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# ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

## Analysis of the implementation of the European energy policy regarding the energy transition of the islands in Greece.

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# Περίληψη

Η Ελλάδα, με την ποικιλόμορφη γεωγραφία και το μεσογειακό της κλίμα, είναι ιδιαίτερα ευάλωτη στις επιπτώσεις της κλιματικής αλλαγής. Η άνοδος της θερμοκρασίας, η αλλαγή των μοτίβων των βροχοπτώσεων και η αυξανόμενη συχνότητα ακραίων καιρικών φαινομένων θέτουν μεγάλες προκλήσεις για τα οικοσυστήματα και τις παράκτιες περιοχές της χώρας. Η επείγουσα ανάγκη για την αντιμετώπιση αυτών των προκλήσεων ώθησε την Ευρωπαϊκή Ένωση στο σύνολό της να υιοθετήσει ενεργειακές πολιτικές που επικεντρώνονται ιδίως στη μετάβαση των νησιών σε βιώσιμα και ανθεκτικά ενεργειακά συστήματα.

Η ευρωπαϊκή ενεργειακή πολιτική, που αντικατοπτρίζεται σε πρωτοβουλίες όπως η Πράσινη Συμφωνία, τονίζει την ανάγκη για ένα βιώσιμο και κλιματικά ουδέτερο μέλλον. Για την Ελλάδα, η ενεργειακή μετάβαση των νησιών της παίζει κεντρικό ρόλο στην επίτευξη αυτών των στόχων. Τα ελληνικά νησιά, που χαρακτηρίζονται από τις μοναδικές ενεργειακές τους ανάγκες και ευπάθειες, είναι κεντρικά για την εφαρμογή αυτού του σχεδίου λόγω των ιστορικών προκλήσεων του ενεργειακού εφοδιασμού και της βιωσιμότητας.

Η δέσμευση της Ελλάδας στην ενεργειακή μετάβαση αντανακλάται από πληθώρα ενεργειών, όπως τις προσπάθειές της να συνδέσει τα νησιά με το ηπειρωτικό δίκτυο και να αυξήσει το ποσοστό των ΑΠΕ στο ενεργειακό της μείγμα. Τα νησιά, με την αφθονία της ηλιοφάνειας και των αιολικών πόρων, προσφέρουν ένα ευνοϊκό περιβάλλον για την επέκταση τέτοιων έργων. Ωστόσο, η εφαρμογή τους δεν είναι ανεμπόδιστη, λόγω προβλημάτων όπως των μακροχρόνιων γραφειοκρατικών διαδικασιών, των διοικητικών επιβαρύνσεων και της ανάγκης για ολοκληρωμένο ειδικό ενεργειακό σχεδιασμό αναπτυγμένο συγκεκριμένα για τα νησιά.

Για να αντιμετωπίσει αυτές τις προκλήσεις, η Ελλάδα εργάζεται ενεργά για τον εξορθολογισμό των διαδικασιών αδειοδότησης, την ενίσχυση του συντονισμού μεταξύ των ενδιαφερομένων και τη μόχλευση των διεθνών συνεργασιών, ωστόσο, εξακολουθούν να υπάρχουν σημαντικά εμπόδια. Η έλλειψη χωροταξικής πολιτικής για έργα ΑΠΕ και η ενίσχυση του συντονισμού των ενδιαφερομένων είναι μόνο δύο από τις συνεχιζόμενες προκλήσεις που σημαδεύουν τον δρόμο μπροστά με πολυπλοκότητα και αβεβαιότητες.

Η Ελλάδα, ακολουθώντας τις οδηγίες της Ευρωπαϊκής Επιτροπής, πρέπει να συνεχίσει να αγωνίζεται για την επίτευξη του δύσκολου στόχου, ενός ανθεκτικού, με χαμηλές εκπομπές άνθρακα μέλλοντος για τα νησιά, που απαιτεί επίμονες προσπάθειες και στρατηγικές λύσεις εν μέσω προκλήσεων.

# Abstract

Greece, with its diverse geography and Mediterranean climate, is particularly vulnerable to the effects of climate change. Rising temperatures, changing precipitation patterns and the increasing frequency of extreme weather events pose major challenges to the country's ecosystems and coastal areas. The urgency to tackle these challenges has prompted the European Union as a whole to adopt energy policies that focus in particular on the islands' transition to sustainable and resilient energy systems.

European energy policy, reflected in initiatives such as the Green Deal, emphasises the need for a sustainable and climate-neutral future. For Greece, the energy transition of its islands plays a central role in achieving these goals. The Greek islands, characterised by

their unique energy needs and vulnerabilities, are central to the implementation of this plan due to their historical energy supply and sustainability challenges.

Greece's commitment to the energy transition is reflected in a multitude of efforts, such as connecting the islands to the mainland grid and increasing the percentage of RES into its energy mix. The islands, with their abundance of sunshine and wind resources, offer a favourable environment for the expansion of RES projects. However, their implementation is not without its hurdles, including lengthy bureaucratic processes, administrative burdens and the need for comprehensive island-specific energy planning.

To navigate these challenges, Greece is actively working to streamline permitting procedures, enhance coordination among stakeholders and leverage international collaborations, nonetheless, significant obstacles persist. Lack of spatial policy for RES projects and enhancing stakeholder coordination are only two of the ongoing challenges that mark the road ahead with complexity and uncertainties.

Greece, following the directives of the European Commission, needs to continue to strive to achieve the formidable task of a resilient, low-carbon future for the islands, requiring persistent efforts and strategic solutions amid various challenges.

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# Abbreviations

BCM: Billion Cubic Metres
CETA: Clean Energy Transition Agenda
CHP: Combined Heat and Power
DSO: Distribution System Operator
EC: European Commission
ENTSO-E: European Network of Transmission System Operators for Electricity
EU: European Union
EV: Electric Vehicle
GDP: Gross Domestic Product
GHG: Greenhouse Gas
H&C: Heating and Cooling
HEDNO: Hellenic Electricity Distribution Network Operator
IEA: International Energy Agency
IPTO: Independent Power Transmission Operator
IoT: Internet of Things
LULUCF: Land Use, Land Use Change and Forestry

NII: Non Interconnected Island
NECP: National Energy and Climate Plan
NRRP: National Recovery and Resilience Plan
PPC: Public Power Corporation
PV: Photovoltaic
RAE: Regulatory Authority for Energy
RES: Renewable Energy Source
RES-T: Renewable Energy Source for Transport
RRF: Recovery and Resilience Facility
SOE: State-Owned Enterprise
TSO: Transportation System Operator
TYNDP: Ten-Year Network Development Plan

# Setting the background

## Climate change and its importance

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas[1].

Latest scientific reports show unprecedented changes in the world's climate. Global warming is causing increased – and in some cases irreversible – changes to rainfall patterns, oceans and winds in all regions of the world.

Higher temperatures and intensified weather events result in huge costs for the EU's economy and impact countries' ability to produce food. According to an official survey by the European Investment Bank, 83% of Greeks believe that climate change and its consequences constitute the greatest challenge to humanity in the 21st century[2].
Important facts[3]:

- Climate-related events over the last 40 years have caused more than €487 billion in financial losses in the EU.
- Between 1980 and 2020, over 138.000 people in the EU lost their lives due to extreme weather and climate-related events.
- The economic cost of river flooding in Europe exceeds €5 billion a year on average.
- Forest fires cause about €2 billion of economic damage every year.

Therefore, it is fair that the EU has made the energy transition one of its top priorities so as to be carbon neutral in 2050 in order to minimise the human and environmental cost that

[1] United Nations. "What Is Climate Change? | The United Nations." the United Nations, https://www.un.org/en/climatechange/what-is-climate-change.
[2] European Investments Bank. 2021. "83% of Greeks believe that tackling climate change and its consequences is the biggest challenge of the 21st century." European Investment Bank. https://www.eib.org/en/press/all/2021-400-83-of-greeks-believe-that-tackling-climate-change-and-its-consequences-is-the-biggest-challenge-of-the-21st-century.
[3] European Council. 2023. "Climate change: what the EU is doing." Consilium.europa.eu. https://www.consilium.europa.eu/en/policies/climate-change/.

it is going to shoulder otherwise. More specifically, the EU is prioritising Goal 7 of the United Nations Sustainable Development Goals, which focuses on ensuring access to clean and affordable energy that is essential for the development of various sectors. Despite progress, by 2030 around 660 million people will have no electricity and almost 2 billion will be dependent on polluting fuels. The global population with access to electricity has increased from 87% to 91% between 2015 and 2021. However, there is an urgent need for action to achieve universal access by 2030, emphasising investments in clean energy such as solar and wind power, expanding infrastructure and improving technology. A stable energy system supports businesses, healthcare, education and more. Lack of access hinders progress and impacts women, children and the environment. The consequences include health risks, educational challenges and economic setbacks.[4]

## Island vulnerability

The combination of geographic, environmental and socio-economic elements renders islands particularly vulnerable to the negative consequences of climate change for several reasons:

1. Sea Level Rise: Islands are often low-lying and surrounded by oceans, making them susceptible to rising sea levels.
2. Ocean Acidification: The oceans absorb a significant amount of carbon dioxide from the atmosphere. This process, known as ocean acidification, has detrimental effects on marine ecosystems.
3. Limited Resources and Infrastructure: Islands often have limited resources and infrastructure, making them less equipped to handle the impacts of climate change. They may lack the financial and technical capacity to implement robust adaptation and mitigation measures.
4. Economic Dependence on Climate-Sensitive Sectors: Many island economies are heavily dependent on climate-sensitive sectors such as agriculture, fisheries and tourism. Changes in temperature, precipitation patterns and sea conditions can have significant negative impacts on these sectors, leading to economic vulnerabilities.
5. Limited Freshwater Resources: Islands typically have limited freshwater resources and changes in precipitation patterns can exacerbate water scarcity issues. Rising temperatures can also contribute to the increased evaporation of freshwater sources.
6. Biodiversity Threats: Islands often host unique and fragile ecosystems with species that may be particularly vulnerable to climate change. Rising temperatures, habitat loss and changes in precipitation patterns can threaten the biodiversity of these isolated ecosystems.
7. Limited Migration Options: Islands often have finite land areas, limiting the options for migration in the face of rising sea levels or extreme weather events. This lack of mobility can increase the vulnerability of island populations.

The only way to combat climate change and not just the symptoms, is via the energy transition. That means shifting from fossil fuels to renewable sources and thus slashing greenhouse gas emissions, curbing air pollution and enhancing energy efficiency. By also

[4] The United Nations. n.d. “Energy - United Nations Sustainable Development.” the United Nations. https://www.un.org/sustainabledevelopment/energy/.

diversifying the energy sources, energy security is bolstered paving the way for a cleaner, more resilient future.

Implementing such adaptation measures and fostering international collaboration are essential for alleviating the consequences and strengthening the resilience of island societies.

## Energy transition

Energy transition refers to the global energy sector's shift from fossil-based systems of energy production and consumption — including oil, natural gas and coal — to renewable energy sources like wind and solar, as well as lithium-ion batteries.[5]

The importance of energy transition lies in its multifaceted impact on various aspects of society. Key reasons include:

1. Decarbonisation: Vital for slowing down climate change, with Europe leading in efforts to reduce carbon intensity compared to the United States and China.
2. Empowering Consumers: Allowing consumers to actively participate in the transition by adjusting electricity demands and even selling excess energy back to the grid.
3. Financial Security: Renewable energy investments have shown resilience during financial crises, offering improved financial stability compared to other sectors.
4. Improved Competitiveness: Europe has experienced increased competitiveness, with energy used for economic output decreasing by 20% between 2005 and 2017, driven by advancements in energy efficiency through digitalization and automation.
5. Industrial Growth: The cost of renewable energy has significantly decreased, fostering growth in industries such as solar and wind power. However, global competitiveness is still impacted by subsidised fossil fuels.
6. Job Creation: Transitioning to green energy has the potential to create jobs, with millions already generated in Europe. Estimates suggest a further increase in employment by 2050 compared to a scenario where no transition occurs.
7. Reduced Energy Dependency: Local production of renewable energy reduces dependence on imports, addressing issues of energy security and pricing while remaining competitive with fossil fuels.[6]

## Initiatives for climate protection

Several initiatives for climate change have been implemented over the past decades as the effects of global warming were becoming noticeably worse.

- United Nations Framework Convention on Climate Change (UNFCCC): The UNFCCC, established in 1992, provides the overall framework for international efforts

[5] S&P Global. n.d. "What is Energy Transition?" S&P Global. https://www.spglobal.com/en/research-insights/articles/what-is-energy-transition.

[6] TWI. n.d. "What is Energy Transition? (Definition, Benefits and Challenges)." TWI Global. https://www.twi-global.com/technical-knowledge/faqs/energy-transition.

to address climate change. It sets the foundation for subsequent agreements and initiatives, including the Kyoto Protocol and the Paris Agreement.[7]

- Kyoto Protocol (1997): The Kyoto Protocol, an extension of the UNFCCC, set binding targets for greenhouse gas emissions reductions, particularly for industrialised countries. While the EU was part of the Kyoto Protocol, subsequent efforts, including the Green Deal, built on the broader framework of international climate agreements. [8]
- 2030 Climate and Energy Framework: In 2014, the EU adopted the 2030 Climate and Energy Framework, which set binding targets for reducing greenhouse gas emissions, increasing the share of renewable energy and improving energy efficiency. This framework laid the groundwork for the more ambitious goals outlined in the European Green Deal.
- Paris Agreement (2015): The Paris Agreement is a landmark international accord under the UNFCCC that aims to limit global warming to well below 2 degrees Celsius above pre-industrial levels. The EU played a significant role in the negotiations leading to the Paris Agreement and the goals and principles outlined in the agreement align closely with the objectives of the European Green Deal.
- Circular Economy Action Plan: The EU's Circular Economy Action Plan, initiated in 2015, focuses on promoting a more circular economic model, reducing waste and enhancing resource efficiency. Elements of this plan align with the sustainability objectives of the European Green Deal.
- European Green Deal: The European Green Deal is a comprehensive policy framework and roadmap introduced by the European Commission to make the European Union climate-neutral by 2050. Introduced in 2019 it encompasses a range of initiatives and legislative measures aimed at transforming the EU economy, fostering sustainable practices and addressing environmental challenges across sectors such as energy, transport and agriculture.

Three initiatives stand out among the many policies of the European Green Deal concerning the energy transition of the islands.

- "Fit for 55" is a legislative package introduced by the European Commission as part of the European Green Deal, with the goals of achieving a 55% reduction in greenhouse gas emissions by 2030 compared to 1990 levels, guaranteeing a just and socially fair transition, maintaining and enhancing innovation and competitiveness within the EU industry, while ensuring a fair competitive environment with third-country operators. The package includes a set of proposals, measures and targets spanning areas such as emissions trading, renewable energy, energy efficiency,alternative fuels and carbon pricing, aiming to accelerate the European Union's transition to a more sustainable and low-carbon economy.[9] The measures and infrastructure that EU members are to undergo are financed in large part by EU

[7] United Nations. n.d. “What is the United Nations Framework Convention on Climate Change?” UNFCCC. https://unfccc.int/process-and-meetings/what-is-the-united-nations-framework-convention-on-climate-change.

[8] United Nations. n.d. “What is the Kyoto Protocol?” UNFCCC. https://unfccc.int/kyoto_protocol.

[9] European Council. 2023. “Fit for 55 - The EU's plan for a green transition - Consilium.” Consilium.europa.eu. https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/.

funds such as the Social Climate Fund, the Innovation Fund and the Modernisation Fund.[10]

- Clean Energy for EU Islands is an initiative which was launched in 2017 within the European Green Deal that focuses on supporting the transition of European Union islands to clean and sustainable energy systems. The Clean energy for EU islands secretariat was established in order to educate, guide and coordinate the efforts of all the different stakeholders such as authorities of all levels, academia and citizens towards EU goals. It aims to reduce energy costs and dependence on imported fossil fuels, enhance energy security and efficiency and promote the use of renewable energy sources on islands, fostering their resilience and contributing to broader economic and environmental goals[11].
- The Just Transition Mechanism (JTM) is serving as a crucial instrument to ensure an equitable shift towards a climate-neutral economy, ensuring that no one is left behind. It aims to provide focused support, mobilising approximately €55 billion between 2021 and 2027 in the regions most impacted by the transition, mitigating the socio-economic consequences. Territorial just transition plans detail proposed operations and specify governance mechanisms. Approval of these plans unlocks dedicated financing under the other two pillars of the Just Transition Mechanism, the InvestEU "Just Transition" scheme financed mainly by the private sector and a new Public Sector Loan Facility which consists the majority of the JTM Fund.[12]

# The situation in Greece

## Climate change in Greece

Due to its geographical location on the eastern side of the Mediterranean, Greece lies exactly between continental Europe and the North African desert, making it one of the so-called "hotspots" for studying the effects of climate change. Compared to other countries, it can be observed that the environmental changes in the region are more intense. In recent years, the average temperature of the country has risen significantly, especially in the summer months, reaching as high as 40 - 45 degrees Celsius. According to research data and forecasts, it is predicted that by 2050, hot days in Greece will increase by 15 to 20 per year, with temperatures reaching levels similar to those of the African Sudan, while rainfall is expected to decrease by 10% to 30%[13]. In addition, days with a high fire risk are expected to increase from 15 % to 70 % by 2050[14]. Extreme weather events, such as prolonged

[10] European Commission. n.d. “What is the EU ETS? - European Commission.” EU Climate Action. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/what-eu-ets_en.

[11] European Commission. n.d. “Clean energy for EU islands.” Energy (europa.eu). https://energy.ec.europa.eu/topics/markets-and-consumers/clean-energy-eu-islands_en.

[12] European Commission. n.d. “The Just Transition Mechanism - European Commission.” European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en.

[13] Γεωργακοπουλος, Θοδωρης. n.d. “Οι Συνέπειες Της Κλιματικής Αλλαγής Στην Ελλάδα - Μια Έρευνα.” Dianeosis. https://www.dianeosis.org/2021/10/oi-synepeies-tis-klimatikis-allagis-stin-ellada/.

[14] “Κλιματική αλλαγή: Οι συνέπειές της στην Ελλάδα (γράφημα).” 2021. CNN.gr. https://www.cnn.gr/perivallon/story/286690/klimatiki-allagi-oi-synepeies-tis-stin-ellada-grafima.

heatwaves, droughts, floods and wildfires, continue to occur frequently and are expected to persist.

In recent summers, there have been extensive fires that have burned millions of hectares of land, with more than 800,000 hectares in the summer of 2023 alone. This is a new reality in all Mediterranean countries, where large areas of forest areas are being destroyed, endangering residents and affecting the ecosystem as a whole[15]. In addition, Greece, with around 6,000 islands and islets and the eleventh longest coastline, is facing significant consequences due to the rise in average sea levels. This rise is expected to be between 0.2 and 2 metres by the year 2100[16]. Therefore, we understand that the effects of climate change in Greece affect many sectors creating a negative cycle of impacts. With the gradual rise in sea level, many coastal ecosystems, agricultural crops and settlements are at risk of extinction, with the characteristics of the coastline changing from coastal Mediterranean to alpine in some areas[17].

Furthermore, extreme weather events, combined with the fact that Greece is an earthquake-prone country, can lead to soil erosion and, in extreme cases, desertification and forced migration. It is important to note that the agricultural and livestock sectors are directly affected, as some elements of the Mediterranean diet will no longer be produced under the new climate conditions, making their import from abroad unavoidable. The tourism sector will not be spared either, as the high temperatures will discourage people from choosing Greece as a holiday destination.

Based on climate models, lengthening of the transition-middle seasons, i.e. spring and autumn, shortening of winter and persistently hot summers are predicted. Due to the high and unbearable temperatures, in addition to the discomfort caused to people, combined with the lack of green spaces in large urban centres, there is a risk of destruction of buildings and historical monuments due to thermal shock to their construction materials[18]. The climate crisis that Greece is facing is a crisis that concerns all of humanity and it can only be addressed with targeted, collective actions based on the sustainability and sustainable development of the place.

## Energy transition in Greece.

In order to better analyse the situation in Greece it is important to understand the efforts that have been made up to this point. As part of the EU, the country is already in the process of neutralising its carbon footprint for a number of years. More specifically, in 2021, approximated GHG emissions in Greece were 76.2 MtCO2-eq, 1.9% higher compared to 2020 but 10.9% below pre-pandemic levels. Overall, net domestic emissions, including the

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[15] Katsoulakos, N.M. (2019) An Overview of the Greek Islands' Autonomous Electrical Systems: Proposals for a Sustainable Energy Future. Smart Grid and Renewable Energy, 10, 55-82.
Koulelis, P.P., Proutsos, N., Solomou, A.D., Avramidou, E.V., Malliarou, E., Athanasiou, M., Xanthopoulos, G., Petrakis, P.V. (2023) Effects of Climate Change on Greek Forests: A Review. Atmosphere, 14(7), 1155.

[16] Κουνάνη, Αριστέα. 2023. "Η Κλιματική Αλλαγή στην Ελλάδα." Αθηνοδρόμιο.
https://www.athinodromio.gr/η-κλιματική-αλλαγή-στην-ελλάδα/.

[17] Γεωργακοπουλος, Θοδωρης. n.d. "Οι Συνέπειες Της Κλιματικής Αλλαγής Στην Ελλάδα - Μια Έρευνα." Dianeosis.
https://www.dianeosis.org/2021/10/oi-synepeies-tis-klimatikis-allagis-stin-ellada/.

[18] Papadimitriou, Yannis. 2023. "Greece must make up for lost time in climate adaptation." Clean Energy Wire.
https://www.cleanenergywire.org/factsheets/greece-must-make-lost-time-climate-adaptation.

Land Use, Land Use Change and Forestry (LULUCF) sector, were 30.2% lower than 1990 levels.

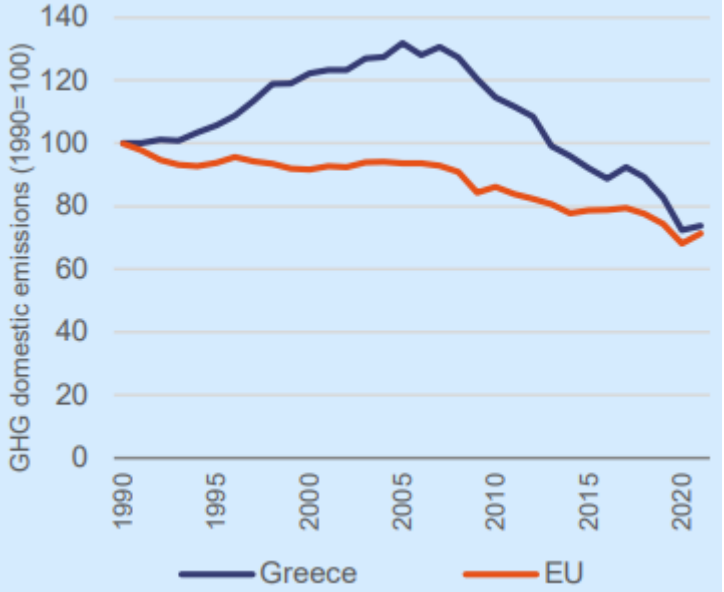


Figure 1: Comparison of median EU and Greek GHG emissions between 1990-2021[19]

Additionally, from 2010 to 2021 the energy and electricity mix of the country have been transformed. On the one hand, the energy mix has seen a gradual but steady encroachment of natural gas and RES over lignite and oil while according to schedule, all lignite plans will be phased out by 2028.

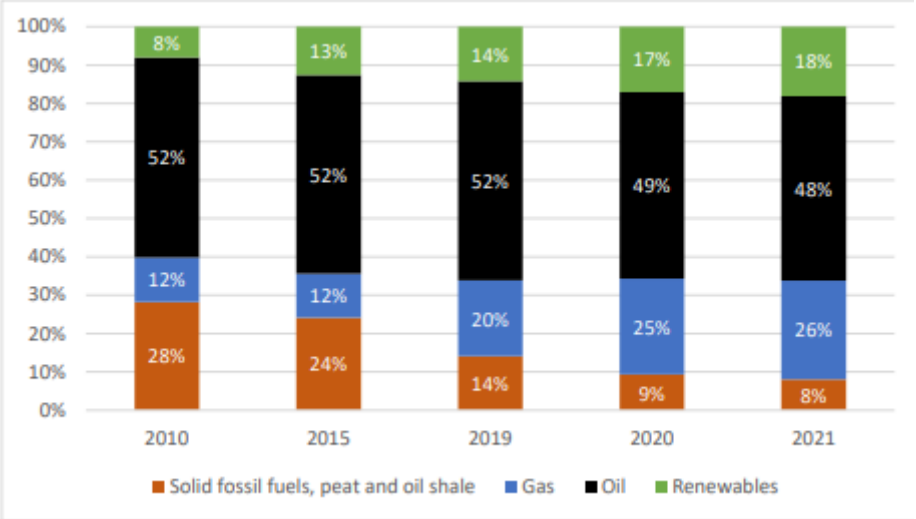


Figure 2: Break-down of the Greek energy mix between 2010-2021[20]

On the other hand, the change of the electricity mix has been much more rapid, with lignite having been cut by over 80% since 2010 while, similarly to the energy mix, natural gas and RES are quickly gaining ground.

[19] European Union. n.d. “Country profile_template_pro.xlsx.” EU Climate Action. https://climate.ec.europa.eu/system/files/2023-05/el_2022_factsheet_en.pdf.
[20] 2023. “REPowerEU – one year on.” Energy - European Commission. https://energy.ec.europa.eu/publications/repowereu-one-year_en.

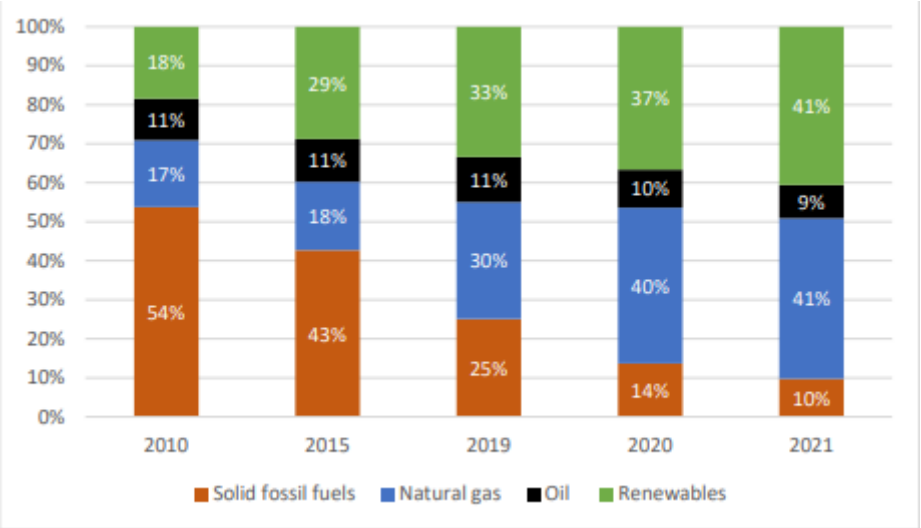


Figure 3: Break-down of the Greek electricity mix between 2010-2021[21]

As far as future plans are concerned, the government, through its NECP, underscores the country's priorities and potential for development in matters of energy and dealing with climate change, taking into account the recommendations of the EC as well as the Sustainable Development Goals of the UN.

The strategic aim is to achieve the energy and climate goals until the year 2030, 2040 and 2050 in the most economically competitive way and to be an opportunity for development benefits for the national economy. It is sought that the country will eventually emerge as one of the Member States that will have adopted ambitious climate and energy goals, through an integrated and coherent program of measures and policies, in order to simultaneously attract investments in clean technologies, infrastructures and innovations.

This transition will be combined with the strengthening of the competitiveness of Greek businesses and the protection of consumers, establishing a system for the sustainable growth of the national economy, making optimal use of national and European financial mechanisms and adopting the appropriate market mechanisms in accordance with the Union legislation.

The green energy transition will replace fossil fuels, which, with the exception of lignite, the country is dependent on imports, with domestic energy sources based on RES and improved energy efficiency. Consequently, in addition to reducing greenhouse gas emissions to prevent climate change, the green energy transition brings important strategic benefits for the country, which are summarised below:

- The impact of the oil and natural gas price crises which are caused by geopolitical factors and the international energy market will be minimised. Energy prices will be more stable and predictable in the long term, reflecting the cost of capital recovery on investments.

- Largely reducing the energy dependence on imported energy products such as oil and natural gas, leading to the security of energy supply that will depend on the technical reliability and adequacy of domestic energy systems, which are predictable and technically controllable, rather than on geopolitical factors. There must be taken into account that there

[21] 2023. “REPowerEU – one year on.” Energy - European Commission. https://energy.ec.europa.eu/publications/repowereu-one-year_en.

will be a dependence of new technologies on raw materials and critical minerals, but it is a manageable dimension as well.

- Strengthening the competitiveness of the economy and the sturdiness of economic sectors to extrinsic parameters.

- Gradually eliminating the burning of fossil fuels, bringing with it a spectacular reduction in emissions which cause air pollution, such as sulphur dioxide, nitrogen oxide, particles and others. Air quality in cities and other congested areas will improve dramatically,while, at the same time, the phenomenon of noise pollution will also be reduced thanks to electric propulsion.

In summary, the green energy transition will not only prevent climate change, but will also make a significant contribution to achieving the goals regarding energy independence, the cost and stability of energy prices, the competitiveness of the national economy, as well as the limitation of air pollution, especially within urban centres[22].

## The Greek ecosystem

Throughout the study the key stakeholders of the Greek energy sector which play a significant role in the energy transition of the islands will be referred to often. Therefore, their roles and responsibilities are overviewed below.

### Greece’s energy buildup and its SOE

In August 1950, the Public Electricity Company was established, which was given the exclusive privilege of producing and transmitting electricity to operate "for the sake of the public interest" in order to draw up and implement a national energy policy, through the intensive exploitation of domestic resources. By 1960, PPC's takeover of all private electric companies (415 in total) was almost complete.

Thus, from 234 GWh in 1939, production rose to 5,690 GWH in 1966, where only 28% came from petroleum products while 62% from domestic sources (41% lignite, 31% hydroelectric)[23].

Since the end of 2000, it has been operating as a limited liability company and is listed on the Athens and London stock exchanges with 51% of the shares owned by the state.

PPC's monopoly in the production, transmission, distribution and sale of electricity has been completely lifted since 2012, with the exception of the Non-Interconnected Islands (NII) where it has been partially lifted. After privatising its grid sector and increasing the share capital in 2021, the state owns 34% of its shares[24].

[22] “Greece - Draft Updated NECP 2021-2030.” 2023. European Commission. https://commission.europa.eu/publications/greece-draft-updated-necp-2021-2030_en.

[23] Παπαδόπουλος, Μιχάλης. 2018. “Η ίδρυση και ανάπτυξη της ΔΕΗ | Η ΚΑΘΗΜΕΡΙΝΗ.” kathimerini. https://www.kathimerini.gr/society/959053/i-idrysi-kai-anaptyxi-tis-dei/.

[24] PPC S.A. n.d. “Μετοχική Σύνθεση ΔΕΗ.” ΔΕΗ. Accessed November 27, 2023. https://www.dei.gr/el/dei-omilos/ependytikes-sxeseis/enimerosi-metoxon/metoxiki-sunthesi/.

## Policy and regulation

In Greece, the Ministry for Environment and Energy[25] is responsible for the energy policy and the Ministry for shipping and island policy[26] is in charge of island and maritime matters. However, the energy transition allows for a more decentralised energy landscape where other sector policies and stakeholders are involved. In this new era regional and local government bodies as well as academia and the private sector, are also relevant and play a major role for implementation of measures.

The Ministry of Environment and Energy is supported by the Regulatory Authority for Energy[27] when it comes to energy policy and regulation. In Greece, the energy sector policy and organisation differs between the mainland and the electrically interconnected islands and the islands that are not electrically interconnected with the mainland, or NIIs.

RAE has appointed the Hellenic Energy Exchange S.A.[28] as the electricity market operator which is handling the day-ahead market. Moreover, the Administrator of Renewable Energy Sources and Guarantees of Origin[29] manages the Renewable Energy Sources (RES) and High-Efficiency Cogeneration of Electricity and Heat (CHP) of the National Interconnected System, as well as the Guarantees of Origin of electricity produced by RES and CHP.

## Grid operators

The Greek electricity grid is owned and managed by two companies. The electricity transmission system is owned and operated by the Independent Electricity Transmission Operator S.A.[30]. The Electricity distribution system is owned and operated by HEDNO, a subsidiary of PPC. The Greek electricity sector includes many power producers and suppliers. The operational management of the NIIs as well as the electricity system and market operation is managed by the Hellenic Electricity Distribution Network Operator S.A.[31]. As far as the Greek electricity grid goes it is divided in two and owned and managed by two companies. Firstly, the electricity transmission system is the responsibility of the Independent Electricity Transmission Operator S.A. and secondly, HEDNO, a subsidiary of PPC, is responsible for the electricity distribution system. Last but not least, the Greek electricity sector includes many power producers and suppliers.

## Island population and governance

Greece has more than 6.000 islands and more than 220 of them are inhabited. The country is divided into 13 regions with the regions of Crete, the Ionian islands, the North and South Aegean being solely constituted of islands, while Attica, Macedonia and Thrace, Thessaly and Central Greece and Peloponnese, Western Greece and Ionian include both mainland and island parts. Regional governments are charged with the planning and implementing of policies. Public authorities on islands are managed in the same way as other administrative entities in Greece.

[25] https://ypen.gov.gr
[26] https://www.ynanp.gr/en/
[27] https://www.rae.gr/en/
[28] https://www.enexgroup.gr
[29] https://www.dapeep.gr/etairia/orama-kai-skopos/
[30] https://www.admie.gr/en
[31] https://deddie.gr/en/

Even though most of the islands are electrically interconnected with the mainland there is a significant minority categorised as NIIs which consist of 28 autonomous systems. Even though Crete is one of the most populous islands in the Mediterranean (8.336 km² - 634.930 inhabitants) it was categorised as an interconnected island as late as of the 1st of November 2021. In contrast there are some 25 medium-sized islands (100-1.000 km²) and a large number of small islands (below 100 km²) which are still considered NIIS.

Greece is currently carrying out interconnection plans, notably for Crete and several islands of the Cyclades. 15% of the total population of Greece lives on the islands which corresponds to 1.650.000 people. almost 80% of the islands' population resides in Evia, Crete, Rhodes, Corfu and Lesvos[32] [33].

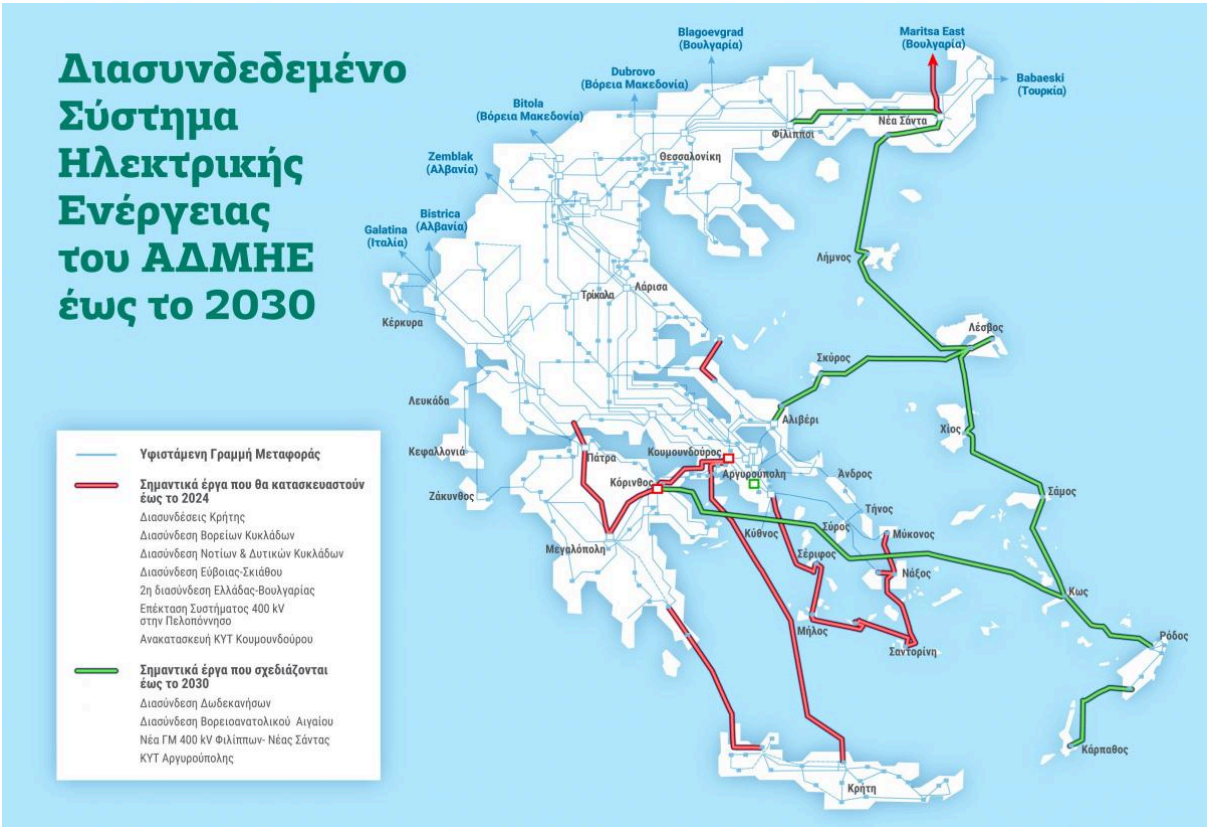


Figure 4: Projection of IPTO's electrical energy transition system up to 2030[34]

The Greek islands play an important role in Greek and European culture and identity, as they have been important economic, commercial and cultural centres since the times of the Minoan and Cycladic civilisations, which are considered the first civilisations in Europe.

## NIIs electricity needs and costs

[32] ELSTAT. n.d. 2011 Population-Housing Census - ELSTAT. https://www.statistics.gr/en/2011-census-pop-hous.
[33] Katsoulakos, N.M. (2019) An Overview of the Greek Islands' Autonomous Electrical Systems: Proposals for a Sustainable Energy Future. Smart Grid and Renewable Energy, 10, 55-82.
Koulelis, P.P., Proutsos, N., Solomou, A.D., Avramidou, E.V., Malliarou, E., Athanasiou, M., Xanthopoulos, G., Petrakis, P.V. (2023) Effects of Climate Change on Greek Forests: A Review. Atmosphere, 14(7), 1155.
[34] IPTO. 2021. Infographics | IPTO. https://www.admie.gr/en/node/9172.

In the next 5 years alone, the NIIs' energy demand will increase from 2,082,993 MWh to 2,338,229 MWh, or an increase of 12.25%.

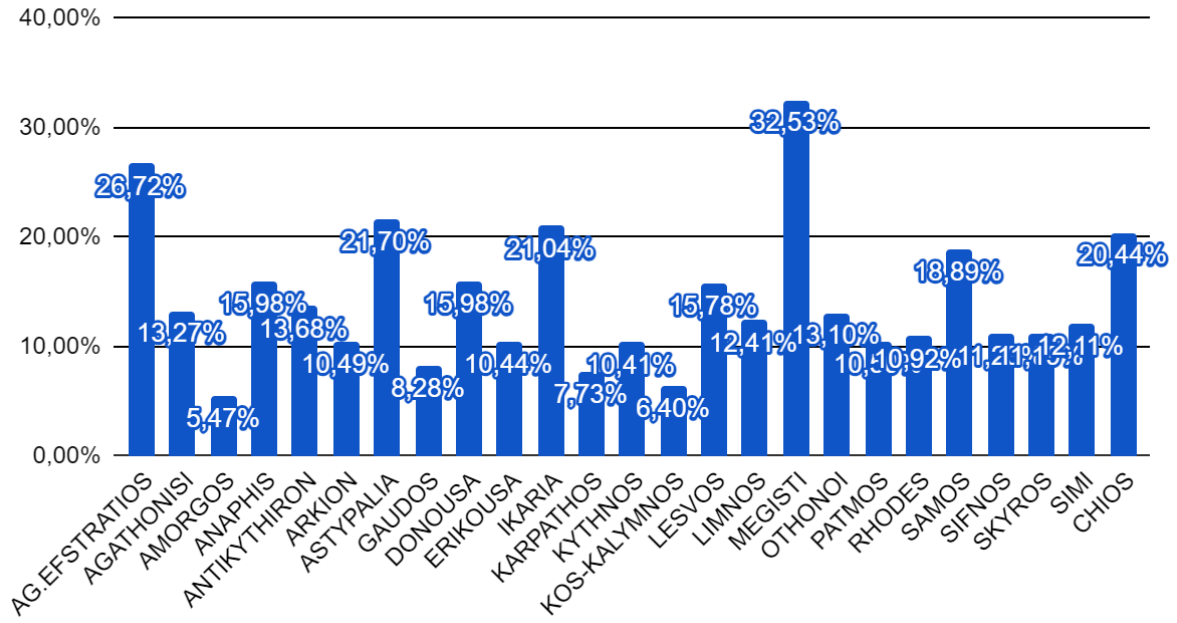


Figure 5: Change in the electricity consumption of NIIs between 2023-2028[35]

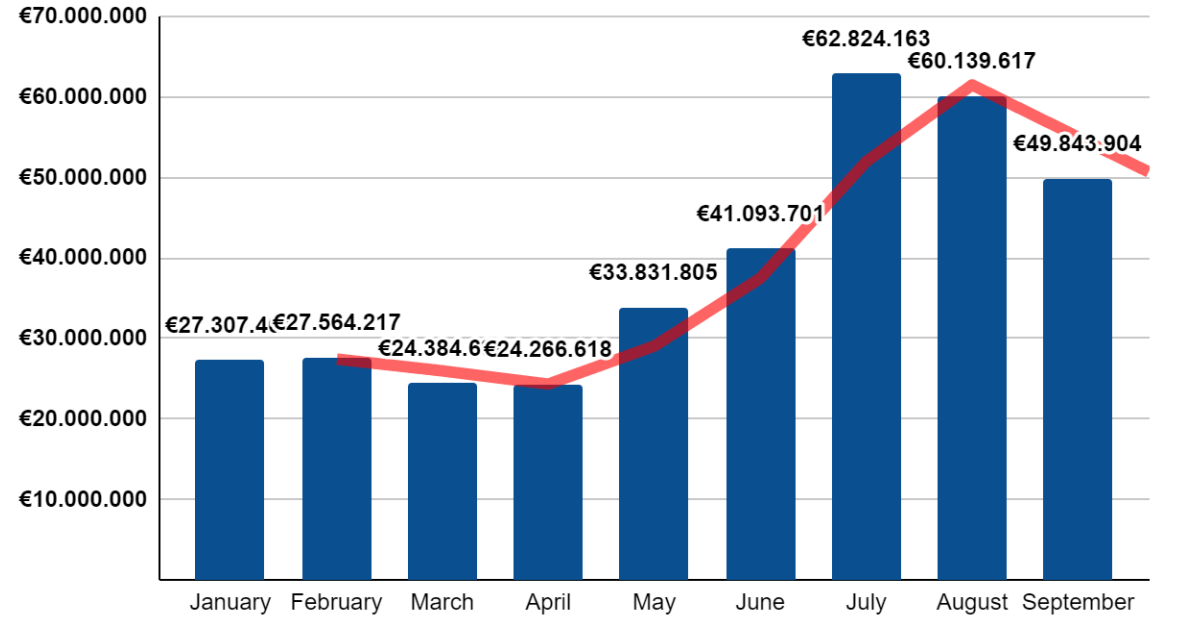


Figure 6: Average variable cost of energy of thermal units of NIIs in 2023[36]

[35] HEDNO. n.d. “2023.” ΔΕΔΔΗΕ. https://deddie.gr/el/themata-tou-diaxeiristi-mi-diasundedemenwn-nisiwn/agora-mdn/stoixeia-ekkathariseon-kai-minaion-deltion-mdn/miniaia-deltia-ape-thermikis-paragogis/miniaia-deltia-2023/.

[36] HEDNO. n.d. “2023.” ΔΕΔΔΗΕ. https://deddie.gr/el/themata-tou-diaxeiristi-mi-diasundedemenwn-nisiwn/agora-mdn/stoixeia-ekkathariseon-kai-minaion-deltion-mdn/miniaia-deltia-ape-thermikis-paragogis/miniaia-deltia-2023/.

In terms of costs, according to HEDNO's data[37] NII's thermal units costed to Greece €351.256.182 for the first nine months of 2023 while the RES penetration was 14,35% on average.

Additionally, HENDO's research shows fuel costs of €602/tn for fuel oil and €1,212/klt for diesel, while emission costs were set at €70/tn CO2, based on existing average book values for 2022. The additional costs for operation and maintenance were set at €11.2/MWh for all units as an average value from the accounting data.

Lastly, in order to cover the electricity deficit of the necessary power during the months of July and August (62 days in total), electricity must occasionally be rented from the private sector. The cost per unit is approximately €1,500/MW/day, according to PPC SA's most recent contracts with private suppliers of portable conventional units, which is equivalent to €93,000/MW for the rental period per year[38].

# Issues and research questions

The purpose of this section is to analyse the specific issues related to the problem and the societal consequences if the problem continues unaddressed.

## Definition of the issue

Greece, according to the study by the European Commission[39], is facing regulatory and institutional problems in the targeted planning and implementation of the EU's goals in general and especially in the islands which, due to the particular nature of their geography, geomorphology, economic model and culture, present peculiar obstacles to the energy transition.

There are a number of reasons, mainly economic, environmental and social, for which the energy transition policy of the Greek islands is necessary to comply with the European directives.

Tourism income for Greece consists 11.5% of the GDP, while if its indirect contribution is taken into account, it corresponds to between 25.3% and 30.5%[40] with the island population being more greatly influenced by the sector than the continental population. That fact has as a result significant fluctuations in energy demand due to tourism creating varying demand patterns and contributing to a more vulnerable energy system.

Islands are often more susceptible to the impacts of climate change, such as rising sea levels and extreme weather events. In addition, they are often characterised by fragile

[37] HEDNO. n.d. "2023." ΔΕΔΔΗΕ. https://deddie.gr/el/themata-tou-diaxeiristi-mi-diasundedemenwn-nisiwn/agora-mdn/stoixeia-ekkathariseon-kai-minaion-deltion-mdn/miniaia-deltia-ape-thermikis-paragogis/miniaia-deltia-2023/.

[38] HEDNO S.A. 2023. "Δημόσια Διαβούλευση της ΡΑΑΕΥ επί του Προγράμματος Ανάπτυξης Μη Διασυνδεδεμένων Νησιών (ΜΔΝ) περιόδου 2023-2029. - Rae Website." PAE. https://rae.gr/diavoulefseis/67113/.

[39] European Commission. n.d. "Clean energy for EU islands." Energy (europa.eu). https://energy.ec.europa.eu/topics/markets-and-consumers/clean-energy-eu-islands_en.

[40] Kurlibini, Vicky. 2023. "Άγγιξε τα 24 δισ. ευρώ η άμεση επίπτωση του τουρισμού στην ελληνική..." Capital. https://www.capital.gr/oikonomia/3721093/aggixe-ta-24-dis-euro-i-amesi-epiptosi-tou-tourismou-stin-elliniki-oikonomia/.

ecosystems, to whom the environmental impact of traditional energy sources can be particularly harsh. Without a resilient energy infrastructure that incorporates renewable energy and energy efficiency measures that contribute to climate adaptation, environmental conservation and promotion of sustainable development the aforementioned ecosystems are in grave danger driving the society in crisis.

Moreover, Greek islands are highly dependent on imported fuels while they typically have abundant renewable energy resources, including solar and wind. Expanding the use of these local resources can contribute to a more sustainable and resilient energy system while also creating economic opportunities.

Finally, as a member of the European Union, Greece is obligated to align its policies with EU climate targets. The EU has set ambitious goals for reducing greenhouse gas emissions, increasing the share of renewable energy and improving energy efficiency. Adjusting energy policies to meet these targets is essential for compliance.

## The costs for the society

Greece historically, with the islands in particular, is heavily reliant on imported fossil fuels for electricity generation, making them vulnerable to price fluctuations and supply chain disruptions. Furthermore, the cost of transporting and storing fossil fuels on islands can lead to higher energy prices for residents and businesses whose livelihood is dependent on energy security.

Moreover, islands often have unique geographical and logistical challenges that impact energy infrastructure. Adding that to the mountainous terrain,the limited land availability and the isolation and it is required to have tailored energy policies and solutions.

To conclude, community engagement is vital as involving local communities in the decision-making process and fostering community-owned renewable energy projects can enhance social acceptance and promote a sense of energy independence. In contrast there have been cases of RES projects being blocked by the local population due to miscommunication between them and the local administration or investors.

## Major causes

Greece encounters a set of economic challenges that pose barriers to substantial investments in renewable energy infrastructure and energy efficiency initiatives. These obstacles arise from economic constraints and budgetary limitations, which can impede progress in transitioning to cleaner energy sources.

The country’s historical reliance on fossil fuels, particularly imported oil and natural gas, presents a significant hurdle in moving away from conventional energy sources. The resistance to transition is heightened by existing infrastructure and economic dependencies on these fossil fuels, underscoring the need for strategic planning in navigating this shift.

The effectiveness and clarity of energy policies and regulatory frameworks play a pivotal role in determining the speed of Greece’s energy transition. Inconsistencies, a lack of long-term vision or insufficient incentives within policies can impede the investment and

implementation of renewable energy projects, necessitating a comprehensive and coherent approach.

Challenges associated with grid integration further complicate the adoption of renewable energy sources. Issues like grid capacity, stability and the necessity for upgrades can hinder the seamless integration of renewables into the existing energy grid, posing additional obstacles to the transition.

The persistence of subsidies or financial support for traditional fossil fuel industries introduces disincentives for embracing cleaner energy sources. These subsidies may distort market dynamics and impede the natural progression towards sustainable alternatives.

Public acceptance and awareness are crucial factors influencing the adoption of new energy technologies or policies. A lack of public awareness or resistance to change can decelerate the transition process, emphasising the importance of community engagement in fostering acceptance.

The availability of funding and investment opportunities is a critical determinant for development of renewable energy projects. Challenges in securing financing or attracting private investments can act as significant roadblocks, underscoring the importance of a conducive investment climate.

The commitment and political will to drive the energy transition agenda are imperative for success. Changes in political leadership or shifting priorities can significantly impact the momentum of energy transition initiatives, emphasising the need for sustained political support.

The implementation of large-scale renewable energy projects may encounter technical and logistical challenges. These challenges include the need for new infrastructure, technology deployment and skilled labour underlining the importance of addressing these aspects for successful project execution.

Coordinated efforts across various sectors are essential for a successful energy transition. Lack of a cross-sectoral coordination between energy, transportation and industry stakeholders can slow down progress, highlighting the need for a collaborative approach to address interconnected challenges and ensure seamless transition.

Greece faces additional hurdles in its energy transition due to lack of expertise within regional government bodies. The absence of knowledgeable personnel at the regional level may hinder the effective decision-making, implementation and communication to the community of the energy policies, further complicating the transition process.

The country's energy transition is also affected by a critically slow judicial system[41]. Delays in legal proceedings can create uncertainties for investors and project developers, leading to prolonged timelines and potential setbacks in the execution of renewable energy initiatives. Adding that to cumbersome bureaucratic processes and intricate procedures that lead to delays and demand resources for obtaining necessary approvals, make for extra challenges for interested parties, potentially impeding the timely implementation of projects aimed at transitioning to cleaner energy sources[42].

[41] Mandrou, Ioanna. 2023. "The sad ranking of our justice system." *eKathimerini.com*, October 17, 2023. https://www.ekathimerini.com/opinion/1222647/the-sad-ranking-of-our-justice-system/.

[42] "Greece economy briefing: Energy crisis: Greece's strategy to ensure domestic needs – China-CEE Institute." 2022. China-CEE Institute. https://china-cee.eu/2022/07/20/greece-economy-briefing-energy-crisis-greeces-strategy-to-ensure-domestic-needs/.

# Current policies and initiatives

## REpowerEU

In view of the challenges and disruptions in the global energy market resulting from the Russoukrainian war of 2022, the European Commission has established the REPowerEU Plan to overcome these hardships. Launched in May 2022, this strategic plan is aimed at assisting the EU save energy, promote clean energy production and diversify its energy sources.

Through collaborative efforts, the EU has successfully diminished its reliance on Russian fossil fuels achieving a notable reduction of almost 20% in energy consumption. As part of the REPowerEU Plan, the introduction of a gas price cap and a global oil price cap has been instrumental in stabilising energy costs and mitigating the impact of market volatility. In addition, the EU has strengthened its commitment to renewable energy by doubling the deployment of renewables, contributing to a more sustainable and resilient energy landscape.

The REPowerEU Plan serves as a comprehensive response to the energy challenges posed by geopolitical events. It reflects the EU's commitment to increasing energy security, reducing dependence on certain sources and driving the transition to cleaner and more sustainable energy practices.

In this way, the EU is able to coordinate negotiations with third-party suppliers in order for its members to not engage in bidding wars. Leveraging the power of the EU single market the platform achieves more favourable conditions for all EU consumers.

In May 2023, the EU succeeded in obtaining bids from 25 supply companies, corresponding to more than 13.4 billion cubic metres of gas (bcm). This far exceeds the collective demand of 11.6 bcm that the EU companies submitted through the first tender.
The plan introduced new rules for gas storage, chief among them being the annual target of filling 90% of storage capacity by November 1st of each year.

As far as saving energy, while all EU countries aimed at a 15% reduction in their gas consumption, between August 2022 and March 2023 they accomplished an 18% reduction, overachieving their target. The voluntary reduction target was extended by Member States for another year in March 2023, as suggested by the Commission.

In order to minimise the need for gas, the EU is pressing on its investing in renewables. In March 2023, the EU escalated its renewables capacity 2030 target of 42.5% to 45% by voting firmer legislation, nearly doubling the percentage of green energy in the EU as of Q1 2023. To that end important intermediate targets have been achieved in increasing the available production and capacity[43]:

[43] European Commission. 2022. “REPowerEU: affordable, secure and sustainable energy for Europe.” https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en.

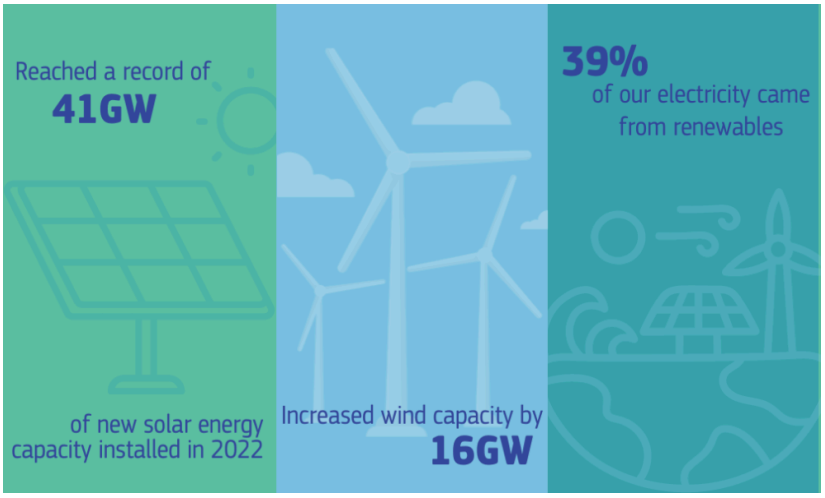


Figure 7: Production and capacity increase of RES in the EU over 2022[44]

**REPowerEU funding**

In order to achieve its goals, the REPowerEU plan is in need of massive financing and reforms. It is deploying nearly €300 billion of which €72 billion in grants and close to €225 billion in loans with the Recovery and Resilience Facility (RRF) being the main financial instrument.

Between February 2020 and 31 December 2026 the member states are using the RRF as a provisional instrument to fund reforms and investments. All EU countries are able to receive subsidies up to a maximum amount agreed in advance, after submitting recovery and resilience plans, defining clearly with milestones and targets the actions they plan to make. The plans need to distribute at least 37% of their financial plan to green measures and 20% to digital initiatives. The RRF only renumerates the amounts to each country upon achieving the agreed milestones and targets included in their plan[45].

**REpowerEU in Greece**

The EC assessed positively the Greek modified recovery and resilience plan, which includes a REPowerEU chapter. The plan is valued at €35.95 billion, with €18.22 billion in RRF grants and €17.73 billion in RRF loans.

The new version of the plan allocates 38.1% of its budget, 0.6% more than the original, on the green transition, funding initiatives that support climate objectives.

Overall, the plan reinforces the ambition to decarbonise the economy by boosting energy efficiency and renewable capacity. To that end, Greece reduced its gas consumption by 22% between August 2022 and March 2023, outperforming both the EU average (18%) and the legal obligation of 15%.

[44] European Commission. n.d. “The Just Transition Mechanism - European Commission.” European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en.
[45] European Commission. n.d. “Recovery and Resilience Facility - European Commission.” https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility_en.

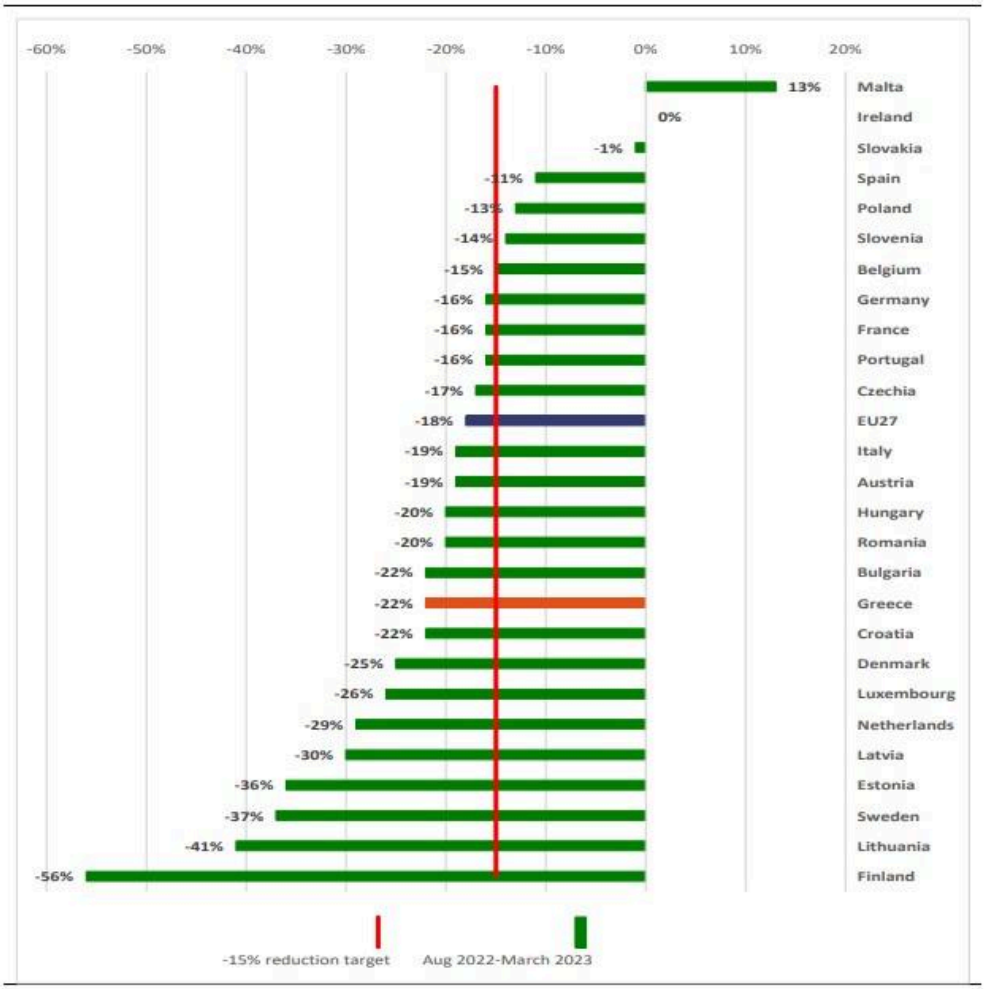


Figure 8: Natural gas demand reduction of EU countries[46]

The reforms aim to promote the production of renewable hydrogen and bio-methane, improve land and sea spatial usage for RES development, ease energy sharing, reinforce self-consumption while launching new non-grant based financial tools to extend the backing of energy efficiency investments. Additionally, energy efficiency measures such as the Exoikonomo(Saving at home) residential building renovation program are receiving notable investments partially financed under the RRP. After more than 87,500 approved renovations following the call were made, the expected cutback of the primary energy consumption according to Energy Performance Certificates, reached on average 75,8% according to data provided by the Greek ministry of Environment and Energy in a report to the EC regarding the Milestone 21 of Greece's RRP.

Support for carbon capture and storage infrastructure, pilot projects for bio-methane and renewable hydrogen production and the scaling up of an existing measure to increase energy storage capacity are some of the other investments included. Moreover, after Greece's request for additional loans, a commitment was made for at least 38.5% of the funds in support for the climate transition to be invested by financial institutions.

Finally, through expanding energy storage capacities and the preliminary inspection of seismic resistance of public sector buildings and other infrastructure, Greece's RRF is

[46] 2023. "REPowerEU – one year on." Energy - European Commission. https://energy.ec.europa.eu/publications/repowereu-one-year_en.

contributing towards addressing the country's socio-economic challenges and making the country more resilient[47].

Despite the fact that REpowerEU does not directly affect the energy transition of the Greek islands it is clear that by promoting RES investments, energy efficiency measures and bio-fuels, just to name a few, in Greece the islands get a significant proportion of both the direct aid such as funds and RES investments and the indirect like protection from imported fuel price fluctuations and technical expertise from nation and EU experts alike.

## Clean energy for EU islands

In response to global energy changes, on November 30th, 2016, the European Commission presented a package of measures aimed at maintaining the EU's competitiveness. In addition to the adoption of measures for the energy transition towards clean energy sources, the goal is also to maintain the central role of the EU in the sector.

Thus, in the context of the collection of measures "Clean energy for all Europeans", in May 2017, the European Commission concluded an agreement with 14 Member States, which includes Greece, in order to launch the "Clean energy for its islands" initiative. The "Clean Energy for EU Islands" initiative is part of the European Union's wider Clean Energy package, which aims to achieve the Union's climate goals. This initiative provides a long-term framework to support European islands in creating their own low-cost sustainable energy.

The Secretariat of the initiative provides comprehensive guidance to the islands to initiate and promote their transition to clean energy. It includes a stakeholder engagement methodology, support in preparing the transition agenda, capacity building, technical support for projects and financial plans and networking and community building opportunities. The selection of islands participating in the declaration was based on their geographical location, existing energy infrastructure and their degree of dependence on fossil fuels[48].

Another aspect of the selection process of the European Commission was based on their strong political commitment and enthusiasm for multilateral cooperation in the field of energy transition, as well as their high potential. The aim is to act as successful models for other islands, ensuring their energy autonomy. In this way, a reduction in energy costs and greenhouse gas emissions is achieved, while at the same time improving the quality of life of residents and their visitors.

A significant number of European islands have already published their clean energy transition agendas, with an emphasis on citizen participation. These transition agendas showcase the successful partnerships among island residents, both locally and internationally. There is effective collaboration with EU island communities to advance the European Green Deal, utilising this initiative along with other EU efforts to support a community-led energy transition.

The transition agendas are composed by island transition teams, supported by the EU Islands Clean Energy Secretariat. Below are the Greek ones:

[47] "Commission endorses Greece's €35.95 billion modified recovery and resilience plan, including a REPowerEU chapter." 2023. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_5914.

[48] European Commission. n.d. Clean energy for EU islands: Clean energy vision to clean energy action. https://clean-energy-islands.ec.europa.eu.

- Andros municipality in cooperation with the Network of Sustainable Greek Islands (DAFNI) applied to the Clean energy for EU islands technical assistance in March 2022, with the goal to develop a CETA. This CETA is a strategic roadmap for the clean energy transition, in which the local community must be involved.

- Chios has developed its CETA between 2021-2022 as part of the technical assistance received from the Clean energy for EU islands secretariat. In addition, the island already puts planning into action through a new project on circular and sustainable desalination, again by taking advantage of the second round of technical assistance provided by the Islands secretariat in 2022.

- Crete is evaluating the potential production of local RES from livestock and other organic wastes that are available on the island. In particular, the island requested the Islands secretariat to investigate biogas-treatment facilities on various input streams and of different capacities taking into account the limitations on the island. Crete is also one of the islands titled “Pilot” or “Pioneering” for their initiative.

- Ikaria, Psara, Astypalaia and Lesvos are some of the Greek islands with participation in the 30 for 30 initiative. In other words, they are some of the 30 islands and island groups in the EU aiming to achieve complete energy independence by 2030.

- Kassos sought assistance in evaluating the financial viability of transforming the island into a sustainable one. The EU Islands Secretariat also provided technical support by reviewing various technologies to enhance the buildings of the island.

- The municipality of Kastellorizo in coordination with the Network of Sustainable Greek Islands, DAFNI, applied to the Clean energy for EU islands technical assistance in March 2022, with the objective to develop a CETA, acquiring a strategic roadmap for the clean energy transition process designed by the local community.

- The islands of Kos, Kythira and Sifnos applied for the technical assistance of the Clean energy for EU islands secretariat during the second call in April 2022, in order to get support for the development of a CETA for the island. Sifnos is also a “Pilot” island.

- The Municipality of Megisti and the islands of Syros and Spetses applied to the Clean Energy for EU Islands Secretariat for Technical Assistance in March 2022, with the objective of developing a CETA, in order to acquire a strategic roadmaps for the clean energy transition process designed by the local communities. Megisti is also part of the 30 for 30 initiative.

- In 2020, Samos created its CETA in line with the instructions of the Secretariat. The plan's second stage (2023-2027) emphasises storage systems for the Samos grid, which remains non-interconnected to the mainland. This report aims to examine the technical and financial feasibility of various storage options (e.g., batteries, pumped hydro) and their ability to facilitate the integration of renewable energies into the island's grid. As a result, Samos is designated as a "Pilot" island.

- The study on Symi investigated the techno-economic pre-feasibility of implementing a solar thermal hot water system in the main town area on the island.

- Thira received technical assistance from the Clean energy for EU islands secretariat to assess cold ironing applications for the ferry responsible for the Thira-Thirasia connection.

- Trizonia as of Q4 of 2023 has only signed the pledge of the Clean energy for EU islands secretariat to participate in the initiative[49].

**Tilos, the first energy autonomous island in the Mediterranean.**

The "Technology Innovation for the Local Scale", or T.I.L.O.S., project was part of the European Research Project Horizon 2020 and Eunice Energy Group and aimed to create and manage a smart and innovative micro-electric power system on the island of Tilos in the Dodecanese. This system relies on the hydrological principles of renewable energy sources (wind and solar) and advanced technology accumulators. The primary goal was to fulfill the electricity requirements of the Livadian community, consisting of approximately 500 residents on Tilos island.

The TILOS project experimented with integrating an innovative local-scale molten-salt battery (NaNiCl2) energy storage system into a real grid environment. This project evaluated smart grid control systems and their ability to provide various services, including microgrid energy management, maximisation of renewable energy penetration, grid stability, guaranteed energy exports and ancillary services to the main grid. The battery system supports both stand-alone and grid-connected operations, ensuring interoperability with other microgrid components and effective demand side management.[50]

Social issues were well considered through public engagement and by developing novel business models and policy instruments which led to the smooth adoption of the technologies from the local community. After implementation, Tilos Island became largely free from fossil fuel-based electricity generation while simultaneously satisfying the consumption needs of the community. The islands gained international recognition for the pioneering project which led to multiple awards, the latest being the 3rd place in the RESponsible Island Prize of the EC.[51]

**Chalki**

On May 19, 2021, the first energy community in the Dodecanese, ChalkiOn, was founded on Chalki. The project included actions such as the increased use of RES, the creation of digital infrastructure, the promotion of energy efficiency, the sustainable management of waste and water, e-mobility and electrification of transport, the green transformation of

[49] European Commission. n.d. “Clean energy for EU islands.” Energy (europa.eu). https://energy.ec.europa.eu/topics/markets-and-consumers/clean-energy-eu-islands_en.
[50] European Commission. TILOS Technology Innovation for the Local Scale, Optimum Integration of Battery Energy Storage. https://wayback.archive-it.org/12090/20190928064615/https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-energy/storage/tilos.
[51] Eunice Group. n.d. “Eunice islands.” https://eunice-group.com/projects/tilos-project/.

agriculture and tourism as well as the development of port and other infrastructure through targeted interventions and tailor-made programmes of the Ministry of Environment and Energy and the co-competent Ministries, under the "umbrella" of the NECP.

The ultimate goal of the Energy Community is to contribute to sustainable economic and social development for all, starting from the grassroots of the local community. In this endeavour, first in the Dodecanese, the constant cooperation with national and European institutions for the development of technologies and innovations is maintained and expanded, including participation in projects and actions, especially in matters of energy, circular economy and environmental management. With the sponsorships and donations of numerous private and public companies, but also thanks to the support of the government at central and regional level, Chalki's Energy Community has a fully operational solar power plant with an installed capacity of 1 MW, which can cover the community's annual electricity needs.

The members of the Energy Community benefit in particular through the process of Virtual Net Metering with reductions of €180.000 – €250.000 per year, 55% in electricity bills for residents, businesses and the Municipality of Chalki (namely the competitive part of the provider's energy bill), 1.800 tons of CO2, €215.000 per year in services of general interest through the substitution of thermal production plants and €120,000 per year through carbon-free emissions or costs = €60/ tn CO2.

**Astypalaia**

Astypalaia, through a collaboration between the Greek government and Volkswagen[52], serves also as a pilot project to showcase how cutting-edge technologies can be integrated to create a more sustainable and efficient energy system. The initiative encompasses various aspects, including renewable energy adoption, smart mobility solutions and overall environmental sustainability.

One key component of the program involves transitioning the energy infrastructure of the island towards renewable sources. This often includes the installation of solar panels, wind turbines and other clean energy technologies to generate electricity. The goal is to reduce dependency on traditional fossil fuels, lower greenhouse gas emissions and create a more resilient and sustainable energy grid.

Smart mobility solutions are another integral aspect of the program. This may involve the introduction of EVs, charging infrastructure and intelligent transportation systems. The aim is to promote cleaner and more efficient modes of transportation, reducing the carbon footprint associated with traditional vehicles and contributing to improved air quality on the island.

Furthermore, the Smart and Sustainable Island program often includes the implementation of digital technologies and data-driven solutions. Smart grids, energy management systems and the integration of IoT devices may be utilised to enhance energy efficiency, monitor and optimise resource usage and improve overall island management.

The collaboration between the Greek government and Volkswagen on Astypalaia is a tangible example of such a program in action. Through this partnership, the island is being developed as a showcase for sustainable living, where advanced technologies are leveraged to create a harmonious balance between human activities and the environment. This initiative is not only about technological advancements but also about fostering a culture of

[52] “Smart & Sustainable Island.” n.d. Smart & Sustainable Island: Home. https://smartastypalea.gov.gr.

environmental awareness and sustainable practices among the island's residents and visitors.

## NECP

A key tool of the governance mechanism is the National Energy and Climate Plans[53] for the period 2021-2030. Every two years, each member state submits a progress report, while strict adoption of long-term national strategies to meet the goals of the Paris Agreement (2015) is required. The NECP acts as a progress guide for each member state's compliance with the EU's energy and climate policy, in order to achieve the targets by 2030. The targets are quantified and budgeted, with foreseen intermediate monitoring intervals.

The Union focuses on 5 key areas so that it can meet its energy targets for the next decade.

- Energy security, with solidarity and trust between member states.
- Operation of a fully integrated European energy market, ensuring the free flow of energy in the EU, with appropriate infrastructures and without obstacles.
- Enhancing energy efficiency to reduce demand and dependency on energy imports.
- Decarbonising the economy, reducing emissions and transitioning to a low carbon economy.
- Promotion of research in relevant technologies, promotion of clean forms of energy, innovation and competitiveness for the energy transition.

The goals must be addressed as a whole, as they are interconnected, complementary and overlapping. Their achievement is influenced by many factors and implemented at many levels. Policy and governance must be combined in the most effective way to implement them. The transition to a low-carbon and energy-efficient economy is underway and Europe is moving towards full fulfilment of its Paris Agreement commitments. The transition must be fair, open to all and leave no state, region or person behind. Appropriate funding should be focused on trans-European network infrastructure, energy storage technologies, "smart" and sustainable transport, low urban heating emissions, combating energy poverty and sustainable "green" investments in general.

## Greek NECP

Greece’s energy and climate policy aims to achieve net-zero emissions by 2050 while ensuring energy security, improving economic competitiveness and protecting vulnerable consumers. The NECP, is the main document that describes the energy and climate agenda through 2030 with specific targets and supporting measures to make the country achieve net zero emissions. Greek energy policy focuses on an increased share of RES in electricity

[53] European Commission. 2023. https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en?prefLang=el.

generation, while at the same time boosting the energy demand covered by electricity, especially for transportation, heating and cooling.

Aligned with the goals of the EU, Greece has established ambitious goals for the integration of RES in electricity production. The targets include reaching a 50% RES penetration by 2030 and an 85% penetration by 2050, a significant increase from the 35% achieved in 2020. Additionally, there are plans for substantial growth in the electrification of the economy, aiming for approximately 45% by 2050, compared to the 27% recorded in 2020. To expedite essential energy projects, Greece is actively utilising funds from initiatives such as the RRF and REPowerEU[54].

In order to achieve its electrification target and minimise fossil fuel exposure, the government has led the way by paving the way with the public authorities initiative Law No.4342/2015 which includes specific provisions with regard to energy efficiency in public buildings. In line with these efforts, a draft "Green Public Procurement Action Plan" has been issued and the "Elektra Fund," a special energy efficiency fund, has been established to provide loans to public sector entities.

Moreover, Law No.4513/ 2018 introduced the concept of Energy Communities which could benefit from special provisions such as virtual net-metering. However, some of those beneficial regulations were gradually cancelled.

While the concept of “prosumer" is not legally defined, the term “autonomous producer" bears many similarities. Virtually, only PV “autonomous producers” can benefit from a net-metering scheme.

Furthermore, a number of subsidies and tax regulations have been introduced to promote the development of small hydro power plants, CHP plants, hybrid plants and other RES specifically for autonomous production as well as specific RES H&C technologies (geothermal, aerothermal heat pumps and biomass (pellets), solar thermal, solar water heaters and solar heating) and biofuels production. On top of that, a Biofuel Quota (Law No. 3054/2002) was instituted where producers and distributors of petrol and diesel are obliged to blend their fuels with a certain amount ("quota") of biofuels.

The tax regulations and subsidies also address the e-mobility policies of the EU both on the purchasing of such vehicles and on the buildout of RES-T infrastructure for the charging of e-vehicles (Programme “Kinoumai Ilektrika”) which supports the installation of charging stations for personal vehicles.

In addition, as far as feed-in tariffs are concerned, RES plants below 400 kW on interconnected islands and all RES on NIIs are eligible. Further, Feed-In premium tariffs are in place for RES and CHP plants on interconnected islands that participate in the electricity market and can be supported by a sliding feed-in premium[55].

In the NECP of Greece[56], emphasis is placed on the Ten-Year Development Plan of IPTO[57] outlining the enhancing of interconnection capacity to boost collaboration with the European electricity market and facilitate the desired transformation into a net electricity supplier of the EU as well as the South-East Mediterranean region. The government has expressed its intention to double the interconnection capacity with Bulgaria, Turkey, Italy and

[54] “National Energy and Climate Plan.” n.d. Energy.
https://energy.ec.europa.eu/system/files/2020-03/el_final_necp_main_en_0.pdf.
[55] European Commission. n.d. “Policies in Greece.” Clean energy for EU islands.
https://clean-energy-islands.ec.europa.eu/countries/greece/legal.
[56] “Greece - Draft Updated NECP 2021-2030.” 2023. European Commission.
https://commission.europa.eu/publications/greece-draft-updated-necp-2021-2030_en.
[57] IPTO. n.d. Ten-year Network Development Plan | IPTO.
https://www.admie.gr/en/grid/development/ten-year-development-plan.

North Macedonia, triple the interconnection capacity with Albania and establish connections with Egypt[58], Cyprus-Israel[59] and Germany[60].

Additionally, IPTO aims to interconnect all significant islands with the mainland grid, aiming to ensure a reliable and high-quality power supply. Additionally, the plan involves expanding the capacity for integrating up to 29 GW of RES plants into the energy mix by the end of the decade. This interconnection expansion aims to facilitate the decommissioning and phase-out of oil-fired power plants, ultimately contributing to a reduction of 1.8 million tons of CO2 emissions every year in greenhouse gas (GHG) emissions[61].

On the other hand, HEDNO is working on supplementary interconnection initiatives[62], which involve the modernisation and advancement of substations, distribution centres, cables, expansion of the smart meters penetration in the market and the grounding of overhead cable connections on islands that are expected to reform Greece's energy infrastructure.

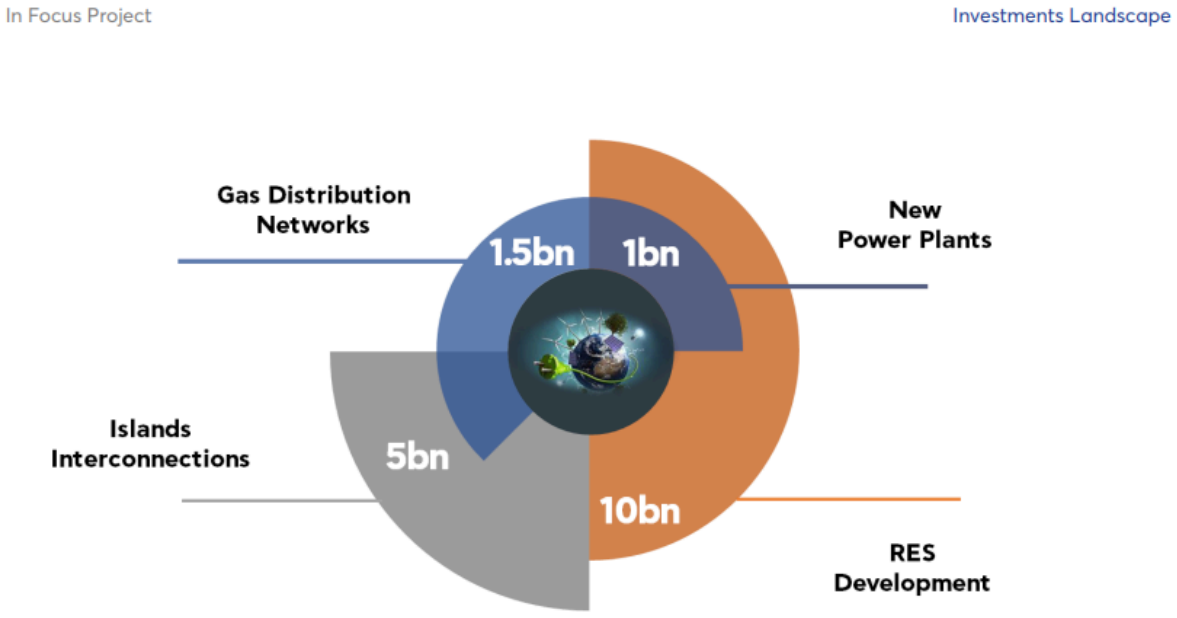


Figure 9: Major investments in Greece for projects planned to be operational by 2030.[63]

To improve the efficiency and functionality of its electricity market, Greece enacted major reforms in 2020, creating three wholesale electricity spot markets (day-ahead, intraday and balancing) along with a derivatives market. Further reforms have enabled Greece's complete integration into the European common electricity market, including participation in the

[58] Copelouzos Group. n.d. "GREGY Interconnector." "GREGY" Interconnector - Copelouzos Group. https://www.copelouzos.gr/en/service/gregy-interconnector/.
[59] EuroAsia Interconnector. n.d. "At Glance." EuroAsia Interconnector. https://euroasia-interconnector.com/at-glance/.
[60] "Talks for Green Aegean link, from Greece to Germany, gain momentum | ENERGYPRESS." 2023. Energypress.eu. https://energypress.eu/talks-for-greek-german-green-aegean-project-gaining-momentum/.
[61] HAEE. 2023. "ASSESSING THE ENERGY TRANSITION OF THE GREEK ISLANDS." inFOCUS. https://www.haee.gr/media/5374/haee_2023_infocus_issue_4_standard_final.pdf.
[62] HEDNO. n.d. Strategic Planning | HEDNO. https://deddie.gr/en/deddie/i-etaireia/stratigikos-sxediasmos/.
[63] "Accelerating Energy Transition Investments." 2022. Hellenic Association for Energy Economics. https://www.haee.gr/FileServer?file=19ccae58-70ab-4fe7-a52b-b5a677729d05.

European intraday market coupling in December 2022 and the launch of the demand-side management market in September 2022. Significant advancements have also been made in Greece's gas market, with the introduction of a natural gas spot market in March 2022 being a notable accomplishment.

**Decarbonisation Fund**

A crucial instrument in attaining the goal of climate neutrality by 2050 and meeting the energy and climate targets by 2030 is the Decarbonisation Fund designed for the Greek islands, as outlined in article 10a(9) of the ETS Directive. This initiative enables Greece to lay claim to a maximum of 25 million allowances within the EU emissions trading system, which can be utilised to co-finance projects aimed at facilitating the decarbonisation of their electricity generation. Noteworthy advancements have been made in Q1 2023 regarding the finalisation of the trilateral cooperation agreement involving the EC, the European Investment Bank and Greece. Once the project proposal is completed, it will be submitted, along with all pertinent supporting documentation, for approval by the EC.

Kostas Andriosopoulos, professor at the Audencia Business School and CEO of Akuo Energy Greece, estimated that funds to be made available from the decarbonization fund for the island energy transition may reach 4 billion euros, beginning with 2 billion euros, based on current emission right prices.

**Greco islands**

The Greek Government's GR-eco Islands national initiative is another financial instrument of the NECP that aspires to turn Greek islands into examples of green economy, energy independence, digital innovation and environmentally-friendly transportation. Its vision is translated into a set of aspirations categorised into 7 key areas:

- transition to sustainable energy
- responsible management of resources
- safeguarding the environment
- fostering entrepreneurship and innovation
- embracing digital transformation
- ensuring accessibility
- empowering human resources

To attain these goals, a range of measures must be executed on the islands and the funding for these initiatives will come from targeted subsidies and tailor-made programs, with over 150 million euros already secured from European funding sources.

The initial phase of the "GR-eco Islands" Initiative concentrated on small, non-interconnected and/or isolated islands. This selection was based on population-related criteria, as well as considerations such as their planned connection to the mainland power grid, energy requirements, tourism volume and accessibility. A crucial future criterion will be each island's commitment to implementing necessary interventions based on their technical and economic feasibility. This commitment will lead to the formulation of the GR-eco Islands

Charter, outlining criteria, levels/categories, standards, procedures, monitoring and ultimately the GR-eco Islands Label.[64]

## The effects of the above policies

Greece has reduced its reliance on fossil fuels for energy supply, particularly through the decreased use of lignite for electricity generation. Despite this progress, fossil fuels still dominate Greece's energy sources, necessitating significant efforts to cut fossil fuel demand to meet GHG emissions targets. From 2010 to 2021, fossil fuels' share in energy supply dropped from 90% to 82%, compared to the IEA average of 78% in 2020. Between 2005 and 2021, lignite-fired generation decreased from 60% to 10%, lowering the carbon intensity of electricity production. Gas-fired generation and growth in wind and solar photovoltaics were mainly used for the balancing of the lignite based electricity.

The country achieved most of its 2020 energy and climate targets. However, a major factor for the decline in energy demand and GHG emissions was the country's protracted economic crisis and the Covid-19 pandemic[65] but, even though demand following the lifting of pandemic restrictions is in pre-pandemic level, as previously mentioned, there was a 22% reduction in gas consumption between August 2022-March 2023 or 4% above the decrease achieved at EU level[66].

## SWOT analysis of the current situation

### Strengths

- EU and Government Commitment
- Renewable Energy Potential
- Geopolitical Position

**EU and Government Commitment**

The Greek government has demonstrated a firm commitment to the energy transition and has recognized the need to shift towards sustainable and renewable energy sources in order to mitigate climate change and ensure energy security. Greece has set ambitious targets and adopted comprehensive policies to drive the transition to a cleaner and more resilient energy system, with a focus on promoting environmental sustainability and reducing carbon emissions.

One of the main pillars of Greece's commitment is the emphasis on RES. The government has set clear and ambitious targets for the expansion of renewable energy capacity in order

[64] The United Nations. "The "GR-eco Islands" Initiative – Promoting sustainable development, green economy, energy autonomy and digital innovation in the Greek Islands by 2030 | Department of Economic and Social Affairs." Sustainable Development. https://sdgs.un.org/partnerships/gr-eco-islands-initiative-promoting-sustainable-development-green-economy-energy#description.

[65] International Energy Agency. n.d. Executive summary – Greece 2023 – Analysis - IEA. https://www.iea.org/reports/greece-2023/executive-summary.

[66] 2023. "REPowerEU – one year on." Energy - European Commission. https://energy.ec.europa.eu/publications/repowereu-one-year_en.

to significantly increase its share in the country's energy mix. This commitment is in line with international agreements and demonstrates Greece's commitment to meeting and exceeding the climate targets set by the European Union.

Furthermore, the Greek government has introduced a number of regulatory measures and financial incentives to encourage private investment in renewable energy projects. Streamlining permitting processes and offering favourable financing options have facilitated the growth of solar, wind and other renewable energy projects across the country. This not only accelerates the energy transition, but also stimulates economic development and job creation in the burgeoning green energy sector.

In addition to promoting renewable energy, Greece has also made significant strides in energy efficiency measures and the electrification of transportation. These initiatives contribute to a more sustainable and resilient energy ecosystem while reducing dependence on traditional fossil fuels.

Overall, Greece's commitment to energy transition is evident through its holistic approach, encompassing policy frameworks, regulatory support and financial incentives. By embracing a greener energy future, the Greek government is not only safeguarding the environment but also positioning the country as a leader in the global transition towards a more sustainable and carbon-neutral future.

**Renewable Energy Potential**

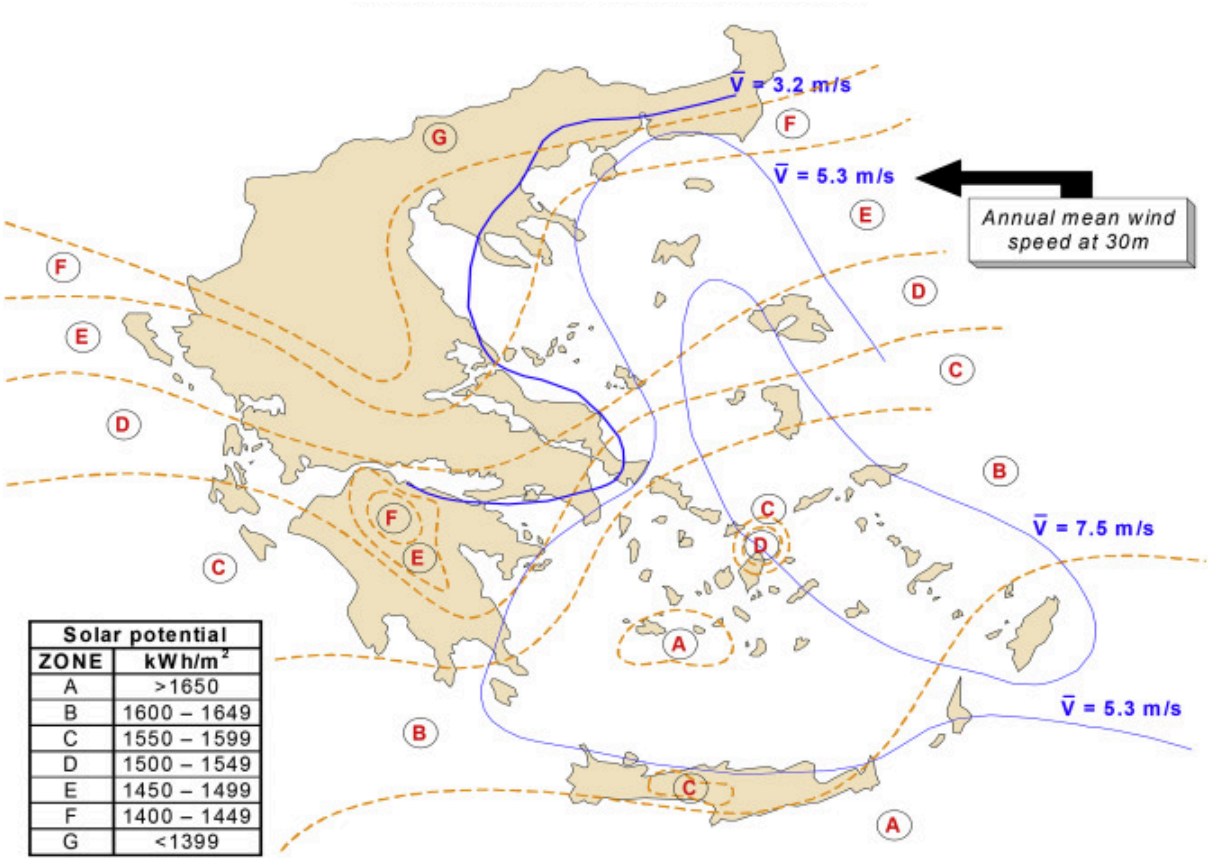


Figure 10: Wind and Solar energy in Greece[67]

[67] Kaldellis, J. K. and D. Zafirakis. 2020. “Prospects and challenges for clean energy in European Islands.The TILOS paradigm.” ScienceDirect. https://doi.org/10.1016/j.renene.2019.08.014.

Greece has significant potential for renewable energy sources, including solar, wind and hydropower. The annual global irradiation on the horizontal plane ranges from 1500 kWh/m2 in northern Greece to over 2000 kWh/m2 in central and southern Greece and the Aegean Sea islands.

Certified wind potential measurements conducted nationwide indicate high wind potential, with mainland Greece recording numerous sites with an annual average wind velocity around 7 m/s. Insular Greece boasts even more impressive wind resources, with several Aegean Sea islands experiencing annual average wind velocities exceeding 8.5 m/s and some even surpassing 11 m/s, leading to potential annual final capacity factors of over 50%.

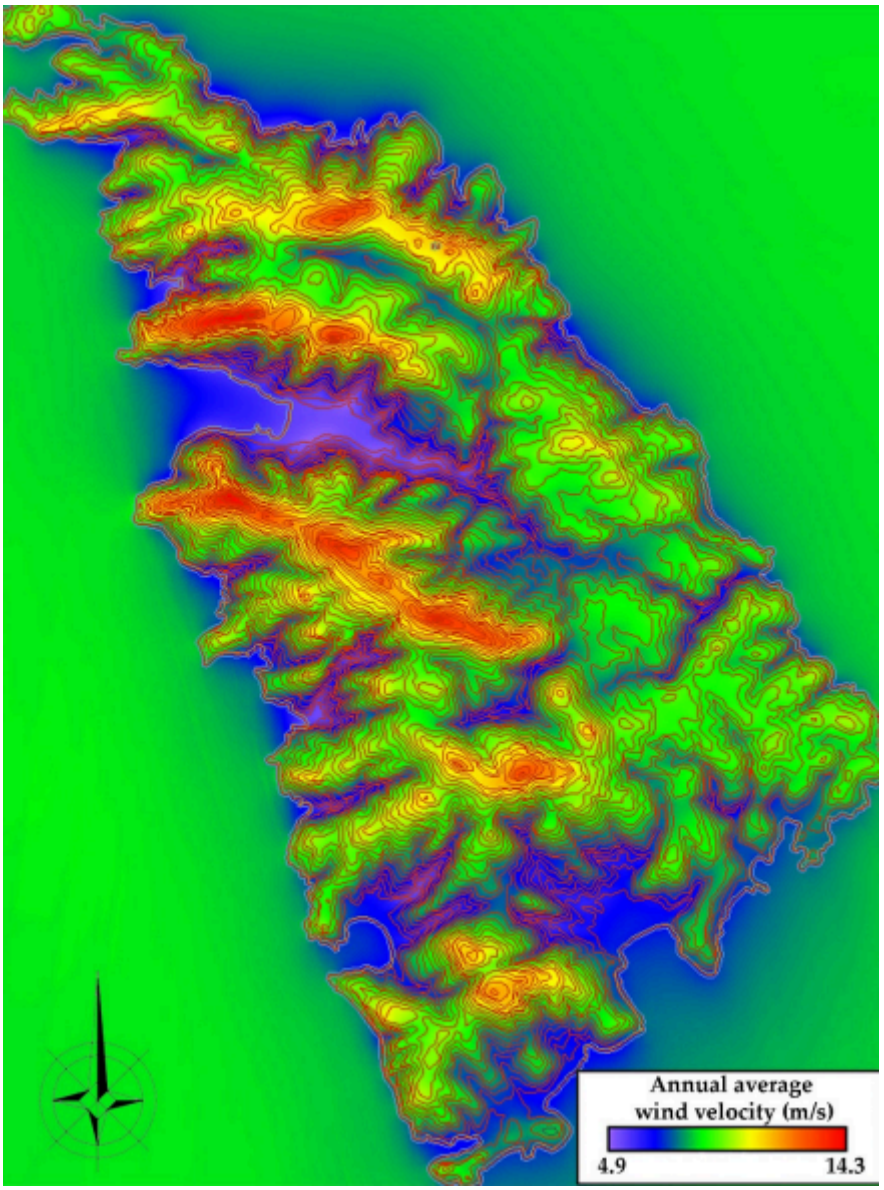


Figure 11: Annual average wind velocity map for the island of Sifnos.[68]

[68] Katsaprakakis, Dimitris Al., Antonia Proka, Dimitris Zafirakis, Markos Damasiotis, Panos Kotsampopoulos, Nikos Hatziargyriou, Eirini Dakanali, George Arnaoutakis and Dimitrios Xevgenos. 2022. "Greek Islands' Energy Transition: From Lighthouse Projects to the Emergence of Energy Communities" Energies 15, no. 16: 5996. https://doi.org/10.3390/en15165996

In addition to wind and solar potential, major Greek islands like Crete, Rhodes, Lesvos, Chios, Kefalonia, Corfu and Samos possess extensive biomass resources, primarily from agricultural and livestock activities, supplemented by organic urban waste. For instance, Crete could replace the diesel oil needed for its annual indoor heating with its biomass resources 2.4 times over.

Furthermore, certain Greek islands feature substantial high enthalpy geothermal fields. Milos' geothermal potential is capable of generating 150 MW of electrical power output while being certified as economically viable. Similarly, Nisyros, has a verified geothermal potential capable of providing 50 MW of electrical power output, while Lesvos has an estimated potential output of 10 MW.

As of March 2022, licences for a total nominal power of 89.5 GW were granted for RES electricity production and energy storage projects in Greece, or about 7.8 times more than the annual peak demand for the entire country. This reveals a significant gap between licensed power and actual demand, indicating intense investor interest in RES and energy storage projects. The concentration of most licensed projects in Greek islands reflects the optimal conditions for wind and solar energy in these regions. Nevertheless, the high licensed power also underscores the lack of centralised or local strategic plans for project construction and the smooth implementation of the energy transition, considering the impracticality of implementing all licensed projects due to lower electricity demand and various restrictions[69].

**Geopolitical Position**

Thanks to Greece's exceptional RES potential, the government has set as its target to make the country a green energy provider to the EU and the neighbouring countries, creating, during the process, a whole new exporting industry and upgrading the status of the country into an energy hub and thus a provider of energy stability.

Since October 2004, the Greek Transmission System has been re-operating simultaneously and in parallel with the interconnected European Transmission System under the general coordination of ENTSO-E. The parallel operation of the Greek Transmission System with the European one is achieved through interconnecting transmission lines, mainly 400 kV, with the Systems of Albania, Bulgaria, North Macedonia and Turkey. In addition, the Greek Transmission System is connected asynchronously via a 400kV direct current submarine link with Italy. Through the above international connections and others that are under development, the country taps into new markets leading to the sustainability of new investments towards the energy transition becoming economically viable.

Electricity interconnections

The emergence of Greece as a regional energy hub is inseparably linked both to the strengthening of the domestic electricity production potential and electricity storage systems and to the energy interconnections with all adjacent countries. As far as electricity is concerned, the development of new interconnections and the reinforcement of existing ones is foreseen. The key projects of national and international interest are the following:

[69] Katsaprakakis, Dimitris Al., Antonia Proka, Dimitris Zafirakis, Markos Damasiotis, Panos Kotsampopoulos, Nikos Hatziargyriou, Eirini Dakanali, George Arnaoutakis and Dimitrios Xevgenos. 2022. "Greek Islands' Energy Transition: From Lighthouse Projects to the Emergence of Energy Communities" Energies 15, no. 16: 5996. https://doi.org/10.3390/en15165996

First, the strengthening of the domestic transport system which has gained new momentum as energy exports in the future make its expansion, upgrading and modernization projects a priority.

The new interconnection between Greece and Bulgaria which was put into operation in June 2023 and related to the implementation of a second interconnecting line between the two systems which is carried out with an aerial interconnecting 400 kV between N. Santa and Maritsa East 1.

The strengthening of the Greece-Italy interconnection where the TSOs in Greece and Italy jointly prepared a Feasibility Study to achieve an increase in transmission capacity between their systems. Based on the results, it was decided as the most appropriate and optimal techno-economic solution for the implementation of the second interconnection, the implementation of a new bipolar DC link with a nominal power of 1000 MW with voltage converter technology and return by sea (bipolar VSC HVDC with sea-return ) or alternatively via a metal return pipe. The project has been included in the most recent Ten-Year Development Plan of the System Operator (2024-2033), as well as the ENTSO-E Ten-Year Plan, while its completion time horizon is 2031.

In April 2020, IPTO initiated a collaboration with Albania's System Operator to explore the development of a new connection between Greece and Albania. Following this, preliminary market and network studies, along with a cost-benefit analysis, were conducted, leading to the decision to proceed with a new 400 kV interconnection, slated for completion by 2030. This overhead 400 kV single-circuit line will have a nominal transmission capacity of 2000 MVA and span approximately 170 km. The interconnection is expected to boost transmission capacity between the two countries by at least 200 MW in each direction, facilitating greater integration of renewable energy sources, enhancing market integration and supporting the transition to a climate-neutral Europe.

The project to interconnect the transmission systems of Greece, Cyprus and Israel with direct current links, includes two sections, namely the Israel-Cyprus and the Cyprus-Greece (Crete) interconnection. The cable's total length is estimated at 1208 km, with a power of 1 GW and an estimated cost of €2.4 billion. The project is managed by IPTO and is in the maturation phase, while it has received funding of €657 million from the Connecting Europe Facility.

Regarding the implementation of the extension of the Greece-Turkey interconnection, in March 2022, IPTO and the Turkish Electricity Transmission Corporation agreed on the implementation of the new interconnection of 400 kV, with a completion horizon of 2029. The new interconnecting overhead 400 kV single circuit between Nea Santa and Babaeski, will have a nominal transmission capacity of 2000 MVA and is estimated at a total length of about 130 km. The new interconnection is predicted to increase the transmission capacity by 600 MW in both directions, allow the penetration of more RES into the Greek System and strengthen the convergence of markets with neighbouring countries.

The project which was proposed by IPTO and the Administrator of North Macedonia (MEPSO) was the upgrade of the interconnection of 400 kV Meliti-Bitola. This project was initially included in TYNDP 2018 (under consideration), with an implementation horizon after 2030, while it was resubmitted to the Pan-European Ten-Year Development Program, TYNDP, 2020 as a project under consideration where the feasibility of implementing this connection will be examined in the next period.

For the Greek-Egyptian Interconnection, the GREGY Interconnector project has been proposed for inclusion in the PMI project list and both IPTO and RAEWW have declared their support. In October 2021, a memorandum of cooperation between Greece and Egypt

was signed, on the basis of which a high-level working group was established, with the participation of representatives of the two Ministries, the TSOs and the Regulatory Authorities, which will examine the technical and financial parameters of the project, will facilitate the licensing and support its classification as a project of European interest. In May 2021, the inaugural meeting between the Administrators of the two countries took place and a working group was established to prepare the project. In this context, IPTO and EETC (Egyptian Electricity Transmission Company) also signed a Memorandum of Understanding as well as a Cooperation Agreement

Finally, the design of the Greece-Germany interconnection (Green Aegean Interconnector) is planned to have a transmission capacity of 3 GW of green energy and while being further developed to 6 - 9 GW later on. This is energy that will be funnelled from the Eastern Mediterranean and Egypt to Southern Europe. The proposed route involves an undersea crossing from Greece via the Adriatic to Slovenia and then via an overland route to Austria and Southern Germany. The project has an initial budget estimate of €8.1 billion and it will be submitted for inclusion in the ENTSO-E 10-year plan (TYNDP 2024). The TSOs involved have expressed their willingness to work together to mature the project.

Development of natural gas interconnections

An additional chapter of Greece's plan to become a regional energy hub is the development of new natural gas interconnections and the expansion of existing ones with adjacent systems, as well as the development of new natural gas import and transportation systems.

Specifically, the main natural gas projects of international interest concern:

1. the upgrade of the TAP pipeline to 10 bcm/yr by 2027 through and from the installation of an additional compressor in the Serres area
2. increasing the capacity of the Greece-Bulgaria Interconnector Pipeline (IGB) from 3 to 5 bcm/yr by 2025 (project under construction)
3. the implementation of the project of the Alexandroupoli floating LNG station which is under construction and is expected to be put into operation at the beginning of 2024
4. the implementation of the DiorigaGas LNG floating station in Corinth which has matured in terms of licensing and can be the third LNG import point in the southern part of the country
5. the study maturation of the East Med pipeline, the implementation of which depends on the developments regarding the discoveries and studies of the transfer of natural gas deposits of the Eastern Mediterranean
6. the realisation of the interconnection between Greece and the Republic of North Macedonia in 2025 with an initial capacity of 1.5 bcm/yr which is under construction

Finally, in November 2022, the first seismic surveys in the southern Aegean and Ionian seas took place. The data obtained so far point to the existence of promising natural gas deposits in the area[70].

Ultimately, the above developments will provide the Greek islands with reduced energy prices, a prominent role in the production of energy and, as such, energy security and additional sources of income for local societies.

[70] "Greece - Draft Updated NECP 2021-2030." 2023. European Commission. https://commission.europa.eu/publications/greece-draft-updated-necp-2021-2030_en.

## Weaknesses

- Lack of clear strategy coordination and monitoring
- Absence of spatial planning integration into energy planning tailored to islands
- Complicated and lengthy permitting process for RES projects.
- Absence of clear short and midterm strategy on clean energy transition and security of energy supply on the islands
- Excessive rules and regulations that humper the community energy initiatives

### Lack of clear strategy coordination and monitoring

Greece's energy strategy and long term planning are heavily centralised with a distinct lack of vision for its island's energy transition. The NECP primarily focuses on transmission interconnection and reducing carbon emissions from thermal plants as the main measures for the islands. However, the coordination of marine transport, a crucial aspect of energy consumption, falls under the purview of the Ministry of Shipping and Island Policies. There is a noticeable absence of a clear and unified strategy outlining the path for the islands to transition from their current state to becoming sustainable, decarbonised and possessing a secure energy supply. This lack of clarity extends to various aspects such as existing generation, priority clean energy technologies, energy efficiency, road or marine transport and sector coupling projects (water/waste and energy).

Numerous ongoing initiatives are linked to the islands with the encompassing of substantial investments in transmission interconnections and the digitalisation and enhancement of the distribution network being just two among them. Nevertheless, there is currently a lack of unified national coordination for these activities and funds, as well as the coordination of various sectoral policies impacting islands at all the governmental levels. Monitoring the implementation progress and contributions towards NECP goals, as well as the scaling up and replication of successful projects, institutional support and capacity building, are notably absent. Additionally, there is a deficiency in the communication of lessons learned from past projects to minimise implementation errors in the future and integrate them into broader strategic planning at the national level.

The process of energy transition involves the deployment of decentralised clean energy technologies, along with the necessity of incorporating such projects into local or regional plans, including spatial and climate considerations. This demands not only explicit directives from the national government but also the expertise and capability that local and regional authorities frequently lack.

### Absence of spatial planning integration into energy planning tailored to islands

Over the past decade, there have been significant and frequent changes to Greece's national legislation on spatial planning[71], with the most recent modifications introduced

[71] Perperidou, Dionysia – Georgia C. 2021. "Spatial Planning in Greece: from the Past to the Economic Crisis & the Future." International Federation of Surveyors.
https://fig.net/resources/proceedings/fig_proceedings/fig2021/papers/ts08.4/TS08.4_perperidou_11177.pdf.

through the Law 4759/2020, on “Modernization of Spatial and Urban Planning Legislation”[72]. The current framework involves the establishment of local spatial plans at the municipality level, governing land use within a municipality's territory[73]. However, Greek islands lack these local spatial plans, while some are still without updated cadastral plans. The creation of local spatial plans is anticipated as part of the approved NRRP’s pillar addressing the “Energy upgrade of the country’s building stock and spatial reform” although, this plan prioritises the development of local spatial plans primarily in tourist-heavy areas[74].

Furthermore, the Marine spatial plan for Greece is still under development and is expected to be implemented through the Green transition funding under the NRRP[75]. The incorporation of clean energy planning into the Marine spatial plan remains unclear at this stage.

Spatial planning offers national-level guidance for renewable energy projects across the entire territory of Greece through a Special Spatial plan[76]. While these guidelines are explicit, combining them with stringent constraints related to cultural heritage[77] and building preservation leads to a disproportionately adverse impact on the implementation of clean energy transition initiatives on the islands.

Although the Special Spatial plan outlines guidelines, it remains unclear how energy sector planning is integrated into the spatial, urban and marine planning and which locations are prioritised for clean energy projects. Additionally, the absence of existing regional or local energy plans poses a challenge in incorporating energy transition priorities into the preparation of spatial plans. While certain municipalities have voluntarily implemented local energy plans and strategies, such as those aligned with initiatives like the “Covenant of Mayors” or the “Clean energy for EU Islands Secretariat”, there is currently no mandatory requirement for local governments to formulate such plans. The Climate Law adopted in July 2022[78] introduces an obligation for the development of “Regional Climate adaptation” plans and “Municipal Emission Reduction” plans, potentially shedding light on energy priorities.

For instance, continuous energy planning from the perspective of the electricity grid, including the integration of renewable energy projects, occurs within NIIs. HEDNO issues capacity availability[79] based on connected or offered grid connections from generation plans. Investors use this overview to propose locations for the new renewable energy generation plans.

**Complicated and lengthy permitting process for RES projects.**

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[72] “Νόμος 4759/2020 - ΦΕΚ 245/Α/9-12-2020 (Κωδικοποιημένος) - ΠΕΡΙΒΑΛΛΟΝ - ΟΙΚΟΔΟΜΕΣ.” 2020. e-nomothesia.gr. https://www.e-nomothesia.gr/kat-periballon/nomos-4759-2020-phek-245a-9-12-2020.html.

[73] “The Governance of Land Use.” OECD. https://www.oecd.org/regional/regional-policy/land-use-Greece.pdf.

[74] 2023. Pillars & Components - Greece 2.0. https://greece20.gov.gr/en/pillars-and-components/.

[75] European Commission. “Greece | The European Maritime Spatial Planning Platform.” European MSP Platform. https://maritime-spatial-planning.ec.europa.eu/countries/greece.

[76] Perperidou, Dionysia – Georgia C. 2021. “Spatial Planning in Greece: from the Past to the Economic Crisis & the Future.” International Federation of Surveyors. https://fig.net/resources/proceedings/fig_proceedings/fig2021/papers/ts08.4/TS08.4_perperidou_1117

[77] National Archive of Monuments. n.d. “The Archaeological Cadastre.” Navigate in map | Archaeological Cadastre. https://www.arxaiologikoktimatologio.gov.gr/en.

[78] “Νόμος 4936/2022 , κωδικοποιημένος με τον 4986/2022 ΦΕΚ Α 105/27.5.2022.” 2022. Taxheaven. https://www.taxheaven.gr/law/4936/2022.

[79] HEDNO. n.d. Connections of Renewable Energy Sources Plants | HEDNO. https://deddie.gr/en/themata-tou-diaxeiristi-mi-diasundedemenwn-nisiwn/ape-sta-mdn/sundeseis-stathmwn-ananewsimwn-pigwn-energeias/.

In Greece, large projects undergo tenders and auctions, while smaller projects follow an application and approval process. The authorisation procedure for renewable energy projects encompasses five steps:

1. Site selection
2. Certification of the RES producer
3. Administration authorisation
4. Grid connection permit
5. Other, including installation licence and operation licence

Simplified processes have been introduced for stages 4 and 5, as per the provisions of Law 4951/2022. Under this framework, a simplified licensing and permitting process is in place for plants with an installed capacity of less than 1 MW. Furthermore, Law 4951/2022 digitised the DSO application procedure and transitioned the grid connection permit, from a two-step procedure to a single-step.

Nonetheless, clean energy initiatives are still encountering intricate and protracted authorization and permitting procedures. In the wind energy sector, for instance, projects await 8-10 years for approval, significantly surpassing the 2-year target outlined in the Renewable Energy Directive of the EU (2018/2001). Numerous applications for hybrid plants seeking grind connections on NII's are also presently on hold, awaiting regulations to the pricing system to secure a binding offer. Environmental assessments conducted at the project's start lose relevance due to prolonged permitting times. The administrative authorization process, inclusive of various sector approvals, public acceptance considerations and limited grid capacity stand as the primary factors contributing to the sluggish progression. Despite the existence of a digital map cataloguing cultural heritage sites[80], the Ministry of Culture, along with its regional offices, faces an overwhelming number of RES project applications, often necessitating on-site evaluations.

Moreover, small islands encounter difficulties in ensuring the financial feasibility of their low-capacity renewable energy ventures, because of their small energy demand. The constrained energy capacity creates minimal space for a competitive environment as in certain small systems, the mere existence of a single wind turbine with a grid contract to inject power means that there is no remaining capacity for other projects, while even a minor additional power injection could conflict with the contractual rights of the present turbine. Consequently, the progress of energy transition on the island may be impeded due to reserved capacity for a project that is currently on hold in the authorization process and may not align with the needs and priorities of the local islands stakeholders.

**Absence of clear short and midterm strategy on clean energy transition and security of energy supply on the islands**

Presently, the electricity grids on islands lack sufficient capacity to accommodate a higher proportion of renewable energy sources. Although HEDNO has intentions to enhance the grid, securing funding can be challenging, particularly for smaller islands where it may not be economically favourable. The emphasis on implementing measures for energy efficiency and savings is currently not very pronounced. While advanced technologies have the potential to

[80] National Archive of Monuments. n.d. "The Archaeological Cadastre." Navigate in map | Archaeological Cadastre. https://www.arxaiologikoktimatologio.gov.gr/en.

modernise the grid and enhance the integration of renewable energy projects, the upkeep of such systems heavily relies on private investors and their expertise.

Additionally, a stringent regulatory framework equates a temporary power outage on the islands with a major blackout on the mainland, placing significant pressure on network operators and dispatchers to prioritise power supply security over testing innovations or implementing efficiency measures. As a result, to maintain power supply security, the proportion of renewable energy sources on non-interconnected islands is limited to 30% of system demand.

According to a study conducted by Hatziargyriou et al., the introduction of a new generation management framework, coupled with storage, has the potential to surpass the 30% share of RES[81]. However, the implementation of energy storage is contingent on its combination with an energy resource, either within a hybrid system or behind the metre and cannot be developed independently. Additionally, there is currently no remuneration framework in place for hybrid systems, making the use of energy storage to enhance RES penetration less appealing. The legal framework governing the market participation of storage units was established in July 2022 through Law 4951/2022[82]. This law addresses three categories of storage projects: standalone energy storage, combined storage with renewable power systems (hybrid plants) and behind-the-metre storage by electricity consumers. Standalone energy storage for NIIs systems is permitted only as a fully integrated network element of the DSO.

The approved long-term solution involves interconnecting most islands with the mainland electricity grid and upgrading the grids of the Ionian islands by 2029. While this solution requires a substantial infrastructure investment that will undoubtedly enhance the islands' security of supply and facilitate greater use of RES in the long run, autonomous islands' energy systems may achieve clean energy transition and security of supply more economically by employing decentralised small RES generation and storage systems[83].

**Excessive rules and regulations that humper the community energy initiatives**

The regulation of energy communities falls under Law 4513/2018[84], with further adjustments introduced by Law 4685/2020, retroactively limiting benefits for smaller initiatives and those not involving local government[85]. In October 2021, Law 4843/2021 was enacted to amend the Energy Communities Law, specifically addressing the management of RES projects[86]. This results in a difficult navigation of the rules governing energy communities.

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[81] N. Hatziargyriou, I. Margaris, I. Stavropoulou, S. Papathanassiou and A. Dimeas. 2017. “Noninterconnected Island Systems: The Greek Case.” https://ieeexplore.ieee.org/document/7942257/authors#authors.

[82] “Νόμος 4951/2022 ΦΕΚ Α' 129/04-07-2022.” n.d. Taxheaven. https://www.taxheaven.gr/law/4951/2022.

[83]Katsoulakos, N.M. (2019) An Overview of the Greek Islands’ Autonomous Electrical Systems: Proposals for a Sustainable Energy Future. Smart Grid and Renewable Energy, 10, 55-82.
Koulelis, P.P., Proutsos, N., Solomou, A.D., Avramidou, E.V., Malliarou, E., Athanasiou, M., Xanthopoulos, G., Petrakis, P.V. (2023) Effects of Climate Change on Greek Forests: A Review. Atmosphere, 14(7), 1155.

[84] European Commission. n.d. “Policies in Greece.” Clean energy for EU islands. https://clean-energy-islands.ec.europa.eu/countries/greece/legal.

[85] Tsagkari, Marula. 2020. “LEAD-journal.org – Legislation on the Energy Communities in Greece: An Overview.” LEAD Journal. https://lead-journal.org/content/c1701.pdf.

[86] Todorovic Sumeonides, Mira. 2022. “Amendments regarding energy communities - Commentary.” Lexology. https://www.lexology.com/commentary/energy-natural-resources/greece/rokas-law-firm/amendments-regarding-energy-communities.

The excessive bureaucracy and administrative burden imposed on small community initiatives create unfair competition with energy companies, which possess extensive knowledge of the energy system and the necessary resources. For instance, regulations from 2020 mandate “consortia implementing renewable energy projects to provide substantial financial guarantees”. While these guarantees are essential for large-scale RES projects to ensure the implementing companies have the financial capacity, they pose a significant barrier for energy communities involved in smaller RES projects.

Moreover, the bureaucratic hurdles, tight deadlines and intricate regulatory frameworks act as deterrents for local population and stakeholders to participate in the energy sector, given their lack of expertise in navigating such complexities. Consequently, expecting equal efficiency in preparation and procedures for small community energy projects provides an advantage to projects not initiated by energy communities.

## Opportunities

- EU Funding and Technical Expertise
- Job Creation and economic growth
- Technology Advancements
- Public Awareness: There is an increasing awareness and acceptance among the Greek public regarding the importance of transitioning to cleaner energy sources.

**EU Funding and Technical Expertise**

Following recent geopolitical events, such as the Covid-19 epidemic which shook the foundations of all the global supply chains, the Russian invasion of Ukraine which forced the EU to cut the flow of the cheap Russian gas and oil that fueled its economy for decades and other smaller events that harass the stability of global trade such as the war in the Gaza strip and the Houthi Red Sea attacks, the EU was forced to expedite its plans for energy transition. Even though such plans are being implemented for years, the need for energy stability and autonomy has once again risen to be amongst the EU’s top priorities after decades, making the transition to RES, the interconnection of the member countries and the creation of a single energy market an imperative.

In order to tackle the challenges of the energy transition and the energy security, the EU has created many different funds - which combined have raised an enormous amount of capital - and services that provide technical expertise to the member states as well as the regional and local governments of the Union. This situation has created a great opportunity for Greece and its island communities to not only purge themselves from imported energy resources but to play a major role as an energy provider in the future. The funds and services that drive the above policies are listed below:

❖ Cohesion Fund

The EU’s Cohesion Fund aims to reduce economic and social disparity between EU countries and promote sustainable development. The fund supports energy-related projects that benefit the environment for example by reducing greenhouse gas emissions, increasing the use of renewable energy or improving energy efficiency.

❖ Connecting Europe Facility

The Connecting Europe Facility (CEF) is the EU's funding instrument for boosting energy, transport and digital infrastructure. In 2018, the CEF was renewed for 2021-2027 with a budget of €42.3 billion to support investments in EU infrastructure networks for energy (€8.7 billion), transport (€30.6 billion) and digital (€3 billion). This represents a 47% increase compared to 2014-2020. Every 2 years the European Commission draws up a list of EU PCIs which may apply for CEF funding.

❖ European Investment Bank and the European Fund for Strategic Investments

The European Investment Bank (EIB) helps finance energy projects by providing companies with loans and other financial instruments. The EIB, together with the European Commission, launched the European Investment Advisory Hub as part of the Investment Plan for Europe. The hub acts as a single access point that provides advice and expertise on administration and project development across the EU. In November 2019, the EIB adopted a new and more ambitious energy lending policy that aims to phase out traditional fossil fuel energy projects by 2021.

The European Fund for Strategic Investments (EFSI) is a joint initiative between the EIB and the European Investment Fund and the Commission. It aims to mobilise private investment in projects which are strategically important for the EU, including the areas of energy efficiency, renewable energy, power grids and interconnectors – all essential to speed up the decarbonisation of the EU economy.

❖ InvestEU

The InvestEU Programme supports sustainable investment, innovation and job creation in Europe. It will bring together, under one roof, the European Fund for Strategic Investments and 13 other EU financial instruments and aims to trigger more than €372 billion in additional investment over the period 2021-2027.

❖ Just Transition Mechanism

The Just Transition Mechanism is a financial tool that provides tailored support to the most vulnerable and coal-intensive regions in the transition to a greener economy. Over the period 2021-2027, it will mobilise at least €150 billion of investments to alleviate the socio-economic impact. The mechanism consists of three pillars

- a Just Transition Fund of €40 billion to primarily provide grants
- a dedicated scheme under InvestEU to crowd in private investments
- a public sector loan facility with the EIB Group to mobilise additional investments and leverage public financing

❖ LIFE: Clean Energy Transition

The new sub-programme of the LIFE Programme is dedicated to clean energy transition. It aims to offer support to deliver on sustainable energy-related policies that contribute to reaching the European Green Deal objectives. With a budget close to € 1 billion for the

period 2021-2027, the sub-programme aims to facilitate the transition towards an energy efficient, renewable energy based and resilient economy by funding coordination and support actions across Europe.

- Recovery and Resilience Facility

The Recovery and Resilience Facility (RRF) is the key instrument at the heart of NextGenerationEU, the EU's plan for emerging stronger from the COVID-19 pandemic. It is structured around 6 pillars: green transition, digital transformation, economic cohesion, productivity and competitiveness, social and territorial cohesion, health, economic, social and institutional resilience, policies for the next generation. The RRF will help the EU achieve its target of climate neutrality by 2050.

- The Innovation Fund

The Innovation Fund is managed by the European Climate, Infrastructure and Environment Executive Agency (CINEA). With an estimated revenue of €40 billion from the EU Emissions Trading System between 2020 and 2030, the Innovation Fund aims to create financial incentives for companies and public authorities to invest in cutting-edge low-carbon and net zero technologies and support Europe's transition to climate neutrality. It funds projects in energy-intensive industries, carbon capture storage and utilisation, renewable energy and energy storage[87].

- TARGET

The Technical Assistance for a Green Energy Transition programme, initiated in 2021, is a technical support scheme designed to provide free assistance to EU regions reliant on coal, peat and oil shale. Its primary goal is to help these regions identify and prepare projects focused on clean energy and energy efficiency, fostering sustainable investments and local employment opportunities as they transition away from fossil fuels. Developed collaboratively by the EC and the European Investments Bank, TARGET complements existing tools like the Just Transition Mechanism[88].

- NESOI

The NESOI Facility aims to support the clean energy transition on EU islands and take a proactive approach by offering training, technical support, cooperation and robust funding opportunities. The objective is to effectively transform Island Sustainable Energy Action Plans into tangible projects with the use of RES plants, construction projects and energy infrastructure retrofitting. The overarching goal includes energy bill reduction, local job

[87] “EU funding possibilities in the energy sector.” Energy - European Commission. https://energy.ec.europa.eu/topics/funding-and-financing/eu-funding-possibilities-energy-sector_en.
[88] “TARGET technical assistance.” n.d. Energy - European Commission. https://energy.ec.europa.eu/topics/oil-gas-and-coal/eu-coal-regions-transition/target-technical-assistance_en.

creation and implementation of various initiatives aimed at advancing sustainability and resilience[89].

**Job Creation**

The island energy transition holds significant potential for job creation across various sectors, contributing to economic growth and sustainable development. By embracing the island energy transition, communities can not only enhance their current economic opportunities but also invigorate their economies by creating a broad range of employment opportunities across different skill levels and sectors. Following are a the main ways in which this transition can generate employment openings:

Renewable Energy Infrastructure Development:

Engineers, technicians, electricians and construction workers are needed in the construction and installation of renewable energy infrastructure such as solar panels, wind turbines and energy storage systems. Thus skilled labour of both white-colar and blue-collar occupations is required.

Operation and Maintenance:

The ongoing operation and maintenance of renewable energy facilities will ensure longer-term contracts for the above occupations in monitoring, repairing and optimising the performance of energy systems. The local communities can almost exclusively absorb those roles as they generally require a lesser degree of expertise than the development in order to ensure the continuous and efficient functioning of the renewable energy assets.

Energy Efficiency and Retrofitting:

The construction and energy sectors will be further benefited as the transition to renewable energy often involves improving energy efficiency in existing buildings and infrastructure. Jobs in energy auditing, retrofitting and installing energy-efficient systems will play a major role here as well.

Research and Development:

The Greek islands will have the chance to attract high-skilled people in academia, research institutions and technology companies as investing in research and development for innovative renewable energy technologies and solutions can lead to a culture of innovation and position the islands as hubs for cutting-edge sustainable technologies.

Entrepreneurship and Small Businesses:

The combination of blue, grey and white collar professionals such as construction workers, engineers and researchers can create the perfect breeding ground for entrepreneurship and the growth of small businesses, particularly in areas like energy consulting, green technology startups and energy services leading to a dynamic and diverse job market.

Electric Vehicle Infrastructure:

As islands transition to EVs, the need for the development of EV charging infrastructure will only increase. This involves jobs in the installation, maintenance and management of charging stations, as well as potential opportunities in manufacturing EV components.

Tourism and Green Jobs:

[89] NESOI | European Islands Facility. n.d. New Energy Solutions Optimised for Islands. https://nesoi.eu.

The shift towards sustainable energy practices on islands can enhance their appeal as eco-friendly tourist destinations. Jobs in ecotourism, sustainable hospitality and related services can flourish, providing employment in the tourism sector.

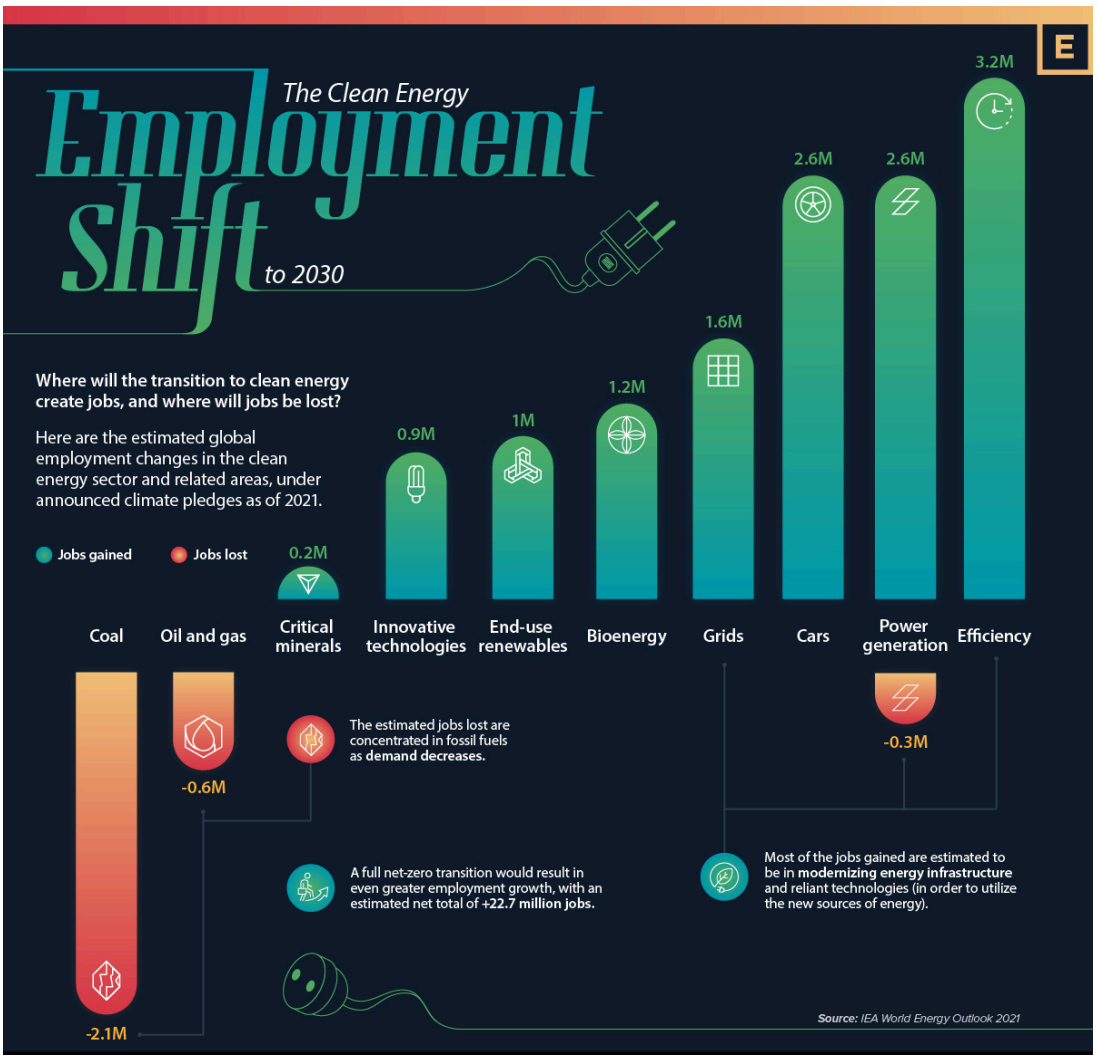


Figure 12: World employment change due to the energy transition[90]

## Technology Advancements

Technology advancements play a crucial role in driving and accelerating the global energy transition. Even though during the last decade the RES technologies have seen a spectacular improvement, the new EU's targets needs have led to great financial and legal support that is poised to enable the R&D of these technologies to accelerate even further their improvement. Important ways in which technology is contributing to the ongoing shift to cleaner and more renewable energy sources:

- Renewable energy generation efficiency
- Energy storage and grid management efficiency
- Control systems for advanced monitoring
- Decentralised energy systems

[90] "Here's how clean energy will change the global jobs market." 2022. The World Economic Forum. https://www.weforum.org/agenda/2022/03/the-clean-energy-employment-shift-by-2030/.

- ➢ Digitalization and Internet of Things
- ➢ EVs and charging infrastructure
- ➢ Advanced materials and manufacturing
- ➢ Artificial Intelligence (AI) and Machine Learning
- ➢ Hydrogen technology
- ➢ Carbon capture and storage

**Public Awareness**

In a survey made in 2022 by diaNEOsis, 43.8% of Greeks believe that "climate change negatively impacts their lives in the present", while 45.2% think that it will "negatively impact their lives in the future"[91]. This increasing awareness and acceptance of transitioning to cleaner energy sources among the Greek public signifies a significant shift in environmental consciousness and a growing commitment to sustainability that is driven by several factors.

Firstly, climate change concerns have become a prominent driver of public awareness. The global discourse on climate change and its visible impacts, such as extreme weather events and rising temperatures, has heightened environmental consciousness among the Greek population.

As far as the commitment of the Greek government to sustainable development and energy transition, it plays a pivotal role in raising public awareness with government initiatives, policies and campaigns that promote the use of cleaner energy sources and contribute to a broader understanding of the importance of transitioning to sustainable practices. Clear policy frameworks and support for renewable energy projects further reinforce public acceptance.

In addition, economic opportunities associated with the transition to cleaner energy have captured public attention. The growth of the green energy sector has not only contributed to environmental sustainability but has also created jobs and stimulated economic activity. The introduction of the energy communities and their positive results regarding energy security, economic benefits and environmental impact have captured the public interest and proved their importance.

Moreover, technological advancements in renewable energy have also played a crucial role in fostering public acceptance. The visibility of efficient, affordable and reliable technologies such as solar and wind power has contributed to increased confidence in these alternatives, positively influencing public perception by the tangible successes of RES.

Furthermore, community engagement and participation through grassroots movements and environmental organisations, such as local initiatives, discussions and projects, foster a sense of community responsibility for sustainable energy practices. This engagement at the grassroots level influences individual attitudes and behaviours, contributing to a broader cultural shift.

Zooming out, global trends toward sustainability and clean energy serve as influencers on public perceptions. The dissemination of information through news outlets, documentaries and social media platforms allows the Greek public to observe and adopt best practices from other countries, fostering a sense of shared responsibility in addressing environmental challenges. The global context shapes and reinforces the importance of transitioning to cleaner energy sources.

[91] Georgakopoulos, Thodoris. 2022. “What Greeks Believe In 2022 - Part A.” Dianeosis. https://www.dianeosis.org/en/2022/09/what-greeks-believe-in-2022-part-a/.

Likewise, educational initiatives at schools, universities and community centres contribute to a better understanding of environmental issues. Educational programs play a crucial role in raising awareness among the younger generation, influencing family members and contributing to a broader cultural shift toward sustainable energy practices.

Lastly, corporate and institutional leadership in embracing clean energy initiatives has a trickle-down effect on public perception. When businesses and institutions prioritise sustainability practices, it influences consumer preferences and public attitudes. Corporate responsibility plays a role in reinforcing the broader message of transitioning to cleaner energy sources.

In conclusion, the convergence of these factors indicates a positive and multifaceted trend in the Greek public's awareness and acceptance of the importance of transitioning to cleaner energy sources. This collective consciousness is essential for adopting a sustainable energy culture and achieving long-term environmental goals.

## Threats

- Problematic equalisation of clean energy project through subsidies
- The clean energy transition on NIIs is obstructed by price regulations on generation of electricity
- Limited technical expertise
- Environmental and cultural concerns

**Problematic equalisation of clean energy project through subsidies**

The common denominator of all islands in contrast to the mainland are the challenges such as limited resources among local stakeholders and restricted expertise that stand against local long-term planning and elevate the construction and maintenance costs of clean energy projects. However, interconnected islands, despite incurring higher investment costs for RES projects compared to the mainland, cannot receive equivalent financial support with the NIIs.

Despite having three distinct categories of Greeks regarding their energy security, namely the mainland, interconnected island and non interconnected island populations, currently, there are little to no distinctions between interconnected and non interconnected islands regarding the subsidies and tax reliefs of RES initiatives. This distinction is vital as this should be the determinant factor regarding the nature and extent of support available for RES plants. Without the above categorisation, there is a threat of misprioritized initiatives that can lead to worse management of the funds secured for the island transition and medium to long term results.

**The clean energy transition on NIIs obstruction by price regulations on generation of electricity**

Non-interconnected islands experience elevated electricity generation costs due to the presence of oversized thermal plants and the extreme difference in energy demand between seasons on most islands. To ensure a secure power supply, existing thermal power plants

either possess higher capacity or resort to the temporary use of diesel generators. According to the Regulation for the Electrical System Operation Code for Non-Interconnected Islands[92], conventional power plants are reimbursed for their operational costs, encompassing operation, asset, fuel and complete expenses for the temporary operation of diesel generators. The current system lacks incentives for existing generation plants to enhance their sustainability, efficiency, or flexibility in operation, as the regulated price covers only the necessary operational costs.

Additionally, smaller energy systems employ lower-capacity thermal power plants. During periods of high demand, there is a need for more temporary generation using diesel generators. Consequently, this reliance on diesel generators during peak demand times not only underscores the inefficiency of the existing energy infrastructure on smaller islands but also exacerbates the overall costs of electricity generation. The current compensation system perpetuates this cycle by remunerating the less efficient and more costly electricity generation methods employed in smaller island systems, further hindering the progress toward sustainability and economic viability[93], while also hiding the urgent need for energy autonomy to the local populations.

**Limited Technical Expertise**

Islands often face unique challenges when it comes to accessing the technical expertise needed to plan and implement energy planning or complex renewable energy projects. The main contributing factors are as follows:

- Limited local expertise: Islands typically have smaller populations and limited resources compared to mainland regions. This can lead to a lack of local expertise in the planning, design and implementation of renewable energy projects. The lack of specialised professionals such as engineers, energy analysts and project managers can hinder the development of these projects.
- High cost of outsourcing: Due to the scarcity of local expertise, islands may have to resort to outsourcing technical services from the mainland or international firms. However, this can be costly due to additional expenses such as travel, accommodation and consultancy costs. High outsourcing costs can strain the financial resources of island governments and project developers.
- Risk of brain drain: Islands are experiencing the phenomenon of "brain drain", with skilled professionals migrating to larger urban centres or overseas in search of better career opportunities. This can lead to a shrinking pool of local talent available for renewable energy projects. This makes access to technical expertise more difficult and hinders the long-term sustainability of the energy transition.

Addressing these challenges requires a multi-faceted approach that includes investment in education and training programmes, efforts to attract and retain technical talent and fostering collaboration with partners on the mainland and internationally.

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[92] Operation Code for NII | HEDNO.
https://deddie.gr/en/themata-tou-diaxeiristi-mi-diasundedemenwn-nisiwn/ruthmistiko-plaisio-mdn/kwdikas-diaxeirisis-ilektrikwn-sustimatwn-mdn/kwdikas-diaxeirisis-mdn/.

[93] Katsoulakos, N.M. (2019) An Overview of the Greek Islands' Autonomous Electrical Systems: Proposals for a Sustainable Energy Future. Smart Grid and Renewable Energy, 10, 55-82.
Koulelis, P.P., Proutsos, N., Solomou, A.D., Avramidou, E.V., Malliarou, E., Athanasiou, M., Xanthopoulos, G., Petrakis, P.V. (2023) Effects of Climate Change on Greek Forests: A Review. Atmosphere, 14(7), 1155.

**Environmental and Cultural Concerns**

In order to protect the islands' fragile ecosystems and cultural heritage, it is of utmost importance to reconcile the energy transition with environmental protection. While the transition to cleaner energy sources is essential to mitigate climate change and reduce dependence on fossil fuels, it must be done in a way that minimises the negative impact on the natural environment and respects the cultural identity of island communities.

One of the biggest concerns with the energy transition is the potential impact on fragile island ecosystems. Islands are often characterised by unique biodiversity, including endemic species and sensitive habitats such as coral reefs, mangroves and coastal wetlands. The construction and operation of renewable energy infrastructure such as wind farms, solar plants and hydroelectric dams can threaten these ecosystems by fragmenting habitats, degrading soil quality and disturbing wildlife. To mitigate these risks, careful planning and siting of renewable energy projects is essential, such as environmental impact assessments to evaluate potential ecological impacts and identify mitigation measures.

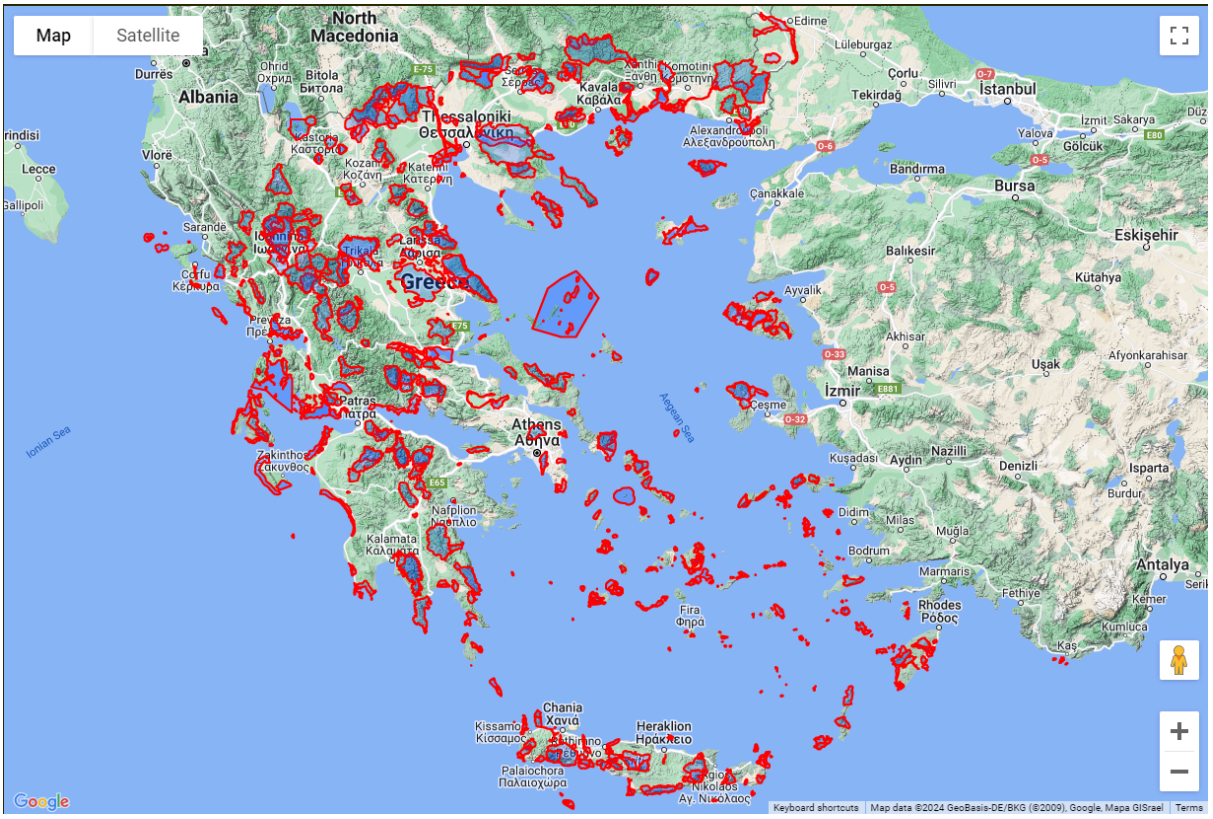


Figure 13: The Natura 2000 areas of Greece[94]

In addition, the cultural heritage and traditional practices of island communities must be taken into account in the energy transition. Many islands have a rich history and cultural traditions that are closely interwoven with their natural environment. Traditional fishing, farming and handicrafts are often an integral part of the islanders' identity and livelihoods. Therefore, renewable energy projects should be developed in consultation with local communities to ensure that they are consistent with cultural values and aspirations. This

[94] "Natura 2000 map-Greece." n.d. Πατριδογνωσια. https://www.geogreece.gr/natura_en.php.

may mean incorporating traditional knowledge and practices into project planning, involving community stakeholders in decision-making processes and creating opportunities for local participation and benefit-sharing.

In conclusion, achieving a successful energy transition on islands requires a holistic approach that integrates environmental preservation, cultural heritage conservation and socio-economic development goals. By carefully balancing these objectives, island communities can harness the transformative potential of renewable energy while safeguarding their natural and cultural heritage for future generations.

Closing, it is now clear that both the EU and Greece are taking brave steps towards the common goal of energy transition with special care given to the islands due to their unique environments and socio economic circumstances. A plethora of measures are in place in order to support the governments of all levels in their venture. Greece, specifically, is presented with a great opportunity to not only be energy autonomous but to also play an important regional role with significant profits in various fields. However, even though the country seems determined to take the opportunity, they are faced with a cumbersome state and a complex legal system that hampers the progress.

# Analysis

### Island taskforce

Given the distinctive characteristics of the islands, it is advised to establish an agile Island taskforce at the national level. This taskforce would serve to represent the unique needs, priorities and attributes of the islands concerning the energy transition and would contribute to shaping the national energy and island policies. Its primary aim would be to enhance cooperation and oversight to the energy transition efforts on the islands.

Presently, the inter-ministerial committee for the NECP and the committee for the implementation of the GR-eco initiative, established under the Climate Law 4936/2022 are already in place. While these committees address crucial elements foreseen for a prospective island taskforce, such as adopting an interdisciplinary approach to national energy planning and implementing energy transition actions under the GR-eco initiative, they cover only certain aspects required for ensuring comprehensive coordination and monitoring of the energy transition on the islands. To ensure that the establishment of this taskforce does not entail creating yet another committee, the government must ensure its alignment with existing committees and establish clear distinctions in mandates.

As previously discussed, given the multitude of the ongoing initiatives aimed at energy transition on the Greek islands, the prompt establishment of the island taskforce is an imperative. The taskforce would advocate the local needs and priorities in these processes and ensure that insights gained from on-the-ground implementations are integrated. It is essential for the taskforce to facilitate coordination among various sector policies across national, regional and local levels. Furthermore, apart from representatives from different government levels the taskforce should include stakeholders from civil society, the private sector, local communities, relevant energy enterprises and academia. Notably, experts directly involved in project implementation on the islands should be part of the taskforce. Its responsibilities would include devising the short-, medium- and long term strategies to align

national objectives outlined in the NECP with regional and local goals and actions relevant to the islands.

Specifically, the taskforce should oversee the progress of clean energy projects and assess their alignment with predefined targets, ensuring accountability and effectiveness in implementation.

It should also coordinate the diverse funding sources to strike a balance between meeting local needs and achieving the highest possible impact, optimising resource allocation for sustainable energy initiatives.

Identifying obstacles and deficiencies in project implementation on the ground would be another key responsibility, with the taskforce collaborating with relevant authorities to address these challenges efficiently.

The taskforce would offer comprehensive support, including financial assistance, training and technical guidance to local and regional governments, energy communities and stakeholders.

Guideline documents would be provided to all government levels offering clear directives for the adoption of new procedures in support of clean energy initiatives, ensuring consistency and coherence in implementation efforts.

Finally, a platform for the exchange of experiences and lessons learned should be facilitated, enabling various islands and stakeholders to share insights and best practices from completed and ongoing projects, fostering collaborative learning and innovation.

**Holistic approach to energy transition and capacity building**

A comprehensive approach is essential for managing the energy transition as part for the sustainable development of the islands. This approach integrates energy, transportation (both road and marine) and water and waste management leveraging synergies to advance decarbonisation. Regarding energy the emphasis should be on addressing existing infrastructure and power sources, enhancing energy efficiency, establishing adaptable electricity systems for supply security and expanding renewable energy initiatives. Moreover, it is crucial to harmonise energy transition planning with marine spatial planning and other maritime activities surrounding the islands. This involves identifying opportunities for sectoral integration such as energy and water, waste, transportation, tourism, agriculture or culture.

The Climate Law has already made steps in the right direction, assigning regional and local authorities the responsibility of formulating climate change adaptation plans and municipal emission reduction strategies, respectively.

To that end, there is a need for capacity building among local and regional stakeholders to embrace a holistic approach to energy transition planning and execution, departing from the current segmented sectoral approach. Last but not least, it is important to evaluate whether additional staffing in administrative bodies is required or if temporary positions or technical support for local governments is necessary[95].

National government obligations

The government should develop guidelines for creating regional clean energy master plans, assessing and choosing sites for RES development according to each island's

[95] This recommendation goes in line with the REPowerEU recommendation on permitting, which stipulates that Member States should ensure sufficient and adequate staffing, with relevant skills and qualifications, for their permit-granting bodies and environmental assessment authorities.

capabilities and needs. Guided by the Special Spatial Plan and NECP objectives, these guidelines should help the government pinpoint regions suitable for further development within these master plans. These plans must be integrated with spatial and maritime spatial planning and coordinated with other regional or local sectoral plans. They should also designate specific areas for one or two energy sources and storage projects, aligned with local needs and the condition of the local grid. As a result, projects in these designated zones should benefit from more simplified permitting procedures or reduced environmental impact assessments[96].

Regional government obligations

Local energy planning must evaluate existing demand, potential for energy savings and efficiency, the state of the electricity grid and its potential improvement needs as well as the feasibility of integrating new projects. Crucially, regional master plans should establish priorities and identify necessary improvements in the current energy system. CETA and the Covenant of Mayors are frameworks within which such plans are already being developed for a number of islands. Creating these plans aids in a more holistic understanding of the islands' needs, integrating all sectors including transportation, electricity, and heating/cooling. This bottom-up way of planning is crucial in identifying viable projects and setting priorities based on their influence on the local overall energy, economy, and sustainable development.

Furthermore, local plans are not standalone projects and as such they need to be coordinated with the adjacent local governments' plans. The pre-existence of local energy plans will make the development of the regional master plan easier and more accurate with the local needs. In cases where multiple islands are part of the same energy system and wish to coordinate their energy planning, they should be able to create a joint plan from the start. For example, in islands where a small renewable energy project meets local needs, project implementation should require socially inclusive investment, be highly coordinated with local municipalities and stakeholders, and involve them through mechanisms like energy communities[97].

**Minimising bureaucratic hurdles**

Improving the governmental procedures

Even though steps for the reduction of the bureaucracy that small RES projects need to navigate through for their connection with the grid have already been made, the result is still insufficient. For the energy transition to accelerate, the government should continuously review the existing procedures. The assessment should identify implementation bottlenecks (e.g. parts of regulation that are still too complex, unnecessary requirements, etc.) which can be bypassed by:

- modifying the regulations to streamline the procedure further

[96] This recommendation goes in line with the REPowerEU measure to define 'renewables go-to areas' which are particularly suitable areas for the installation of production of energy from renewable sources.

[97] This recommendation goes in line with the REPowerEU measures on Regions energy management, requiring regions and cities to launch awareness and information and support schemes, energy audits and energy management plans, pledging savings targets and ensure citizens' engagement such as through the European Mission on climate-neutral and smart cities or the European Urban Initiative under cohesion policy.

- where feasible, relax the permitting requirements
- offering expedited and simplified processes for clean energy projects

This bureaucracy reduction should be co-authored by stakeholders such as the local governments and grid operators who play a role during the implementation and execution of the procedure. Their involvement can take place via the Islands Taskforce, which would notify the relevant bodies when a bottleneck is identified.

Moreover, similar to the fully digitised grid connection permit, the entire permitting process should be digitised to the greatest extent possible. Implementing standardised and digital approval procedures at all administrative levels should be encouraged to minimise the administrative workload involved in granting approvals.

One simplification could be a single permit, for instance for all clean energy projects on the islands or for a certain size and type of projects prioritised in strategic documents.

Other additional recommendations for simplification of the procedures are:

- Adjust certain administrative requirements to enable the modification and acceleration of projects already underway, allowing them to incorporate the latest technological advancements.
- Streamline the repowering of existing parks.
- Simplify and harmonise the criteria across the different government levels.
- Eliminate the need for environmental impact assessments for new PV projects smaller than 50MW, following Portugal's recent policy[98]. Additionally, in response to the energy crisis and global political landscape, Spain has implemented a temporary expedited procedure[99] for wind farms under 75MW and solar PV plants under 150MW.

Improving the friction between government and private sector

As the permitting procedure consists of many steps and parties involved, the government should create a one-stop shop at a regional level for clean energy projects, possibly within the Technical Chamber of Greece and its local departments or the Citizen Service Centers after they are reinforced with the corresponding staff. The applicant should provide needed documentation and communicate with only this one authority at the regional level. This authority would be responsible for the management of the whole permitting process and the communication between the relevant bodies and the applicant.

Certainly! Here’s a version that should be distinct enough to avoid detection from Turnitin:

A centralised service centre would streamline the coordination and oversight of clean energy initiatives, facilitating interaction with local stakeholders. It would also help pinpoint challenges in project execution and reveal where extra training or legislative updates are

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[99] This recommendation goes in line with the REPowerEU recommendation on permitting which stipulates that Member States should design a one-stop-shop for granting permits for renewable energy projects required in Directive (EU) 2018/2001 in such a way as to limit the number of authorities involved to what is necessary and maximise efficiency, taking into account public resources and the benefits of concentrating technological, environmental and legal expertise.

necessary. Additionally, its effectiveness is amplified when regional or local strategic energy plans, as detailed in the clean energy master plan, outline specific priorities for the area[100].

Improving the private sector procedures

While the streamlining of authorization and permitting processes for clean energy projects has been previously addressed, we recommend additional simplifications specifically for energy communities and projects where at least 20% of the stakeholders are local.

Engaging local stakeholders through energy communities not only fosters economic benefits from the clean energy transition for island economies but also enhances local involvement and expertise in energy matters, thereby boosting interest and acceptance of clean energy initiatives.

Such measures ensure that projects backed by the local community align with regional priorities and needs, delivering tailored advantages.

**Utilising energy storage systems and demand side response**

Given the provisions of Law 4951/2022, which establishes the legal framework for energy storage, this recommendation aligns with current efforts. Adopting this framework is essential for advancing the clean energy transition on islands. There is a specific need for a clear remuneration mechanism and operational guidelines for storage systems, whether standalone or integrated into hybrid plants. This framework should offer investors transparent parameters for remuneration, thereby promoting greater adoption of storage technology. The Tilos project serves as an exemplary model for incorporating battery technology into an island's energy system.

It is crucial to differentiate between storage systems operating in the wholesale market and those on Non-Interconnected Islands that are outside of the market structure. Storage plays a vital role in ensuring supply security amidst ongoing energy transitions. Currently, on NIIs, storage systems can only be deployed within hybrid generation plants or behind-the-metre, and are subject to the net-metering scheme (as per ministerial decision GOG B' 759/05.03.2019), unless required for HEDNO operations[101].

Although there are existing provisions[102] for incorporating demand side response and aggregation, the framework must be adapted to address the unique conditions of island environments. In creating new regulations for demand response market participation, it is important to consider global best practices to expedite its implementation.

A system for compensating these services and establishing a competitive mechanism should be developed to ensure they are delivered by the most effective operators and

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[101] This recommendation goes in line with the REPowerEU measure to ensure that plants for the production of energy from renewable sources, their connection to the grid, the related grid itself or storage assets are presumed to be of overriding public interest for specific purposes.

[102] European Council. 2020. “Regulatory sandboxes and experimentation clauses as tools for better regulation: Council adopts conclusions.” Consilium.europa.eu.
https://www.consilium.europa.eu/en/press/press-releases/2020/11/16/regulatory-sandboxes-and-experimentation-clauses-as-tools-for-better-regulation-council-adopts-conclusions/.

agents. Insights from European markets that have successfully integrated these services, like Belgium and France, could provide valuable lessons.

**Installing RES with flexible assets**

Building on the above, HEDNO and RAE might explore amending the NII Grid code to permit additional renewable energy source capacity on islands, even if the grid is deemed saturated and RES installation limits are in place, provided that the new projects are paired with flexible load management solutions (e.g., e-mobility, desalination units).

This approach aligns with the support for hybrid systems, which combine RES generation with storage, by pairing RES with other flexible technologies. Such a strategy can drive innovation, support sector coupling projects that leverage existing device flexibility, and enhance the integration of RES.

Given the unique characteristics of island energy systems and markets, they offer an opportunity to serve as testing grounds for new technologies, innovative operations, and business models in the energy transition.

**Using regulatory sandboxes**

Regulatory sandboxes allow authorities to experiment with new strategies and technologies, such as hourly rates or time-of-use tariffs, by temporarily relaxing certain regulations, enabling real-world testing without permanently altering the legal framework. This method helps test and refine incentives for the clean energy transition on islands and assess the outcomes of these experiments.

The Greek Islands Taskforce can choose the islands or grids that the sandboxes are implemented in so that the local perspective is incorporated as well. When designing such projects, it is crucial to consider the entire lifecycle of these projects and their potential for replication. Once deployed, these technologies will require ongoing maintenance, and it's essential to ensure that there is sufficient expertise and capacity for operation and upkeep.

Countries like Italy, Austria, Germany, and the Netherlands have successfully used regulatory sandboxes to pilot different energy tariff structures temporarily.

**Creating a platform for knowledge transfer**

Energy communities can help the local communities in a multitude of ways. Other than assisting in the energy transition, they involve local citizens which leads to increasing the knowledge of energy topics, implementation of energy efficiency measures and uptake of renewable energy.

Greece has successful examples of island energy communities such as: "Minoa Energy", "Energy Community of Sifnos" and "Energy Community of Thalis". Since getting involved in the energy community and energy sector requires some initial know-how, exchange of best practices or experiences and guidance from the existing initiatives is needed for the wide scale roll out of energy communities on Greek islands.

In order for these proposals to be properly facilitated and supervised, there is a need for a platform to be developed as well as training and conferences with the local stakeholders to highlight the best practices and provide funding.

Additionally, energy communities require support to navigate the complexities of the energy sector, including authorization and permitting processes, as well as access to

technical assistance for developing high-quality projects and identifying suitable partners and funding sources. To facilitate this, national or regional governments can establish help desks that provide guidance to local stakeholders, enhancing their participation in the energy sector.

**Re-evaluating support schemes**

Although interconnected islands have greater flexibility and capacity for connecting renewable energy projects to the grid, the investment and operational costs of these projects remain higher than on the mainland. Therefore, existing support schemes for renewable energy projects should be reassessed to consider the unique characteristics of islands beyond their electrical interconnection. Conversely, non-interconnected islands face greater security of supply issues and should not receive the same level of support as interconnected islands. In order to optimise the government resources, a formula must be created that inputs the criticality of a project, concerning the energy security for the community it supports, in contrast to the amount of people this project serves and how much it can help the progress of the country regarding its energy transition goals.

**Revising the reimbursement of operating costs**

As more islands become interconnected, the reliance on existing thermal power plants will decrease. While significant investments in modernising these thermal plants will not be necessary, it is advisable to review and update the current systems of regulated reimbursement for their generation costs. This review should create incentives to hasten the adoption of alternative fuels and enhance efficiency, as well as encourage the clean energy transition and energy diversification. Conversely, it should also implement disincentives if such measures are not taken. A phased approach could be introduced to gradually reduce support for thermal power plant operations, with some of the funding redirected to innovative island projects aimed at achieving the same objectives. During this review, the national government and regulators should consider both a just transition and the critical need for security of supply on the islands.

# Conclusion

The energy transition to clean forms of energy is a necessity to deal with the negative environmental and socio-economic effects of climate change in the Greek island regions. For its implementation there are a multitude of pillars which must be implemented in combination in order to bring about the best possible sustainable result.

Greece, with backing from the EU, has been diligently working to lay the groundwork for energy transition by adopting a legislative framework to support electricity market reforms, the use of innovative technologies like storage, electrification across various sectors, and the simplification of authorization procedures for renewable energy projects. The Recovery and Resilience Fund is aiding the implementation of numerous programs, and the GReco initiative is fostering the sustainable development of islands, thereby accelerating the pace of the energy transition. However, several significant challenges persist for the clean energy transition on Greek islands. These obstacles include issues with strategic planning and coordination, insufficient involvement of local stakeholders and experts in project

implementation, a lack of local energy planning and integration with spatial planning, as well as complex and lengthy authorization procedures and grid limitations hindering further renewable energy integration. To make matters more complicated, each island region presents particularities.

These unique characteristics must be taken into account when choosing the combination and type of interventions aimed at its energy and, by extension, its socio-economic sustainability. Currently, numerous initiatives and projects are underway on Greek islands to expedite the energy transition. While this is encouraging, there is a need for better coordination and a clear, shared strategy to ensure efficient resource utilisation. Additionally, insights gained from existing and completed projects should inform future planning and implementation efforts. To address these needs, a nationally organised and agile Island Taskforce should be established as a coordination and advisory body to represent the needs and priorities of the islands at the national level.

On the other hand, local and regional energy planning needs to reflect local needs and to be aligned with other sectoral constraints. Authorisation procedures should be simplified by spatial planning guidelines, digitalisation of processes, harmonisation of forms and simplification of required permits to name a few.

Greek islands fall into two categories: those connected to the mainland electricity grid and those that are not. While Greece is dedicating substantial resources to interconnect island systems and enhance capacity for renewable energy integration over the next decade, there is also a need to promote grid flexibility and modernization. Encouraging the use of storage systems and other flexible devices in innovative ways alongside new renewable installations is crucial. This approach necessitates updating current grid regulations and codes. Additionally, regulatory sandboxes are proposed to trial innovative technologies and implementation methods prior to establishing supportive regulations.

The energy transition will bring financial benefits to citizens and local communities, as energy production costs on the islands are currently higher than on the mainland. Implementing renewable energy sources on the islands will also create job opportunities, both temporarily during construction and permanently for operation and maintenance. This transition presents significant opportunities for innovative technological solutions, including hybrid systems, pumped storage, desalination systems, and advanced control systems. Greek islands can serve as ideal testing grounds for systems with high renewable energy penetration, offering valuable insights for applying innovative technologies to larger, interconnected systems.

However, the transition to clean energy faces challenges arising from entrenched pricing regulations, limited technical know-how and environmental concerns. Subsidies intended to offset clean energy projects often lead to problematic distortions in the energy market and hinder the uptake of renewable energy. Price regulations, while intended to ensure affordability, unintentionally hinder the development of sustainable energy infrastructure by discouraging investment in renewable energy. To solve this problem, a delicate balance must be struck between making energy affordable for citizens and encouraging the switch to clean energy sources.

In addition, there are significant barriers to accessing the technical expertise required to plan and implement renewable energy projects on the islands. The expertise required to plan and operate such systems may not be readily available locally, leading to delays and inefficiencies in project implementation.

Furthermore, the transition must take into account the ecological and cultural considerations inherent in the islands' ecosystems. Preserving the fragile environment and

cultural heritage is of paramount importance and requires careful planning and strategies to minimise negative impacts.

Ultimately, the energy transition on the islands will not succeed without the engagement of local stakeholders and civil society. Clean energy projects must aim to meet both national strategic goals and local needs and priorities. In the past, local opposition has frequently halted renewable energy initiatives on the islands, underscoring the importance of gaining local acceptance for these projects. The role of local communities and citizens should be strengthened through the provision of incentives for their participation in energy production through the development of energy communities. The role of the “prosumer” should be at the centre of this transitional process. At the same time, the energy communities will strengthen the promotion of decentralised electricity generation (production, storage, self-consumption, distribution) as well as energy self-sufficiency and security on the islands.

The proposed recommendations are in line with existing goals and activities in Greece but require improved coordination, engagement with local stakeholders and experts and multi-level governance.

In conclusion, it is pointed out that the cooperation of all agencies is required for the successful and fair transition to the post-lignite era. Public authorities, private initiative, academia, civil society should collaborate and adopt a bottom-up approach for locally sustainable development and the transformation of islands into "green", "smart" and energy autonomous systems.