally covered. However, this is expected to change as the forest grows back to its original form.

Energy crops (like rapeseed, sunflower seeds, and winter oats) would not be enough to produce biofuel to meet even a portion of the residents' needs and would require all the available arable land, which could come in conflict with local agricultural priorities.

The interaction between biomass production and water usage is significant. The biomass from olive trees and forests will not change water use. Still, large-scale cultivation for biofuels, especially crops like sunflower or rapeseed (as they do not need irrigation in the climate of North Euboea), can release stress on local water resources. Moreover, using PVs in energy-intensive infrastructure, such as in desalination plants, increases the demand for energy and materials, highlighting the need to optimize energy systems to reduce overall environmental impact. It also noted that another scenario that would help dealing with the intermittent behaviour of solar and wind energy generation would be the utilization of bioenergy exclusively for peak energy demand. However, given the stresses already present in terms of crops and agriculture, our study focused on the role of hydropower (conventional or pumped storage) and batteries in this regard. Although energy production from wind turbines and photovoltaics is noteworthy, their stochastic nature (i.e., double periodic, marginal, and long-term persistent behaviours) demands significant investments in energy storage projects to stabilize the system.

With double the estimated installations' investment for wind and solar energy in energy storage, daily regulation could be achieved by also making the generated energy, which exhibits a stochastic nature, more of practical use.

Specifically, the results include:

- The residents' energy needs could be met with 81 wind turbines, the energy needs for agriculture with 48 wind turbines, and the energy for desalinating water for drinking and irrigation with 27 wind turbines.
- The residents' energy needs could also be met with 600 ha of photovoltaics, the energy needs for agriculture with 300 ha, and the energy for desalinating water for both drinking and irrigation with 200 ha.

Further research could explore ways of using the non-used energy by PV and wind turbines, as for example, by:

- Estimating a reservoir's storage capacity to efficiently store the desalinated water.
- Exploring the possibility of producing energy-intensive fertilizers, which account for 80% of the energy required in agriculture.

In this way, desalinated water or fertilizers could be a battery that stores energy in an alternative form.

Further research could also give valuable results since the energy produced by all the above sources is electrical, and so, these solutions could also require technological adaptation (electric cars, electric tractors, and the replacement of all tools with electric power tools). In all the above (PV, wind turbine) new tools, life expectancy and time needed to depreciate the investment cost should also be estimated. The embodied energy of constructing and installing the PV and wind turbines could also be included in the calculations for a more general approach. This energy should then be assessed to determine when and if it is offset or gradually subtracted by the valuable productive energy over its lifespan.

The broader area of the Municipality of Mantoudi-Limni-Agia Anna covers 57,852 ha and has a population density of 0.2 inhabitants per hectare. By comparison, an urban area of similar size, such as the Athens basin with an area of 34,500 ha, has a population density of 104.5 inhabitants per hectare [43] (Figure 20).

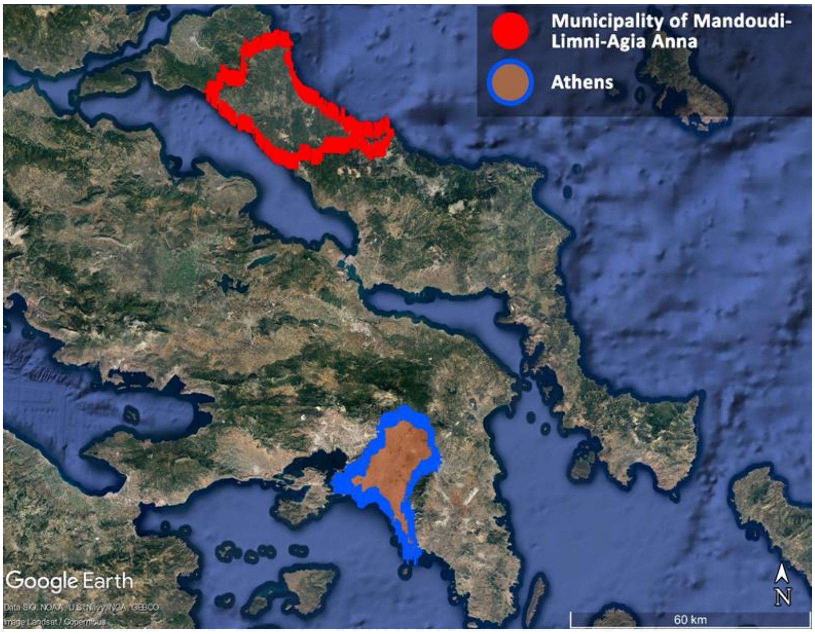


Figure 20 Municipality of Mandoudi-Limni-Agia Anna and Athens.

The fact that significant infrastructure (wind turbines and PVs) and a substantial technological overhaul of society are required to meet the energy needs of just around 10,000 residents in an area like North Euboea, highlights the vulnerability (especially by energy transition), which becomes higher in cities of developed countries [44].

Considering a roadmap for achieving energy self-sufficiency, the following steps must be taken: (1) Encourage public participation in energy planning to support self-sufficiency and thus, increase social acceptance [45, 46]; (2) Prioritize social cohesion, by placing care in identifying if there is local opposition and particularly so, if it is expressed through public administration bodies, projects should be stopped; (3) Utilization of available resources for funding schemes and relevant research (both academic and administration oriented) to assess the cost-benefit analysis and the overall environmental evaluation of the involved infrastructures; (4) Promotion of research for the investigation of the optimum energy mix; (5) Promotion of research into efficient biomass cultivation and forest management according to the local conditions; (6) Providing subsidies or financial incentives for the efficient technological adaptation (for production and consumption); (7) Providing subsidies or financial incentives for energy storage systems; and (8) Developing regulatory frameworks that prioritize energy resilience and sustainability for rural communities.

Author Contributions

Conceptualization G.F.S.; methodology G.F.S.; validation G.F.S., O.L., N.M.; formal analysis, G.F.S., R.I., P.D.; investigation, G.F.S., M.K.; data curation, G.F.S., N.M.; writing-original draft preparation, G.F.S.; writing-review and editing G.F.S., R.I., O.K., P.D., M.K., D.K.; visualization, G.F.S. project administration, n/a.; All authors have read and agreed to the published version of the manuscript.

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Competing Interests

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Data Availability Statement

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