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INTEGRATION BARRIERS FOR WIND AND SOLAR TECHNOLOGIES IN GREECE AND THE EU

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Dedicated to my wife and daughter who supported me on this journey of knowledge.

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INTEGRATION BARRIERS FOR WIND AND SOLAR TECHNOLOGIES IN GREECE AND THE EU

Abstract

The European Union is now moving forward with efforts that seek to make Europe the world's first climate-neutral continent by 2050. The pursuit of this undertaking has presented significant difficulties stemming from deficiencies within the legislative structure, complications in technical execution, and the wide range of political aspirations. This Master's Thesis examines the obstacles hindering the implementation of both wind and solar power in Greece and the European Union, focusing on the political and economic structures, markets, administrative procedures, utility regulation, and infrastructure. Furthermore, this Master's Thesis presents instances of effective national best practices employed to promote the development of solar and wind energy technologies.

Keywords: Renewable Energy, Greece, European Union

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Abbreviations & Acronyms

Abbreviations	Full description
APG	Average Monthly Unit Price of Natural Gas
CCS	Carbon Capture and Storage
CDF	Capital Discount Factor
CEP	Clean Energy Package
CHP	Combined Heat and Power Plant
DAPEEP	Operator of RES and Guarantees of Origin (Former LAGIE)
DAS	Day Ahead Electricity Schedule
DSO	Distribution System Operator
EEA	European Economic Area
EEAG	Guidelines on State aid for Environmental protection and Energy 2014-2020
EEX	European Energy Exchange
EnC	European Energy Community
EU	European Union
EU ETS	European Union Emission Trading System
FEC	Final Electricity Consumption
FMARP	Fixed price of Market Access Readiness Premium
GCV	Gross Calorific Value
GHG	Greenhouse Gas Emissions
HEDNO	Hellenic Electricity Distribution Network Operator
HVEW	Hourly Value of Electricity in the Wholesale electricity market
IPTO	Independent Power Transmission Operator
LAGIE	Operator of Electricity Market (Currently DAPEEP)
LCOE	Levelized Cost of Electricity
MARP	Market Access Readiness Premium
NECP	National Energy and Climate Plan
NII	Non-Interconnected Islands
P.A.	Price Mark-up
PPA	Power Purchasing Agreement
PV	Photovoltaic Power Station
RAE	Regulatory Authority for Energy

REC	Renewable Energy Community
RED II	Renewable Energy Directive II or Directive (EU) 2018/2001
R.T.	Reference Tariff
RES	Renewable Energy Sources
RESC	Renewable Energy Sources Capacity
RPS	Renewable Portfolio Standards
sFiP	Sliding Feed in Premium
SMP	System Marginal Price
SpMP	Special Market Price
STHPP	Solar Thermal Hybrid Power Plant
TFEU	Treaty on the Functioning of the European Union
TSO	Transmission System Operator

Term definitions

Connection Agreement Once the power plant has received its Final Connection Offer and the owner has submitted a Connection Application to the Competent Operator, the parties enter into a Connection Agreement to establish a means of connecting the plant to the electrical infrastructure.

Operator of RES and Guarantees of Origin is responsible for entering into operating aid contracts with the proprietors of combined heat and power (CHP) and renewable energy source (RES) and CHP power plants as mandated by Law No. 4414/2016. Acquires funds from said companies to cover investment and operating expenses. Submits bids for the energy that the Roof Photovoltaics network and the RPS network are anticipated to contribute to the national electricity grid.

Day-ahead Electricity Schedule The structure of the Greek wholesale energy market adheres to the Day-ahead energy schedule model. A day in advance, wholesale electricity can be purchased or sold due to the day-ahead electricity schedule.

Feed-in-Premium contract Refers to the agreement between DAPEEP S.A. and the owner of a RES or CHP power facility. It results in the power plant's integration into the operating aid support program, which is based on a premium above the market price of their energy generation, and the connection of the power plant to the electrical grid.

Feed-in-Tariff contract Is a contractual agreement between the proprietor of a RES or CHP power plant and DAPEEP S.A. or HEDNO S.A., the latter of which is responsible for the Non-Interconnected Islands. The purpose of this agreement is to enable the NIIs to connect to the power grid of the mainland or the NIIs' grid and receive a fixed rate of operating aid support.

Final Connection Offer: The power plant is given the final connection offer once the environmental terms have been accepted. Before asking for approval of the environmental terms, the power plant owner must first get an offer to link to the electricity network from a qualified operator.

Hellenic Electricity Distribution Network Operator S.A. (HEDNO S.A.)
HEDNO S.A. was formed by separating the Distribution Department from PPC S.A. in accordance with L.4001/2011 and the 2009/72/EC EU Directive on electricity market organization, with the goal of carrying out the functions of the Hellenic Electricity Distribution Network Operator. PPC S.A. now owns 51% of the Company's shares, while Macquarie Asset Management owns 49%.

Independent Power Transmission Operator S.A. (IPTO S.A.) was founded by Law 4001/2011 and is organized and functions as an Independent Transmission Operator in accordance with EU Directive 2009/72/EC. The Company is the owner and operator of the Hellenic Electricity Transmission System (HETS), in compliance with the rules of Law 4001/2011, the Grid Code, and the HETS operation license.

Letter of Guarantee In exchange for a fee, a credit institution will issue a letter of guarantee on behalf of a customer who has signed a contract to purchase products or services from a supplier. The letter informs the provider of those goods or services that he will be compensated for his efforts. This letter of guarantee is used in the energy sector to promise that a power plant will be built, connected to the electricity grid within a given time frame, and have a predetermined installed capacity.

National Regulatory Authorities (NRAs) for Energy: National Regulatory Authorities (NRAs) for Energy are separate governing bodies that have many responsibilities, such as overseeing the domestic energy market, protecting consumers, making sure there is a secure supply of energy, approving power plant permits, and keeping an eye on how the national transmission and distribution system operators do their jobs. Most of the time, the NRAs can make suggestions to the right state agencies and take action to promote health and market freedom.

The Paris Agreement was established on December 12, 2015, in Paris. It is a significant agreement among the parties to the United Nations Framework Convention on Climate Change to accelerate and enhance the investments and measures needed for a sustainable low-carbon future and to tackle climate change. The Paris Agreement seeks to foster international collaboration in combating climate change, limit the increase in average global temperature compared to pre-industrial levels to 2 degrees Celsius this century, and strive for a maximum limit of 1.5 degrees Celsius.

Power Exchange Code for Electricity establishes the technical and economic criteria that govern the Day-Ahead electricity schedule and all electricity trading-related transactions. The establishment and operation of both short-term and long-term electrical markets are also subject to regulation by the Code. The Market Operator composes and delivers the Code to RAE. Following public consultation with electricity system consumers and market participants, RAE issues its Decision in support of the Code, incorporating any necessary modifications.

Renewable Energy Community denotes a legally recognized entity that operates autonomously on the principle of open and voluntary participation, and is effectively governed by shareholders or members located in close proximity to the renewable energy projects it owns and develops. Such a community is established in accordance with the applicable national legislation. Municipalities are natural persons, SME members, and regional economic community proprietors.

Renewable Energy Sources Special Account (ELAPE) Renewable energy producers are reimbursed through the ELAPE for the use of such sources. The RES Sub-account of the Non-Interconnected Islands and the RES Sub-account of the Interconnected System comprise the RES Special Account. The Non-Interconnected Islands RES sub-account is administered by HEDNO S.A., while the Interconnected System RES sub-account is managed by DAPEEP. The principal source of revenue for the account is the ETMEAR RES levy, which is incorporated into electricity invoices for consumers.

System Operation Code ensures that without discrimination, all users of the System can access and utilize it in the most straightforward and cost-effective manner feasible. A generator from any power plant may participate in a nondiscriminatory auction to distribute operating aid to RES or CHP power plants, irrespective of the technology used by the power plant to produce energy. A technology-specific auction is the antithesis of an auction that is technology neutral.

Aggregator of Last Resort When a standard licensed aggregator is unable to represent the owner of a power facility in the energy market for a temporary period of time, the Aggregator of Last Resort is tasked with this responsibility for CHP and RES power facilities.

Balancing Responsibility Refers to the obligation of market participants to rectify any discrepancies that may arise in the electricity load between the tangible electricity generated by electricity-producing units and the predetermined physical delivery of the load.

Introduction

The utilization of renewable energy is of utmost importance not only in the European Union's (EU) efforts to combat climate change, but also in the establishment of a stable, sustainable, and economically viable energy industry. In pursuit of this objective, the European Union has diligently endeavored to establish an Energy Union[1]. This initiative involves diversifying Europe's energy sources and enhancing supply security. Additionally, the EU aims to establish a fully integrated internal energy market[2] that facilitates the unrestricted movement of energy across Member States, provided they possess sufficient infrastructure, while simultaneously reducing technical and regulatory obstacles. Furthermore, the EU seeks to enhance energy efficiency and diminish dependence on imported energy resources.

The global community has embraced the move to renewable energy as a key approach to tackle energy reliance, climate change, and international political agreements. Nevertheless, this objective is not trivial. The development of renewable energy sources in EU[3] and globally[4] is hindered by considerable difficulties stemming from deficiencies within the political and economic environment. The aforementioned weaknesses involve a wide array of concerns that have not been sufficiently addressed at the European Union level or on a domestic scale in Greece. The objective of this Master's Thesis is to analyze the progression of the legislative framework in Greece and the European Union during recent years, while also identifying any prevailing deficiencies.

Understanding the historical backdrop is crucial in order to fully grasp the European Union's shift towards renewable energy sources and the subsequent intensification of efforts throughout the course of time. The European Union has enacted numerous energy efficiency and energy conservation measures by establishing a comprehensive regulatory framework. Of particular significance among the preliminary measures are Regulation (EC) No 1099/2008[5] of the European Parliament and of the Council, along with Directives 2001/77/EC[6] and

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[1] European Council. Energy Union , www.consilium.europa.eu/en/policies/energy-union/. Accessed 26 Dec. 2022.

[2] European , Parliament. "Internal Energy Market: Fact Sheets on the European Union: European Parliament." Fact Sheets on the European Union | European Parliament, www.europarl.europa.eu/factsheets/en/sheet/45/internal-energy-market. Accessed 26 Dec. 2022.

[3]Czyżak, Paweł, et al. "Ready, Set, Go: Europe's Race for Wind and SolarEurope's Race for Wind and Solar." Ember, 15 Nov. 2023, https://ember-climate.org/app/uploads/2022/07/Report_-Ready-Set-Go_-Europes-Race-for-Wind-and-Solar-2.pdf

[4] Susskind, L. *et al.* (2022) 'Sources of opposition to renewable energy projects in the United States', *Energy Policy*, 165, p. 112922. doi:10.1016/j.enpol.2022.112922.

[5] Lex - 32008R1099 - En - EUR-Lex." EUR, eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008R1099. Accessed 26 Dec. 2022.

[6] Lex - 32001L0077 - En - EUR-Lex." EUR, eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32001L0077. Accessed 16 July 2023.

2003/30/EC[7] of the European Parliament and of the Council. The aforementioned recommendations have highlighted numerous technologies that are designed to facilitate the integration of renewable energy sources into the transportation sector. The adoption of the policy aimed at encouraging the utilization of renewable energy sources (RES) can be attributed primarily to the influence of the Kyoto Protocol[8]. Within the framework of this international accord, the European Union made a firm commitment to decrease its emissions of greenhouse gases (GHG) by 8% within the designated timeframe of 2008 to 2012. This commitment was later extended by the Doha amendment[9] and eventually supplanted by the Paris Agreement in 2015. The Paris agreement[10], in turn, saw participating nations pledge to limit global warming to a level significantly below 2 °C.

The disruptions in energy supply from Russia to the European Union also had a significant impact. The disruptions in gas supply and the crisis between Russia and Ukraine in January 2009[11] served as the initial key spark. The reputation of Russia as a supplier to Europe and Ukraine as a transit nation has been negatively impacted. European customers have increased their endeavors to diversify their energy sources, reducing their reliance on Russian gas. The expression of this effort to promote diversity was manifested through the implementation of an EU Directive[12]. The adoption of a directive in 2009 aimed at advocating for the utilization of renewable energy sources. The Renewable Energy Directive (RED I) was implemented to enforce mandatory[13] national targets for all Member States with regards to the percentage of renewable energy in the European Union's overall final energy consumption. The minimal targets, although exhibited variation among the Member States, collectively facilitated the attainment of the 20% target across the European Union. The objective outlined in RED II was augmented in 2018[14], with the aim of reaching a target of 32 percent by the year 2030. This action was undertaken as a response to the 2016 Paris Agreement, which established the

[7] Lex - 32003L0030 - En - EUR-Lex." EUR, eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32003L0030. Accessed 14 July 2023.

[8] Wohlgemuth, N. and Missfeldt, F. (2000) 'The Kyoto mechanisms and the prospects for Renewable Energy Technologies', Solar Energy, 69(4), pp. 305–314. doi:10.1016/s0038-092x(00)00103-1.

[9] European Parliament. Doha Amendment to the Kyoto Protocol. https://www.europarl.europa.eu/EPRS/EPRS-AaG-559475-Doha-Agreement-Kyoto-Protocol-FINAL.pdf .Accessed 26 December 2022.

[10] European Council. Energy Union , https://www.consilium.europa.eu/en/policies/climate-change/paris-agreement/#EU

[11] Stern, Jonathan P. et al. "The Russo-Ukrainian Gas Dispute of January 2009: A Comprehensive Assessment." *Oil, Gas & Energy Law Journal* 7 (2009): n. pag.

[12] Lex - 32009L0028 - En - EUR-Lex." EUR, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009L0028. Accessed 26 Dec. 2023.

[13] Johnston, A., and Van der Marel, e. (2016). 'How binding are the EU's "binding" renewables targets?', Cambridge Yearbook of European Legal Studies, 18, pp. 176–214. doi:10.1017/cel.2016.7.

[14] European Commission. Renewable energy – recast to 2030 (RED II), EU Science Hub. Available at: https://joint-research-centre.ec.europa.eu/welcome-jec-website/reference-regulatory-framework/renewable-energy-recast-2030-red-ii_en. Accessed 6 May 2023.

objective of mitigating global warming to a level much below 2°C, with a preference for limiting it to 1.5°C.

Amidst the Covid 19 pandemic, which has heightened apprehensions regarding climate change, the European Commission has enacted a legislative proposition on 14 July 2021 to amend the Renewable Energy Directive II[15]. This initiative is a component of the extensive revision of European Union climate and energy regulations, commonly referred to as the "Fit for 55" Package[16]. The main purpose of this initiative was to fulfill the European Union's climate action objective of attaining a minimum reduction of 55 percent in greenhouse gas (GHG) emissions by 2030, in comparison to the levels recorded in 1990. This endeavor aims to establish a more solid trajectory for the European Union towards achieving its ultimate goal of climate neutrality[17], which entails reaching a state of net zero GHG emissions, by the year 2050.

The incursion of Russia into Ukraine in February 2022 has heightened the urgency for the European Union to pursue a strategy of diversification[18], particularly in relation to reducing dependence on Russian gas and fossil fuels. Furthermore, it had an impact on the deliberations around the revision of the Renewable Energy Directive. The primary objective behind the redesign of RED II was to align it with the more ambitious goals set forth in the 2030 climate and energy frameworks. Additionally, the revision aimed to develop a unified system that would effectively encourage the utilization of renewable energy sources across all sectors. The amendments, referred to as RED III/IV, stipulate that the proportion of renewable energy in the European Union's total energy consumption must rise to a minimum of 42.5% by 2030[19]. Additionally, there is an informal objective across the EU to achieve a 45% share of renewable energy by the same deadline. These targets are set to align with the EU's legally binding objective of reducing greenhouse gas emissions by 55% by 2030, relative to the levels recorded in 1990.

Greece, a country characterized by a substantial dependence on fossil fuels and a historical pattern of importing substantial volumes of natural gas and oil from

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[15] European Parliament *Revision of the renewable energy directive: Legislative train schedule*, *European Parliament*. https://www.europarl.europa.eu/legislative-train/package-fit-for-55/file-revision-of-the-renewable-energy-directive.Accessed 26 December 2023.

[16] Grimm, V., Sölch, C. and Zöttl, G. (2022) 'Emissions reduction in a second-best world: On the long-term effects of overlapping regulations', *Energy Economics*, 109, p. 105829. doi:10.1016/j.eneco.2022.105829.

[17] Weitzel, M. *et al.* (2023) 'A comprehensive socio-economic assessment of EU climate policy pathways', *Ecological Economics*, 204, p. 107660. doi:10.1016/j.ecolecon.2022.107660.

[18]European Parliament.EU Energy Security and the war in Ukraine: From Sprint to marathon. https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/739362/EPRS_BRI(2023)739362_EN.pdf. Accessed 21 March 2023.

[19]Reuters (2023) *EU reaches deal on higher renewable energy share by 2030*. https://www.reuters.com/business/sustainable-business/eu-reaches-deal-more-ambitious-renewable-energy-targets-2030-2023-03-30/. Accessed 15 April 2023.

Russia[20], found itself unable to evade the consequences. The Hellenic reaction to the crises of 2009 and 2022 entailed a deliberate effort to augment the proportion of renewable energy sources within the nation's energy matrix. Therefore, Greece exhibited full alignment with the political interests of Europe.

The National Climate Law of Greece[21], which went into effect in May 2022, establishes specific goals for reducing global greenhouse gas (GHG) emissions. These objectives include a 55% reduction in GHG emissions by 2030, an additional 80% reduction by 2040 (compared to 2005 emission levels), and the achievement of net negative emissions by 2050. Furthermore, Greece expresses its support for the achievement of targets targeted at decreasing greenhouse gas emissions within the European Union by 55% in comparison to levels seen in 1990, as well as the realization of net zero emissions by the year 2050. The National Energy and Climate Plan (NECP) serves as the primary document outlining the essential measures for addressing emissions in Greece, aiming to attain the nation's emissions reduction goal by 2030 and transition towards a net-zero energy system. From 2011 to 2021, Greece had a significant increase in the proportion of renewable energy in its total final energy consumption (TFEC), rising from 11% to 20%. The primary cause of this increase can be primarily attributable to the enhanced production of wind and solar photovoltaic (PV) electricity. From 2011 to 2021, Greece had a significant increase in the production of renewable energy, with the ability to generate power rising from 8.1 terawatt-hours (TWh) to 22 TWh.

In response to Russia's invasion of Ukraine, Greece has significantly augmented the utilization of renewable energy sources to diminish its dependence on Russian gas[22]. The country has lately adopted many significant enhancements to its renewable electricity generation support program with the aim of enhancing deployment and ensuring cost-effective power pricing. At present, the allocation of subsidies is carried out through auctions that accurately mirror the prevailing market conditions. Greece is currently expediting the procedures associated with licensing, permitting, and grid integration of renewable energy sources. The objective of the National Energy and Climate Plan that was presented in August 2023[23] is to enhance the renewable energy generation potential. According to its new NECP, Greece plans to have 13,4GW of solar PV capacity by 2030, which is significantly higher than the nearly 7.7GW it aimed for when it published its original NECP in 2019. The country aims for 40,3 GW of solar by 2050. And

[20] Nakou , G. (2023) *Country report greece - library.fes.de, Energy Without Russia*. Available at: https://library.fes.de/pdf-files/bueros/budapest/20476.pdf . Accessed 11 April 2023.

[21] International Energy Agency (2023) Energy Policy Review, Greece 2023. https://iea.blob.core.windows.net/assets/7b570018-82d5-4ea3-b1ad-806234b7b184/Executivesummary-WorldEnergyOutlook2023.pdf. Accessed 01 July 2023.

[22] Papakanellou, D. (2023) *Balkan gateway: Greek gas exports save the day as renewables shine at home*, *KPMG*.https://kpmg.com/gr/en/home/insights/2023/06/balkan-gateway-greek-gas-exports-save-the-day-as-renewables-shine-at-home.html. Accessed 26 July 2023.

[23] Floudopoulos, C. (2023) Ποιοι είναι οι νέοι εθνικοί στόχοι για την ενέργεια - Τι λέει το νέο ΕΣΕΚ, Capital.gr. https://www.capital.gr/oikonomia/3733817/poioi-einai-oi-neoi-ethnikoi-stoxoi-gia-tin-energeia-ti-leei-to-neo-esek/. Accessed 2 September 2023.

Greece now aims to attain 1,9GW of offshore wind capacity by 2030. The objective for onshore wind capacity was revised up, to 7.6GW by 2030. The country has no offshore wind farms at present but intends to install 17.3GW by 2050. Renewable energy generation in Greece is projected to increase to 53.7 TWh/yr by 2030, up from 22.2 TWh/yr in 2021. By 2030, it is anticipated that renewables will account for 79% of total electricity consumption [24]. And renewables will produce 44% of total cumulative energy consumption.

The adoption of more ambitious renewable energy objectives requires the expeditious deployment of solar photovoltaic and wind energy technologies in Greece and other European Union Member States. Currently, as the European Commission itself admits[25], there is a lack of comprehensive regulations within the European Union member states that effectively facilitate the implementation of solar and wind energy systems in the coming years and beyond. The progress of these technologies in Europe is inhibited by several impediments, resulting in a deceleration of their development[26].

This Master's Thesis examines the obstacles to the deployment of wind and solar power projects in Greece and the other 27 EU Member States, taking into account country-specific development estimates. If European nations and the EU consistently serve the commitment to reduce their reliance on Russian gas and fossil fuels in general, then these obstacles must be overcome so that wind and solar projects can be constructed more quickly in the coming years. Understanding the hurdles to the deployment of solar and wind energy in EU Member States and Greece allows for the adoption of tailored and efficient solutions. The causes for these barriers are numerous, complicated, and frequently overlapping. Permitting and other administrative delays have been noted by the European Commission as a common impediment to the implementation of renewable energy projects across all Member States. The regulatory complexity, unpredictability, and slowness of procedures all delay and increase the cost of projects, discouraging investors.

The analysis revealed that the rate of progress in renewable energy development and the factors hindering this progress differ among various regions within the European Union. Consequently, it would be unsuitable to regard the European Union as a unified entity in this context. The European Union had a leading role in implementing measures to reduce CO2 emissions and integrate renewable energy

[24]Aposporis, H. (2023) Greece’s revised NECP targets much less energy storage, more natural gas, Balkan Green Energy News. https://balkangreenenergynews.com/greeces-revised-necp-targets-much-less-energy-storage-more-natural-gas/. Accessed 2 September 2023.
[25]Lex - 32022R0720- En - EUR-Lex.” EUR, eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R0720. Accessed 26 July 2023.
[26] Taskin, D., Dogan, E. and Madaleno, M. (2022) ‘Analyzing the relationship between energy efficiency and environmental and financial variables: A way towards sustainable development’, Energy, 252, p. 124045. doi:10.1016/j.energy.2022.124045.

sources into electrical generation[27]. The European Commission implemented an energy policy that establishes strict and obligatory objectives on the transition to "green" energy. This approach rests on two fundamental principles: a significant reduction in carbon emissions and the control of the European Union's reliance on foreign sources of energy. By doing so, it aims to guarantee both economic and environmental sustainability.[28].

The findings of the analysis indicate that there is no statistically significant association between the challenges faced by renewable energy sources in the European Union and the variations in the share of renewable energy in overall energy consumption. The long-term prospects for the contribution of renewable energy sources (RESs) to energy consumption are significantly influenced by several obstacles, including political, administrative processes, and market and economic barriers. These impediments have a statistically significant impact on the implementation of RESs technology[29]. When examining specific countries, there were relationships and statistically significant effects of the assessed restrictions on the development of renewable energy sources.

In order to accelerate the use of renewable energy, it is crucial to simplify administrative procedures[30], enhance environmental planning, and minimize expenses in these locations. renewable energy sources development faced substantial challenges due to grid limitations, notably in specific locations such as Southern-Central Europe and Greece[31]. The challenges were sluggish construction of grid infrastructure, obscure procedures for grid connection, and exorbitant connection prices. Resolving these concerns is crucial for unleashing the full capacity of renewable energy in these regions.

Enhanced allocation of public funds towards research and development, along with enhanced assistance systems for creators, will play a crucial role in propelling innovation in renewable energy technologies and promoting sustainable economic expansion throughout the European Union. It has been determined that administrative process constraints have a substantial or extremely substantial effect

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[27] International Energy Agency (2023). *IEA Energy and Carbon Tracker 2022 - data product, IEA.* at: https://www.iea.org/data-and-statistics/data-product/iea-energy-and-carbon-tracker-2022. Accessed 21 January 2023).

[28] Halkos, G.E. and Tsirivis, A.S. (2023) 'Electricity production and sustainable development: The role of renewable energy sources and specific socioeconomic factors', *Energies*, 16(2), p. 721. doi:10.3390/en16020721.

[29] Shivakumar, A. et al. (2019) 'Drivers of renewable energy deployment in the EU: An analysis of past trends and projections', Energy Strategy Reviews, 26, p. 100402. doi:10.1016/j.esr.2019.100402.

[30] Kaur Dosanjh,M. et al. (2023) How to resolve the bottlenecks that slow down the Green Transition, World Economic Forum. https://www.weforum.org/agenda/2023/01/speeding-up-sustainable-energy-bottlenecks-and-how-you-resolve-them-davos2023/. Accessed 5 February 2023.

[31] Liaggou, C. (2023) Industry pressure on Res Grid Capacity, https://www.ekathimerini.com/economy/1223559/industry-pressure-on-res-grid-capacity/ Accessed 2 December 2023.

on the introduction of clean energy sources in the majority of EU member states. However, in light of market economic limitations, the level of social development had a substantial influence on the percentage of energy consumption derived from renewable sources. Relatively modest levels of social development impeded progress.

Most EU member states are affected by different types of obstacles. In economically disadvantaged European Union nations, the presence of recession or slow economic growth presented a significant barrier to the advancement of renewable energy sources. An increase in GDP per capita encourages a corresponding growth in the use of renewable energy sources for both electricity production and overall energy consumption. The economies of less prosperous member states of the European Union were significantly impacted by administrative impediments[32]. In countries where a significant or significantly rising amount of power came from renewable sources, the surplus capacity in the renewable market had a significant impact on development[33].

The status of the grid infrastructure in Southern–Central European nations, especially Greece, has been identified as a significant barrier to the development of renewable energy sources (RES). This includes delayed development, complicated processes for connecting renewable energy sources to the grid, and high grid connection charges[34]. A number of policymaker-advocable recommendations regarding the promotion of renewable energy can be derived from this analysis. Considerable priority should be given to socioeconomic advancement, specifically focusing on fostering economic expansion and removing bureaucratic obstacles in underdeveloped economies. This can be accomplished by optimizing environmental planning methods[35] and decreasing their length. It is crucial that more advanced nations give higher importance to reducing overcapacity in the renewable energy industry.

Another conclusion is the absence of research on the state of barriers in every member state of the European Union, which would hinder the ability to track advancements in this area of study. The existing body of literature lacks sufficient attention to the significant influence that socioeconomic factors exert on the progress of renewable energy sources and the degree to which member states meet their target indicators. The statistical analysis of the RES barriers that were submitted illustrates the importance of taking into account the differences and

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[32] European Commission (2016). Clean Energy for All Europeans—Unlocking Europe's Growth Potential. IP_16_4009. https://europa.eu/rapid/press-release_IP-16-4009_en.htm. Accessed on 26 April 2023.

[33] Rafiq, S., Salim, R. and Nielsen, I. (2016) 'Urbanization, openness, emissions, and energy intensity: A study of increasingly urbanized emerging economies', *Energy Economics*, 56, pp. 20–28. doi:10.1016/j.eneco.2016.02.007.

[34] Gajdzik, B. et al. (2023) 'Barriers to renewable energy source (RES) installations as determinants of energy consumption in EU countries', Energies, 16(21), p. 7364. doi:10.3390/en16217364.

[35] Lazzari, F. et al. (2023) 'Optimizing planning and operation of renewable energy communities with genetic algorithms', Applied Energy, 338, p. 120906. doi:10.1016/j.apenergy.2023.120906.

needs of different groups of countries when formulating strategies to overcome these challenges. The elimination of obstacles to the development of a diversified energy system[36] is linked to the implementation of RES policies in countries. Despite the fact that EU directives are universally applicable across the European Union, the analysis unveiled that impediments to the development of renewable energy sources are not uniform across the EU. Furthermore, specific barriers or determinants impeding the progress of renewable energy sources in Europe are often country-specific or region-specific. Significantly a greater emphasis ought to be given to the obstacles that hinder the advancement of infrastructure for renewable energy infrastructure[37] and technologies when formulating specific policies.

The measures implemented in recent years are a significant step in the right direction, but they will not alter the course of climate policy unless obstacles are eliminated decisively in the years to come. The achievement of ultimate success in the energy sector necessitates the consistent implementation of reform initiatives and a significant increase in public investment in research and development, including from domestic sources. Additionally, the continuous improvement of tools that support innovators, which includes the utilization of expertise acquired from completed projects in recent years, is crucial[38]. As with any research endeavor, this one has limitations. The principal constraint is the annual monitoring of barriers for EU member states, which is necessary for future analysis, as well as the challenges associated with data access. Furthermore, it is suggested that future research endeavors undertake analyses in subsequent years, extend analyses to encompass groups of European Union member states, and endeavor to make international comparisons.

The analysis presented in this Master's Thesis captures the picture up to the beginning of 2024 and many of the figures listed will soon be out of date. This study aims to make a methodological contribution to pertinent research and illustrate that numerous challenges impeding the progress of photovoltaic and wind energy sources can be surmounted through systematic monitoring and documentation of conditions—a responsibility that the European Commission should to undertake more consistently[39].

[36] De Rosa, M. et al. (2022) 'Diversification, concentration and renewability of the energy supply in the European Union', Energy, 253, p. 124097. doi:10.1016/j.energy.2022.124097.

[37] García-Gusano, D., Iribarren, D. and Garraín, D. (2017) 'Prospective analysis of energy security: A practical life-cycle approach focused on renewable power generation and oriented towards policy-makers', Applied Energy, 190, pp. 891–901. doi:10.1016/j.apenergy.2017.01.011.

[38] Chalvatzis, K.J. and Ioannidis, A. (2017) 'Energy Supply Security in the EU: Benchmarking diversity and dependence of primary energy', Applied Energy, 207, pp. 465–476. doi:10.1016/j.apenergy.2017.07.010.

[39] Lacal Arantegui, R. and Jäger-Waldau, A. (2018) 'Photovoltaics and wind status in the European Union after the Paris Agreement', *Renewable and Sustainable Energy Reviews*, 81, pp. 2460–2471. doi:10.1016/j.rser.2017.06.052.

Literature Review Methodology

This Master's Thesis literature review was developed using multiple methodologies to create substantial sections of the thesis. The preceding items include the following:

In order to ascertain the current context of solar and wind energy in Greece and Europe, I formulate research questions based on the most recent policy impacts, market trends, environmental impacts or challenges, and technological advancements. Several questions were raised pertaining to the following, as an illustration: What are the impacts of renewable energy and fossil fuels on the European Union and Greece? To what extent do the existing policies implemented in each European Union member state facilitate the advancement of wind power and solar power industries? Can indigenous research enhance the efficacy and affordability of power generated from renewable energy sources? Will the implementation of renewable energy sources result in more opportunities in Greece and the European Union? What types of financial assistance and potential rewards are associated with renewable energy initiatives? What are the most advanced technological solutions accessible for each resource, and what is the level of expertise possessed by the professionals in this field? Does the European Union and Greece have sufficient energy security measures in place for their renewable resources?

Using academic databases, online archives, research journals, and industry publications, a search strategy was developed to identify relevant literature in order to identify peer-reviewed articles and reports concerning advancements in wind and solar energy in European Union countries and Greece. The identified literature was thoroughly collected and organized in accordance with the predetermined research questions in the subsequent phase. In addition, a summary of the most significant findings and perspectives from each source was included.

I evaluate the quality and credibility of the sources using a number of variables, such as the renown of the authors, the rigor of the research methodology employed, and the applicability of the findings to the research questions. After that I engage in an in-depth examination of the current status of solar and wind energy in the member states of the European Union and Greece by integrating data from a variety of sources using selected sources and articles. The task at hand required the identification of pervasive patterns, research gaps, and topics requiring additional study.

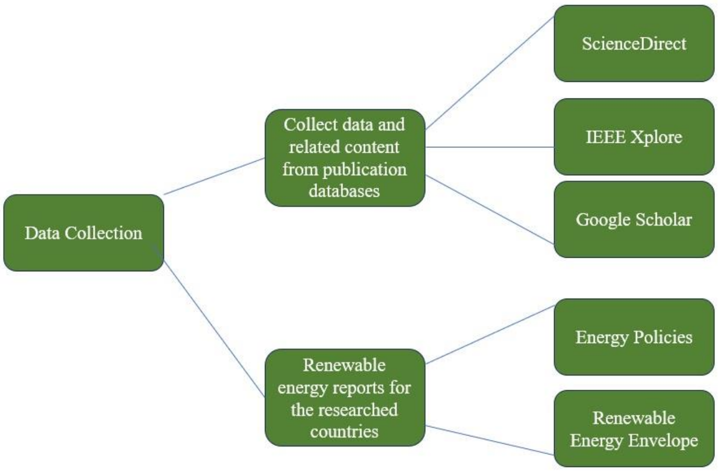

Figure 1. Analysis of the data collection method

In order to classify the gathered data, I implemented the following methodology: The articles gathered primarily focused on renewable energy sources. These articles were obtained from reputable academic databases such as IEEE Xplore[40], Science Direct[41] (Scopus Indexed and Science Citation Index), and Energy policies. Previous researchers examined the implementation of renewable energy in various countries, considering the specific policies and available resources in those regions. Google Scholar[42] has successfully recognized the scholarly works authored by previous researchers who have conducted their investigations within the specified domain. The data pertaining to the utilization of renewable energy resources and financial requirements of the nations mentioned in this study has been gathered from the Renewable Energy portfolio. At the outset, a total of 700 articles were taken into consideration for the purpose of this review.

During the secondary step, a thorough examination was conducted to identify and delete unnecessary articles, leaving only those that are pertinent to the present study. Subsequently, the articles that were reclaimed undergo a thorough examination, wherein no regard is given to those items that fail to match the specified criteria for formal analysis. During the final stage, specific papers were selected for this study, and reputable articles gathered from the databases of numerous research portals. My analysis encompasses a comprehensive compilation of 145 publications in the entire work cited.

[40]IEEE Xplore. https://ieeexplore.ieee.org/Xplore/home.jsp. Accessed 1 September 2022.
[41] Explore scientific, technical, and medical research on ScienceDirect (no date) ScienceDirect.com | Science, health and medical journals, full text articles and books. https://www.sciencedirect.com. Accessed 1 September 2022.
[42]Google scholar. https://scholar.google.com. Accessed 1 September 2022.

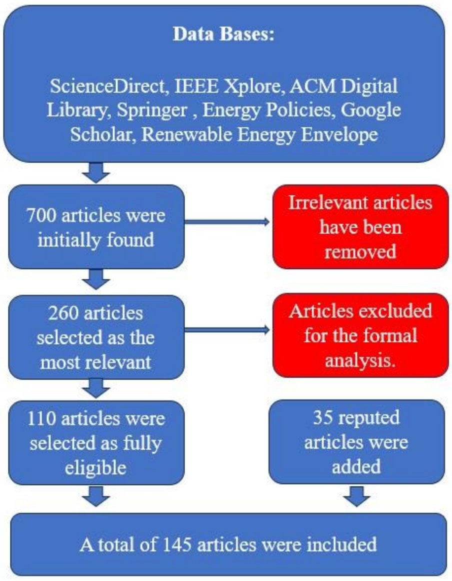

Figure 2. The process of prioritizing key publications for research compilation

SWOT Analysis Methodology

For the purpose of developing the Master's Thesis, the SWOT analysis was selected as the suitable methodology for assessing the internal strengths and weaknesses, as well as the external opportunities and threats, pertaining to the advancement of solar and wind energy in Europe and Greece. The analysis was conducted with the objective of identifying and scrutinizing the primary elements that have the potential to influence the success and expansion of solar and wind energy technologies within a defined environment, such as a country, region, or market.
In order to do the SWOT analysis for solar and wind energy, a series of stages were undertaken as follows:

The pertinent data and information regarding the present status of solar and wind energy implementation in Greece and Europe were gathered, with a specific emphasis on technological breakthroughs, regulatory frameworks, market trends, and other factors that exert influence on the industry. Next, an assessment was conducted on the internal characteristics that confer a competitive edge onto solar and wind energy in comparison to alternative energy sources. The elements considered in this study encompassed ample solar or wind resources, decreased carbon emissions, scalability, technical developments, and government assistance through renewable energy objectives and incentives.

Subsequently, an examination was conducted to assess the internal elements that may impede the expansion or efficacy of solar and wind energy. The challenges investigated encompassed issues such as intermittency, energy storage demands, disputes related to land usage, and the impact of seasonality on energy production.

In the subsequent phase, an analysis was conducted on the external factors or market conditions that have the potential to foster growth in solar and wind energy sectors inside Greece and other European Union member states. The research focused on analyzing many aspects related to green energy investments, including trends, supportive policies, technological breakthroughs, market demand, and potential synergies with industries such as electric vehicles or energy storage.

Next, I engaged in the process of evaluating potential risks and hazards. I assessed the external elements and difficulties that may present potential dangers to the advancement and acceptance of solar and wind energy inside Greece and the European Union. In addition to other aspects, my research primarily centered on the examination of competition arising from traditional energy sources, shifts in regulatory policies, economic considerations, and disruptions within the supply chain.

Upon the completion of the aforementioned stages, I proceeded to prepare two SWOT matrices. The findings were presented by classifying the discovered factors into four quadrants, namely Strengths, Weaknesses, Opportunities, and Threats. These matrices offer a comprehensive analysis of the present condition and future potential of solar and wind energy in Greece and the European Union.

Drawing upon the findings of the SWOT analysis, I formulate plans that leverage organizational strengths, address points of weakness, exploit potential opportunities, and minimize potential threats. These strategies have the potential to provide guidance in decision-making processes and facilitate the optimization of the development and deployment of solar and wind energy technologies.

SWOT analysis of Renewable Energy Technology in Europe

	STRENGHTS	WEAKNESS	OPPORTUNITIES	THREATS
SOLAR ENERGY	Abundant Solar Resources: The European Union possesses considerable solar energy resources, as different areas within its territory receive great amounts of sunlight, particularly in Southern Europe.	Intermittency: Is a characteristic of solar energy generation whereby its output is contingent upon the availability of sunshine. This intermittency poses challenges in meeting energy demand, particularly during periods of cloud cover or during nocturnal hours. The vulnerability in question exhibits a greater degree of prominence within states located in northern Europe.	Technological Advancements: Ongoing developments in solar technology, including the improvement of solar panels' efficiency and the enhancement of energy storage technologies, have the potential to augment the performance and cost-efficiency of solar energy systems. The European industrial sector's manufacturing of solar energy components contributes to the economic stability and growth of the local community.	Extending government subsidies:The impact of alterations in government regulations, incentives, or feed-in tariffs on solar energy has been acknowledged as a determinant of the appeal of solar investments and the feasibility of projects. Nevertheless, the implementation of such a strategy is compelled by budgetary limitations inside the European Union. On the contrary, several corporations and interest groups engage in lobbying activities across multiple nations, urging governments to implement regulations that prioritize their own interests, often at the expense of the wider advantages associated with the sustainable development of solar energy.
	Reduced Carbon Emissions: The utilization of solar energy as a sustainable and ecologically sound energy source contributes to the European Union's efforts in addressing climate change and reducing carbon emissions.	Energy Storage Requirements: The necessity of energy storage in solar energy systems is of paramount importance due to the intermittent nature of solar power generation. The incorporation of energy storage technologies is often necessary to mitigate the effects of intermittency. Europe is currently experiencing advancements in the field of energy storage technologies, which are being supported by endeavors to construct a comprehensive legislative framework.	Integration with Storage and Smart Grids: The integration of solar energy with energy storage systems and smart grids has the potential to enhance grid stability and optimize energy management, hence increasing the reliability and value of solar power. By adopting this approach, the European Union enhances its energy security and expedites the attainment of sustainable development objectives.	Competition from Other Energy Sources and Other Activities: Solar energy encounters competition from conventional fossil fuels, as well as alternative renewable energy sources like wind and biomass, and the utilization of nuclear energy. In nations such as France, characterized by a substantial agricultural sector and a major reliance on nuclear power to meet energy demands, the adoption and integration of solar energy technologies is not as widespread as its potential suggests.
	Decentralized Generation: The utilization of solar energy enables the adoption of decentralized power generation, thereby allowing residential and commercial consumers to independently produce electricity and reduce their dependence on centralized fossil fuel power plants. Solar technologies enable energy producing facilities to be located in close proximity to the place of energy consumption. Facilitates the optimized usage of renewable energy sources, in conjunction with the integration of combined heat and power systems, thereby reducing the reliance on fossil fuels and fostering the enhancement of ecological efficiency.	Land Use Concerns: The implementation of large-scale solar projects may encounter resistance or disputes on land utilization, particularly in regions where there are conflicting demands for agricultural purposes or conservation efforts.	Community Solar Initiatives: In numerous European Union (EU) nations, the advancement of photovoltaic initiatives is facilitated through collaborative efforts among local entities, operating within the context of energy communities. Community solar efforts offer a viable avenue for individuals to collaboratively engage in solar energy endeavors, so affording them the opportunity to receive solar electricity without the necessity of installing solar panels on their personal properties.	Economic Factors: Economic downturns, changes in material pricing, as well as volatility in energy prices might potentially impact investment choices in solar initiatives. This phenomenon was experienced within the global pandemic, wherein there was a substantial surge in the prices of raw materials and a widespread occurrence of shortages in essential components.
	Renewable Energy Targets: The European Union has set forth lofty targets for renewable energy, showcasing its dedication to enhancing the share of renewable sources in its energy mix. In recent years, there has been a notable development in the creation of a regulatory framework that promotes and supports solar energy ventures.	Seasonal Variability: The output of solar energy may experience fluctuations on a seasonal basis because of differences in the duration of daylight hours. These fluctuations have implications for energy supply, necessitating the need for alternative power sources to serve as backups. The variability is readily apparent in the European Union's northern nations.	Electrification and Electric Vehicles (EVs): The importance of solar energy in facilitating the expanding electrification of transportation through the utilization of renewable energy to charge electric vehicles is becoming increasingly apparent. With the anticipated rise in the use of electric vehicles, the significance of solar energy is poised to escalate.	Solar Component Shortages: Historically, the European Union has heavily depended on the importation of solar components from nations such as China. Consequently, any disturbances in the supply chain have the potential to impact project costs and deadlines. Currently, there is a notable increase in the domestic manufacture of solar components, and it is anticipated that this issue will be largely resolved in the foreseeable future.
	Scalability:Solar energy systems possess the intrinsic capacity to be easily expanded from small-scale residential setups to large-scale utility projects, so successfully catering to a diverse array of energy needs.	Integration of the Grid: Grid integration is a pressing concern in various European Union nations, particularly those in the southern region. The current grid infrastructure in these countries may necessitate enhancements to effectively accommodate the growing	Hybrid Solutions: The European Union is currently placing more emphasis on the integration of solar energy with other renewable sources, like wind and hydrogen, with the aim of augmenting overall energy reliability and diversifying the energy supply. This endeavor	Multi-speed Transition: The transition towards solar energy and the establishment of a more sustainable energy system within the European Union is characterized by a multi-speed dynamic, encompassing diverse trajectories and incorporating various levels of technology and

		adoption of solar energy and provide seamless integration into the electricity system.	will result in a decreased reliance on fossil fuels and a mitigation of the enduring expenses associated with generating electricity from renewable sources.	commercial uncertainties. Energy companies must proactively acknowledge potential risks and exhibit adaptability in order to effectively manage the shift. A crucial requirement for this endeavor is the presence of a consistent and reliable institutional framework, which unfortunately is not uniformly provided throughout all European nations.
	STRENGHTS	**WEAKNESS**	**OPPORTUNITIES**	**THREATS**
WIND ENERGY	Abundance of Wind Resources: The European Union has a significant abundance of wind resources, which are defined by their strong and consistent nature. These resources are found in many places, with a special emphasis on coastal areas and offshore sites.	Intermittency and Grid Integration: The intermittency of wind energy presents significant issues in terms of grid stability and integration, necessitating the allocation of resources towards energy storage and grid infrastructure to effectively manage the fluctuations in energy generation.	Offshore Wind Potential: The European Union possesses considerable potential for the development of offshore wind energy in the North Sea, Baltic Sea, and Atlantic Ocean. These regions present favorable conditions for the establishment of expansive and highly productive wind farms.	Political Ambiguity: Political and regulatory uncertainty persists in the European context, as member states pursue their individual national agendas despite the overarching goal of achieving zero emission sources. The alteration of governmental priorities or regulatory frameworks in certain instances can significantly influence the appeal of wind energy investments and add a level of uncertainty for developers.
	Renewable Energy Targets: The European Union has established ambitious targets for renewable energy, with the objective of substantially increasing the proportion of renewable sources in its overall energy composition. This dedication establishes a conducive regulatory framework for the implementation of wind energy initiatives.	Land Use and Environmental Impact: The issue of land use and environmental impact arises in relation to onshore wind farms throughout the EU, which frequently face opposition stemming from land use conflicts and apprehensions regarding their visual and environmental consequences, especially in densely populated areas.	Grid Interconnections: Enhancing cross-border interconnections facilitates the transfer of wind energy across nations, so bolstering energy security and enabling the exportation of surplus energy.	Competition from Other Energy Sources: In certain EU nations, wind energy confronts competition from conventional fossil fuels and other renewable sources, including solar and biomass. Interest groups that wish to advance their own technologies and maintain their influence are attempting to slow the spread of wind energy.
	Market Leader in Wind Technology: The European Union holds a prominent position as a market leader in wind technology, showcasing its global leadership in the field of	Permitting and Regulatory Hurdles: The presence of intricate permitting processes and regulatory obstacles frequently leads to project delays and cost escalation within	Green Recovery and Investments: The European Union's emphasis on green recovery in the aftermath of the epidemic offers prospects for heightened investments in	Economic Challenges: In nations where the advancement of renewable energy sources relies on government subsidy programs, the stringent adherence to the Stability and
	wind energy technology and innovation. Numerous companies within the EU have successfully developed and manufactured cutting-edge wind turbines and associated components.	wind energy initiatives across the European Union. Wind farm development is forbidden by national defense ministries, particularly in the Nordic countries and countries bordering Russia, due to interference with military radars.	renewable energy, including as wind farms.	Growth Pact creates financial challenges for energy initiatives. The potential impact of economic downturns and financial instability on investment in wind energy projects should be considered.
	Job Creation: The development of wind energy in the European Union has been found to have a positive impact on job creation and economic growth. This impact is notably evident in industries such as manufacturing, building, and maintenance.	Subsidy Capture: Within the European Union, there exists a common pattern wherein individuals or entities known as rent-seekers endeavor to obtain subsidies and financial incentives for wind energy initiatives, without demonstrating a sincere dedication to efficiently building or operating those projects. Frequently, actors employ political influence or engage in lobbying activities as a means to secure access to governmental money designated for the purpose of promoting the advancement of renewable energy.	Complementary Technologies: The integration of wind energy with other renewable sources, such as solar and hydrogen, has been explored in recent years as a means to optimize energy production in EU and improve grid stability.	Energy Market Fluctuations: The effect of energy price fluctuations on investments in wind energy initiatives has been particularly pronounced, particularly in the wake of the pandemic.
	Decentralized Energy Production: The utilization of wind energy enables the decentralization of power generation, hence enabling the implementation of community-oriented initiatives and diminishing dependence on centralized fossil fuel power plants.	Cartel Formation: Within certain European Union countries, there exists a propensity for certain entities to pursue the establishment of monopolies or cartels within the wind energy industry. This strategic action aims to restrict competition and exert control over pricing mechanisms, thereby impeding market efficiency and creating barriers for potential market entrants.	Energy independence and diversification of sources: The utilization of wind energy has the potential to make a substantial contribution towards attaining energy independence for numerous European Union member states. This, in turn, would mitigate the reliance on expensive imports of fossil fuels from nations like Russia.	Transition Risks and Preparedness: The shift to renewable energy and the establishment of a sustainable energy system encompass inherent uncertainty in both scientific advancements and market dynamics. Energy companies must proactively acknowledge and mitigate potential risks while showcasing their ability to adapt and endure in order to effectively navigate through the transitional period. Research has demonstrated that there exists variation among European Union member states in terms of their preparedness for a smooth transition.

SWOT analysis of Renewable Energy Technology in Greece

	STRENGHTS	WEAKNESS	OPPORTUNITIES	THREATS
SOLAR ENERGY	Reduced Carbon Footprint: Increased adoption of solar energy can help Greece reduce its dependence on fossil fuels and lower carbon emissions, contributing to environmental sustainability.	Rent-seeking: Rent-seeking in the context of solar energy in Greece refers to the practice of individuals or entities trying to gain economic benefits or profits without creating any corresponding value or productivity.	Government Incentives: The Greek government offers various incentives, feed-in tariffs, and subsidies to support solar energy development, attracting investors and stimulating the market.	Changing Policies: Changes in government policies or support mechanisms for renewable energy could impact the attractiveness of investing in solar projects.
	Renewable Energy Targets: The Greek government has set ambitious renewable energy targets, including a significant increase in solar capacity, creating a favorable regulatory environment for solar energy projects.	Grid Integration: The existing grid infrastructure may require upgrades to handle the increasing penetration of solar energy and ensure smooth integration into the electricity system.	Energy storage investments: Battery storage devices will aid in grid stabilization by balancing energy supply and demand.	Lobbying: Companies and interest groups frequently lobby the government to adopt policies favorable to their interests, while ignoring the broader benefits of sustainable solar energy development.
	Abundant Sunshine: Greece has a high solar irradiance due to its geographic location, making it an ideal region for solar energy production.	Seasonal Variability: Greece experiences seasonal variations in sunlight, which may impact solar energy generation, especially during the winter months.	Hybrid Solutions: Integrating solar energy with other renewable sources, such as wind and hydrogen, could enhance overall energy reliability and supply diversity.	Transition Risks: The transition to renewable energy and a more sustainable energy system involves technological and market uncertainties. Energy firms need to address potential risks and demonstrate resilience to navigate through the transition successfully.
	Tourism Potential: The tourism industry in Greece presents an opportunity for solar energy integration in hotels, resorts, and other tourist facilities, showcasing environmental responsibility and sustainability to visitors.	Land Use Conflicts: Large-scale solar projects may face opposition or conflicts over land use, especially in areas with competing interests for agricultural or environmental preservation.	Rural Electrification: Solar energy offers an opportunity to extend electricity access to remote and off-grid areas in Greece, improving the quality of life for rural communities.	Competing Energy Sources: Conventional energy sources like natural gas and LNG present competition in the energy market, potentially affecting the demand for solar projects.
	Distributed Generation: Solar panels can be installed on rooftops and in remote areas, reducing transmission losses and enhancing energy security for local communities.	Intermediaries or middlemen are exploiting their position to extract excessive profits from solar energy transactions, inflating costs without adding significant value to the supply chain.	Island Energy Independence: Solar energy can significantly contribute to achieving energy independence for Greece's numerous islands, reducing dependence on costly fossil fuel imports.	Imported Solar Components: Greece may rely on importing solar components, and any disruptions in the supply chain could affect project timelines and costs.

	STRENGHTS	WEAKNESS	OPPORTUNITIES	THREATS
WIND ENERGY	Abundant Wind Resources: Greece possesses substantial wind resources, particularly in coastal regions and its islands, rendering it very suitable for the development of wind energy.	Intermittent Characteristic: Wind energy exhibits an intermittent nature as it relies on the availability of wind, which is subject to temporal fluctuations, hence resulting in fluctuations in energy generation.	Advancements in Wind Technology: Continual progress in wind turbine technology, characterized by the development of larger and more efficient turbines, coupled with the expertise of Greek manufacturers, contributes to the enhanced cost-effectiveness and performance of wind energy initiatives.	Policy Shifts: Regulatory and policy alterations refer to changes made to governmental laws or regulations, which might potentially affect the incentives and assistance available for wind energy projects.
	Renewable Energy Targets: Greece has established ambitious objectives for renewable energy, which encompass a notable expansion in wind energy capacity, thereby fostering a legislative framework conducive to the implementation of wind energy initiatives.	Grid Integration Difficulties: The integration of substantial quantities of wind energy into the grid necessitates meticulous planning and grid enhancements to uphold grid stability and ensure the equilibrium between supply and demand.	Offshore Wind Potential: Greece possesses considerable potential for offshore wind energy, with the development of offshore wind projects offering the opportunity to harness previously unexploited wind resources while mitigating problems related to land usage.	Competition from Other Energy Sources: Growth and investment in wind energy could be hampered by competition from other energy sources like traditional fossil fuels or alternative renewables. The high percentage of gas in Greece's energy mix is indicative of this.
	Reduced Carbon Emissions: Wind energy production in Greece plays a significant role in mitigating climate change and minimizing the country's carbon footprint due to its absence of greenhouse gas emissions.	Visual and Environmental Impact: In a country such as Greece, where the tourism industry plays a crucial role, the installation of expansive wind turbines can potentially lead to visual and environmental ramifications. These effects have the potential to elicit criticism from neighboring communities and environmental advocacy groups.	Energy Export Potential: Greece possesses the potential to serve as an energy exporter to its neighboring nations due to its advantageous geographical location, which enables it to capitalize on its wind energy resources.	Economic Factors: Changes and ambiguity in the economy might affect the confidence of investors and the cost-effectiveness of wind energy projects. Low rates of return on financial investment and risk have become more likely during the recent economic crisis, which has reduced the typical profitability of wind energy projects.
	Job Creation: The establishment of wind energy projects has the potential to generate employment opportunities and foster local economic growth, particularly in rural and coastal areas that are commonly chosen as sites for wind farms.	Land Use Conflicts: Land use conflicts often emerge in Greece when wind farms, due to their substantial land requirements, conflict with other land uses, such as agricultural activities or the preservation of natural habitats. In certain instances, there exist protracted legal conflicts.	Energy Storage Development: The incorporation of energy storage technologies into wind energy systems holds promise in addressing the issue of intermittency and enhancing the stability of power grids.	Public Sentiment: Concerns over the visual impact and environmental ramifications of wind farms have swayed public opinion, which might slow down or even kill the projects. Many people have objected to and filed lawsuits against the siting of wind turbines in Natura areas and on church-owned land.

	Complementary to Solar Energy: Wind energy serves as a complementary source to solar energy due to its tendency to reach peak levels during periods when solar energy output is diminished. This characteristic contributes to a more harmonized and well-rounded renewable energy supply.	Misuse of Environmental Impact Assessments: The misapplication of Environmental Impact Assessments (EIAs) has been observed in the context of the Greek wind energy market, where certain companies engaged in rent-seeking behavior have sought to influence or distort the outcomes of EIAs. Their objective is to secure authorization for wind energy initiatives in environmentally vulnerable regions.	Island Energy Independence: Energy independence: Wind energy possesses the capacity to significantly contribute to the achievement of energy independence for the many islands of Greece, therefore reducing dependency on costly imports of fossil fuels.	Imported Wind Components: Greece is dependent on wind components that are imported, specifically wind turbines. Any potential delays in the supply chain could have adverse effects on project schedules and financial expenditures.

Chapter 1: The current landscape in Europe and Greece

1.1 The Renewable Energy Directive's Evolution
1.2
Increasing the proportion of renewable energy across all sectors of the economy is a crucial building element for achieving the EU's energy and climate goals[43]. In this context, EU legislation pertaining to the promotion of renewable energy has evolved significantly over the past fifteen years. As indicated in the introduction, energy supply issues related to Russia have acted as a "legislative accelerator" in some instances, with the relevant European policies having been largely endorsed by EU citizens [44].

The original Renewable Energy Directive, adopted on 23 April 2009 (Directive 2009/28/EC[45], repealing Directives 2001/77/EC and 2003/30/EC), mandated that by 2020, 20% of the EU's energy consumption must be derived from renewable sources. The directive required all Member States to obtain 10% of their transport fuels from renewable sources and outlined a variety[46] of mechanisms Member States could employ to meet their targets, including support schemes, guarantees of origin, joint projects, and cooperation between Member States and third countries, as well as sustainability criteria for biofuels. The directive validated the existing national renewable energy targets of each country until 2020, considering both the initial value and the overall potential of renewable energy. In a national renewable energy action plan, each EU member state outlined its strategy for achieving its specific objective and the overarching approach to its renewable energy policy. To assess the advancement made towards domestic objectives, national renewable energy progress reports were published every two years by EU member states.

The amended Renewable Energy Directive[47] ((EU) 2018/2001) came into force in December 2018 as part of the 'Clean energy for all Europeans' package[48], with the goal of keeping the EU as a global leader in renewables and meeting its emissions

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[43] Lex - 52013DC0169 - En - EUR-Lex.” EUR, eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A52013DC0169. Accessed 16 July 2023.
[44]Eurobarometer: Europeans show strong support for the EU energy policy and for EU’s response to Russia’s invasion of Ukraine and more optimism regarding economy (2023) European Neighbourhood Policy and Enlargement Negotiations (DG NEAR). https://neighbourhood-enlargement.ec.europa.eu/news/eurobarometer-europeans-show-strong-support-eu-energy-policy-and-eus-response-russias-invasion-2023-07-10_en. Accessed 4 August 2023.
[45] Lex - 32009L0028- En - EUR-Lex.” EUR, eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0028. Accessed 16 July 2023.
[46] Klessmann, C. et al. (2010) ‘Design options for cooperation mechanisms under the new European Renewable Energy Directive’, Energy Policy, 38(8), pp. 4679–4691. doi:10.1016/j.enpol.2010.04.027.
[47] Lex - 32018L2001- En - EUR-Lex.” EUR, eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L2001. Accessed 16 July 2023.
[48]Capros, P. et al. (2018) ‘Outlook of the EU Energy System up to 2050: The case of scenarios prepared for European Commission’s “Clean energy for all Europeans” package using the primes model’, Energy Strategy Reviews, 22, pp. 255–263. doi:10.1016/j.esr.2018.06.009.

reduction goals under the Paris Agreement. The aforementioned directive, which necessitated national implementation in EU member states by June 2021, set forth a novel obligatory objective for renewable energy in the EU: a minimum of 32% of final energy consumption by the year 2030. Furthermore, it incorporated a provision for a potential upward revision by 2023 and augmented the target for the proportion of renewable fuels in transportation to 14% by 2030. EU member states are obligated to establish national energy objectives and formulate national energy and climate strategies (NECPs) for the period 2021-2030, in accordance with Regulation (EU) 2018/1999. The Commission evaluates the NECPs and monitors their progress with progress reports every two years. In doing so, it may take action at the EU level to ensure that the NECPs remain in line with the overarching objectives of the EU.

The Commission proposed an amendment (RED II) to the Renewable Energy Directive in July 2021, as part of the 'Fit for 55' package[49], to align its renewable energy targets with its new climate ambition[50]. The Commission proposed increasing the binding objective for renewable sources in the EU's energy mix to 40 percent by 2030, while also promoting the use of renewable fuels such as hydrogen in industry and transportation.

In May 2022, the European Commission put out an amendment (RED III) as a component of its REPowerEU initiative[51], which was developed in response to the Russian aggression towards Ukraine. The primary objective of this amendment is to expedite the transition towards clean energy, aligning with the gradual reduction of reliance on fossil fuels sourced from Russia. The proposal put up by the Commission entails the implementation of heat pumps, the augmentation of solar photovoltaic capacity, and the importation of renewable hydrogen and biomethane. These measures aim to elevate the target for renewable energy sources in 2030 to 45%. In its conclusions issued on 20 and 21 October 2022, the European Council called[52] for an expedited simplification of permitting procedures to accelerate the deployment of renewables and grids, including through emergency measures. The Commission proposed a second amendment (RED IV) for a Council Regulation to accelerate the deployment of renewable energy on 9 November 2022[53]. As per the proposition, renewable energy facilities shall be considered to be operating in the highest possible public interest. This would grant particular exemptions from EU

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[49]Lex - 52021DC0550- En - EUR-Lex." EUR, eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0550. Accessed 16 July 2023.

[50]Weitzel, M. *et al.* (2023) 'A comprehensive socio-economic assessment of EU climate policy pathways', *Ecological Economics*, 204, p. 107660. doi:10.1016/j.ecolecon.2022.107660.

[51] Lex - 52022DC0230- En - EUR-Lex." EUR, eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022DC0230. Accessed 14 July 2023.

[52] (2022) European Council conclusions, 20-21 October 2022 - Consilium. https://www.consilium.europa.eu/en/press/press-releases/2022/10/21/european-council-conclusions-20-21-october-2022/ Accessed 14 July 2023.

[53] European Commission (2022) EPowerEU: Commission steps up green transition away from Russian gas by accelerating renewables permitting, European Commission. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_6657. Accessed 14 July 2023.

environmental law and expedite the approval process for renewable energy projects.

Parliament and the Council reached an informal agreement in March 2023[54] to increase the share of renewable energy in the EU's overall energy consumption to 42.5% by 2030 with an additional 2.5% indicative top up that would allow to reach 45%. The negotiators of the Council and the European Parliament reached a provisional agreement on more ambitious sector-specific targets for transportation, industry, buildings, and district heating and ventilation. The objective of the sub-targets is to accelerate the incorporation of renewable energy sources in sectors where incorporation has been sluggish.

1.2 The Greek renewable energy framework

Parallel to changes in European legislation, Greece's energy sector has been experiencing continual transformation. In recent years, both the legislative framework and the energy mix have undergone significant changes[55].
Several years after the introduction of the 2001/77/EC Directive[56], Greece lagged behind the rest of the EU in its adoption of the European framework for renewable energy sources.This came to an end in 2006. In order to speed up licensing procedures and reform electric energy production from renewable energy sources, the Minister of Development finalized and passed through Parliament the Law 3468/2006, Production of Electricity from Renewable Energy Sources and High-Efficiency Cogeneration of Electricity and Heat and Miscellaneous Provisions (Official Gazette A' 129/2006)[57].

The primary objectives of Law 3468/2006[58] were twofold. Firstly, it aimed to implement Directive 2001/77/EC of the European Parliament and Council, which was enacted on September 27, 2001. This directive focused on promoting the generation of electricity from renewable energy sources within the internal electricity market. Secondly, it sought to prioritize the production of electrical power from renewable energy sources and high-efficiency co-generation of electricity and heat plants within the internal electricity market. These objectives were pursued through the establishment of rules and principles.

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[54]European Council conclusions, 23 March 2023.https://www.consilium.europa.eu/en/european-council/conclusions/ Accessed 2 April 2023.
[55] Forouli, A. *et al.* (2019) 'Energy Efficiency Promotion in Greece in light of risk: Evaluating policies as portfolio assets', *Energy*, 170, pp. 818–831. doi:10.1016/j.energy.2018.12.180.
[56] Lex - 32001L0077- En - EUR-Lex." EUR, /eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32001L0077. Accessed 14 July 2023.
[57]*Law 3468-2006 RES* . https://helapco.gr/ims/file/english/law_3468_2006_eng.pdf. Accessed 11 July 2023.
[58] Doukas, H., Patlitzianas, K.D. and Psarras, J. (2006) 'Supporting sustainable electricity technologies in Greece using MCDM', *Resources Policy*, 31(2), pp. 129–136. doi:10.1016/j.resourpol.2006.09.003.

Law 3468/2006 established a new reality and a watershed moment in the production of electric energy from wind farms, solar systems, and hydropower plants intended to serve as a vehicle for meeting the national target of 20% renewable energy output by 2010 and 29% by 2020.

Law 3468/2006 was significantly amended by Law 3851/2010[59], which established requirements to expedite the development of renewable energy sources and their dynamic penetration in the domestic energy mix in order to combat climate change in accordance with Directive 2009/28/EC. This law broadened the application of Law 3468/2006. Introduced[60] a pricing structure for each megawatt-hour (MWh) produced by various renewable energy sources. Law 3851/2010 streamlined the licensing process, enhanced the feed-in-tariff scheme (especially for wind and solar power), lowered existing barriers at the local level, and established specific regulations for the use of RES in buildings.

During the years when Greece was in economic support programs (2010-2018), Law 3468/2006 and Law 3851/2010 formed the essential legislative framework for the development of renewable energy sources[61].

To this end, the Greek State has proceeded to a number of legislative initiatives aimed at simplifying and speeding up licensing procedures. In particular, Law 4685/2020[62] provided the simplification of the application review procedure for the first licensing phase, as well as for automating the review process in a transparent, unbiased and objective manner. Overall, existing procedures were simplified, and shorter and more stringent deadlines were introduced. The new deadlines for submitting Environmental Impact Assessment (EIA) applications, the extension of the Environmental Terms Approval Decision's validity period, the digitization of the environmental licensing process, and the establishment of a Central Environmental Licensing Council are among the most significant changes to the RES licensing system brought about by Law 4685/2020.
Due to the Russian invasion of Ukraine and the cessation of gas and oil imports from Russia, Greece has placed an even greater emphasis on expanding RES power generation. Law 4951/2022 contributed to this by continuing the simplification of the RES system[63]. This law regulated the modernization of the second phase of

[59] Law 3851 -2010 RES . https://helapco.gr/ims/file/english/law_3851_2010_eng.pdf. Accessed 11 July 2023.

[60] Gus Papamichalopoulos (2011) RAE's proposals for the support – Financing of Renewable Energy Sources, Kyriakides Georgopoulos Law Firm. https://kglawfirm.gr/wp-content/pdfs/530b456b5d8b6.pdf. Accessed 12 July 2023.

[61] Angelopoulos, D. et al. (2017) 'Risk-based analysis and policy implications for renewable energy investments in Greece', Energy Policy, 105, pp. 512–523. doi:10.1016/j.enpol.2017.02.048.

[62] ELETAEN (2020). On the clauses of the new law 4685/2020 for the environmental licensing an renewables. https://eletaen.gr/wp-content/uploads/2020/05/2020-5-13-note-on-new-lawf.pdf. Accessed 19 July 2023.

[63] Mitsios, S. (2022) *Law 4951/2022 - Modernization of the Licensing Process for RES Projects & Licensing of Energy Storage*. https://www.ey.com/en_gr/tax/tax-alerts/law-4951-2022-

RES licensing (final connection offer, installation permit, and operating license), which begins with the submission of an application to the competent Administrator for the issuance of a Final Connection Offer and ends with the issuance of an Operation Permit.

From 2006 to the present, the entire network of laws has yielded results. Domestic lignite consumption has decreased, while renewable energy sources have progressively gained momentum. The share of renewable energy in Greece's total final energy consumption (TFEC) increased from 11% to 20% between 2011 and 2021[64], owing primarily to increased electricity generation from wind and solar PV, consistent growth in heating from solar thermal, and a small increase in liquid biofuels in road transportation. In 2021, Greece's renewable energy contribution to the TFEC was rated fourteenth among member countries of the IEA, which is similar to the average contribution of the IEA. Renewable energy sources constituted 22% of Greece's overall final energy consumption, 36% of electricity generation, 36% of heating and ventilation demand, and 4.3% of transportation in the corresponding year.

Greece outperformed its renewable energy 2020 targets[65] in terms of gross final energy consumption, electricity generation, and heating and ventilation. However, the fulfillment of these targets was aided in part by Greece's protracted economic recession and the epidemic[66], which cut energy usage dramatically. Renewable power output in Greece climbed from 8.1 TWh in 2011 to 22 TWh in 2021. The majority of this growth was due to a steady increase in wind generation[67] (from 3.3 TWh to 10.5 TWh). Solar PV rose swiftly from 0.6 TWh in 2011 to 3.7 TWh in 2013, but has slowed significantly since then, reaching 5.1 TWh in 2021. The capacity of renewable energy sources in Greece expanded by 15.3% in 2021, reaching 9 GW, owing mostly to significant development in wind and solar power. In 2022, the nation added approximately 1.3 GW of new solar installations, while

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modernization-of-the-licensing-process-for-res-projects-and-licensing-of-energy-storage. Accessed 26 October 2022.

[64] International Energy Agency (2023) Energy Policy Review, Greece 2023. https://iea.blob.core.windows.net/assets/7b570018-82d5-4ea3-b1ad-806234b7b184/Executivesummary-WorldEnergyOutlook2023.pdf. Accessed 1 July 2023.

[65] Matsaganis, M. and Dellatolas, T. (2022) ELIAMEP – The share of renewables in energy consumption is increasing. https://www.eliamep.gr/en/publication/in-focus-%CE%B1%CF%85%CE%BE%CE%AC%CE%BD%CE%B5%CF%84%CE%B1%CE%B9-%CE%B7-%CF%83%CF%85%CE%BC%CE%BC%CE%B5%CF%84%CE%BF%CF%87%CE%AE-%CF%84%CF%89%CE%BD-%CE%B1%CF%80%CE%B5-%CF%83%CF%84%CE%B7%CE%BD-%CE%BA/. Accessed 2 February 2023.

[66] Karamaneas, A. *et al.* (2023) 'A stakeholder-informed modelling study of Greece's energy transition amidst an energy crisis: The role of Natural Gas and climate ambition', *Renewable and Sustainable Energy Transition*, 3, p. 100049. doi:10.1016/j.rset.2023.100049.

[67] Simoglou, C.K. and Biskas, P.N. (2021) 'Assessment of the impact of the National Energy and Climate Plan on the Greek power system resource adequacy and Operation', *Electric Power Systems Research*, 194, p. 107113. doi:10.1016/j.epsr.2021.107113.

the number of licenses awarded by the Regulatory Authority for Energy (RAE) reached 95 GW, of which only 14% had received operation permits.

Chapter 2: Obstacles impeding the deployment of wind and photovoltaic technologies throughout the EU.

Despite the European Council and European Parliament's March 30, 2023, decision[68] to increase the proportion of renewable energy in the EU's overall energy consumption to 42.5% by 2030, with an additional 2.5% increase suggested to reach 45%, this is not a simple task. Individual analyses of the obstacles encountered by EU countries in the development of RES highlight administrative processes, political and economic framework barriers, significant weaknesses related to market structure, and primarily problems of a special nature related to grid access or the transparency of the grid connection procedure. As we will see later, grid congestion is the biggest impediment[69] to the implementation of new RES projects, particularly in Greece.

2.1 What effect do hurdles have on the deployment of EU RES

The significance of obstacles to the implementation of renewable energy initiatives in each member state of the European Union was assessed by gathering data from external sources. This data was then processed using a SWOT analysis, which involved evaluating the strengths, weaknesses, opportunities, and threats associated with RES deployment in the EU. The severity of these obstacles was taken into account during the analysis, enabling the formation of a comprehensive understanding of their importance. Insufficient political and economic frameworks[70] persist as a primary hindrance to the advancement of solar and wind energy endeavors. These deficiencies include the availability and dependability of a relevant RES or climate plan, issues pertaining to support programs, and the overall pay level for RES. The legislative and economic framework in several European Union countries is incongruent with the necessary speed and extent of renewable energy advancement.

Several EU Member States, including Greece, encounter difficulties due to the implementation of their respective national renewable energy plans. Simultaneously, unforeseen circumstances prompt the European Union and its member states to make expeditious political decisions that, in certain instances,

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[68] European Council (2023) *Council and parliament reach provisional deal on renewable energy directive*. https://www.consilium.europa.eu/en/press/press-releases/2023/03/30/council-and-parliament-reach-provisional-deal-on-renewable-energy-directive/. Accessed 2 April 2023.
[69] Mooney , A. (2023) *Gridlock: how a lack of power lines will delay the age of renewables*. Available at: https://www.ft.com/content/a3be0c1a-15df-4970-810a-8b958608ca0f. Accessed 2 July 2023.
[70] Chen, T. and Vandendriessche, F. (2023) 'Evolution of the EU legal framework for promoting RES-E: A market compatible paradigm shift?', *Utilities Policy,* 83, p. 101608. doi:10.1016/j.jup.2023.101608.

lack thorough deliberation and maturity [71] .The transition from conventional resources to sustainable energy has encountered widespread protest and demonstration. This phenomenon arises due to a deficiency in comprehending the benefits of renewable energy, disruption of the marine environment, and the encroachment upon territory that could have been employed for agricultural, tourism, and other endeavors.

Sustainable development is attained by the satisfaction of human needs through the utilization of socially acknowledged technical systems, as well as the implementation of suitable rules and regulations.[72]. ublic understanding is hindered by a lack of information on ecological and financial benefits, limited awareness of renewable energy technology, and questions about the financial viability of renewable energy installation projects. Individuals tend to endorse renewable energy in general, but not when it directly affects their local area. Proposals for renewable energy projects frequently encounter resistance from various stakeholders, including ordinary citizens, government leaders, grassroots organizations, national interest groups, and occasionally environmental groups. Public opposition arises due to reasons such as landscape effect, environmental degradation, and lack of interaction with local populations.

One significant drawback of renewable energy plants, particularly solar and wind farms, is the extensive land area needed to generate the same amount of electricity as a modest coal-fired power plant. Developing large-scale renewable energy plants to significantly impact global energy use necessitates enormous expanses of farmland. Large portions of rural land, including farms, must be transformed into buildings, roads, or other infrastructure to accommodate a renewable energy facility. In the process, sectors such as agriculture, tourism, and fishing can be impacted. Transitioning universally from fossil fuels to renewable energy sources necessitates a proficient workforce. Skilled individuals are in high demand for designing, constructing, operating, and maintaining renewable energy plants. Inadequate technical expertise and insufficient training institutes hinder the advancement of renewable energy technology.

Renewable energy courses should be taught to provide the necessary skills for installing and operating renewable energy installations through effective training. The scarcity of proficient workforce to supervise the several facets of renewable energy initiatives is a substantial obstacle to the extensive implementation of renewable energy sources.

[71] Parag, Y. *et al.* (2023) 'Energy saving in a hurry: A research agenda and guidelines to study European responses to the 2022–2023 Energy Crisis', *Energy Research & Social Science*, 97, p. 102999. doi:10.1016/j.erss.2023.102999.

[72] Paravantis, John & Stigka, Eleni & Mihalakakou, G.. (2014). An analysis of public attitudes towards renewable energy in Western Greece. IISA 2014 - 5th International Conference on Information, Intelligence, Systems and Applications. 300-305. 10.1109/IISA.2014.6878776.

2.2 Barriers in renewable energy sources penetration in 26 EU countries

According to publicly available data, the most significant obstacles to the expansion of renewable energy sources in each EU country are as follows:

Country	**Barriers in RES penetration**
Germany	Storage capacities are subject to dual taxation as they are classified as both energy producers and energy consumers [73]. For example, storage facilities can be classified as consumers when they utilize electricity and as generators when they generate electricity. The final customer incurs a double charge for electricity from storage facilities due to the imposition of various taxes, levies, and fees on electricity usage. Although there are certain exemptions and allowances for storage projects, the regulatory structure surrounding them remains intricate and necessitates careful examination on a case-by-case basis, especially when a device is intended for usage in various contexts. To bolster the societal acceptance of wind power[74], several jurisdictions have implemented regulations that stipulate minimum spatial separations between wind turbines and adjacent residential zones. The state of Bavaria, which is the largest federal state in Germany, has implemented regulations that require a minimum separation distance for new wind turbines, which is equivalent to ten times the height of the turbines. In addition, federal laws grant authority to individual states to establish a minimum separation of 1 kilometer between onshore wind farms and areas designated for residential use. The initiation of legal proceedings by citizen campaigners and environmental organizations presents further challenges for turbine manufacturers and wind farm operators.

[73] Benhmad, F. and Percebois, J. (2018) ‘Photovoltaic and wind power feed-in impact on electricity prices: The case of Germany’, *Energy Policy*, 119, pp. 317–326. doi:10.1016/j.enpol.2018.04.042.

[74] reNEWS (2022a) ‘Berlin needs to do more to remove hurdles to wind power’, https://renews.biz/78987/berlin-needs-to-do-more-to-remove-hurdles-to-wind-power/. Accessed 19 July 2023.

	Germany has decided to completely eliminate subsidies for the production of renewable electricity [75] during periods of negative pricing, starting from January 1, 2027, with the aim of preventing excessive compensation for producers. The investment risks associated with the tendering procedure [76] were heightened due to the surplus of auctioned capacity in Germany's states, which presented challenges in fully allocating the whole bidding volume. Germany's objective is to achieve 80% renewable energy coverage for its aggregate electricity consumption by 2030, which is one of the most ambitious goals in the world and nearly doubles the proportion achieved in 2021. To achieve this objective, however, will depend heavily on the ability of the largest economy in Europe to promptly adapt its workforce. The growth of Germany's solar and wind energy industries is being hampered by a shortfall of about 216,000 competent people[77].
France	The use of nuclear energy is a hindrance to the implementation of renewable energy sources [78] . Renewable energy exhibits a varied range in the context of France. As of the date of 31 March 2022, the installed capacity of wind power in France amounted to 19.2 gigawatts[79]. By the end of the initial quarter of 2022, the solar photovoltaic (PV) capacity attained a total of 14.6 gigawatts (GW).

[75] Löffler, K. et al. (2022) 'Chances and barriers for Germany's low carbon transition - quantifying uncertainties in key influential factors', Energy, 239, p. 121901. doi:10.1016/j.energy.2021.121901.

[76] (2023) CEER Report on Tendering Procedures for Renewable Energy Sources in Europe. https://www.ceer.eu/documents/104400/-/-/de58ad59-2089-979e-12b4-22f5f250a9a6. Accessed 26 March 2023.

[77] Martinez, M. and Alkousaa, R. (2023) Learn by doing, German renewables companies bid to beat labour shortage. https://www.reuters.com/business/energy/learn-by-doing-german-renewables-companies-bid-beat-labour-shortage-2023-04-20/.Accessed 1 May 2023.

[78] Messad, P. (2022) Draft french renewable energy bill lacks 'overall strategy', critics say. https://www.euractiv.com/section/energy/news/french-renewables-bill-lacks-overall-strategy-critics-say/.Accessed 3 October 2022.

[79] Statista Research Department (2023) France: Installed Wind Power Capacity, https://www.statista.com/statistics/1074682/capacity-production-energy-wind-france/. Accessed 30 March 2023.

	The scope of wind energy development in France, as outlined in the Regional Wind Plans (Schéma Régional Éolien - SRE), is significantly constrained due to the restricted number of regional territories that are considered suitable for such development[80]. In certain cases, these regions may be inadequate in fulfilling the wind energy objectives as stipulated in the regional wind plans. Municipalities have a crucial role in the designation of onshore accelerated development zones, hence contributing to the proliferation of bureaucratic processes. Given the anticipated persistence of elevated market costs, the expenses associated with implementing fresh steps to support solar technology are gradually becoming less significant. Consequently, both existing and prospective contracts for photovoltaic systems obtained through competitive bids may only partially offset a substantial amount of previous expenditures in the coming years. The progress of renewable energy project development is impeded by the substantial expenses and protracted duration associated with grid connection. The connecting method currently exhibits a deficiency in transparency regarding the allocation of costs associated with grid development expenses. The purpose of the tariff for third-party access to the transmission system, also known as Tarif d'utilisation des Réseaux Publics d'Électricité (TURPE)[81], is to provide compensation to the transmission system operator for the various expenses incurred in the operation, development, and maintenance of the network. Additionally, this tariff guarantees that the TSO receives an adequate return on investment. The Energy Regulatory Commission decides the tariff every four years, ensuring compliance with three essential principles.The network operator assumes responsibility for covering any incurred charges.The objective of achieving tariff uniformity, also known as péréquation tarifaire, over the entire area is being pursued. Tariffs remain consistent irrespective of the

[80] Sebi, C. and Vernay, A.-L. (2020) 'Community Renewable Energy in France: The State of development and the way forward', Energy Policy, 147, p. 111874. doi:10.1016/j.enpol.2020.111874.

[81] Understanding the public transmission system access tariff (TURPE) - RTE services portal. https://www.services-rte.com/en/learn-more-about-our-services/understanding-the-public-transmission-system-access-tariff-turpe.html Accessed 2 April 2023.

	geographical separation between the producer and the consumer (timbre-poste). The presence of a feed-in tariff regime in France[82], which prioritizes the direct injection of electricity into the grid rather than its storage, has impeded the growth of the energy storage market. This is noteworthy considering that energy storage[83] plays a crucial role in facilitating the transition towards clean energy sources. The arduousness and duration of the administrative procedure required to get the requisite construction and environmental authorizations provide a noteworthy obstacle. Despite the purported intention of the new single Environmental Authorization to enhance operators' insight into the upstream phase of projects, its effectiveness remains uncertain.
Italy	The Power Purchase Agreement (PPA) faces many obstacles. The market is hindered by exorbitant administrative fees associated with fixed-term power purchase agreement contracts, as well as a rigorous regulatory framework governing the physical delivery of contracted power.[84]. The integration of solar systems into the electrical grid has emerged as a significant concern due to the extensive growth of this renewable energy source, which has placed considerable demand on the existing power infrastructure of the nation. The proliferation of solar systems has faced challenges, particularly in the southern region of Italy[85]. The installation of solar capacity has been most prominent in this area. However, the expansion of solar PV has been

[82] Deboutte, G. (2023) France unveils new fit rates for PV systems up to 500 kW, PV Magazine International.: https://www.pv-magazine.com/2023/03/01/france-unveils-new-fit-rates-for-pv-systems-up-to-500-kw/.Accessed 13 March 2023.

[83] Shirizadeh, B. and Quirion, P. (2021) 'Low-carbon options for the French power sector: What role for renewables, nuclear energy and carbon capture and storage?', Energy Economics, 95, p. 105004. doi:10.1016/j.eneco.2020.105004.

[84] Battista, D. (2022) Government inaction stifling Italian PPA Growth, ICIS Explore. https://www.icis.com/explore/resources/news/2023/07/03/10901141/government-inaction-stifling-italian-ppa-growth-traders/. Accessed 2 February2023.

[85] International Energy Agency (2022) Italy Electricity Security Policy. https://www.iea.org/articles/italy-electricity-security-policy. Accessed 12 January 2023.

	impeded by two primary factors: grid limitations and a scarcity of suitable land for large-scale installations. The main obstacles to the expansion of wind energy are the lengthy and complicated permitting procedures[86]. To ensure the sustainable development of wind energy in Italy, it is necessary to address issues such as the need to ensure the social and environmental sustainability of wind farm development, as well as potential conflicts with other land uses and intermittent wind energy production. The presence of inconsistencies within incentive frameworks. The principal support mechanism for mature renewable electricity technologies (such as PV, wind, hydro, and sewage gas) has been the incentive mechanism established by Ministerial Decree RES1 from 2019. The program provides a feed-in tariff to smaller plants with a capacity of up to 250 kW, while bigger plants, including new, rebuilt, and improved facilities, are eligible for a sliding feed-in premium. Incentives are allocated either through competitive reverse auctions or registers, depending on the capacity of the facility. Other incentives in effect as of mid-June 2022 include the feed-in premium program for energy communities and self-consumption and the FiT/FiP program for minor islands[87]. The absence of effective communication among public institutions represents a notable drawback, as evidenced by the Conference of the States and Regions' failure to adequately support regional and local authorities in their efforts to evaluate renewable electricity initiatives and engage communities in a proactive manner to streamline the permitting procedure[88]. Geographical characteristics and service peculiarities contribute to the proliferation of energy cooperatives;

[86] Tang, A. (2022) Messy permitting leads to yet another undersubscribed wind auction in Italy, WindEurope. https://windeurope.org/newsroom/press-releases/messy-permitting-leads-to-yet-another-undersubscribed-wind-auction-in-italy/ Accessed 3 February2023.

[87] (2022) Italian Regulatory Authority for Energy, Networks and Environment (ARERA . https://www.arera.it/allegati/docs/22/133-22.pdf Accessed 12 January 2023.

[88] Di Nucci, M.R. and Prontera, A. (2021) ‘The Italian energy transition in a multilevel system: between reinforcing dynamics and institutional constraints.’, Zeitschrift für Politikwissenschaft, 33(2), pp. 181–204. doi:10.1007/s41358-021-00306-y.

	however, the private sector's involvement in energy production and administration of the local populace presents an efficiency concern[89].
Spain	The Spanish market is currently facing a significant problem of overcapacity, which is expected to continue for the foreseeable future. In order to achieve economic sustainability in the electricity market and ensure compliance with the European Union's emission limits, it becomes imperative to undertake the closure of power facilities. Grid operator Red Electrica de Espana (REE) is straining to offer grid access. This backlog has been fueled by massive speculation in permit auctions, with some actors acquiring grid connections without intending to build plants[90]. The exponential growth of renewable energy installations poses the potential challenge of a surplus[91] in solar energy, leading to a solar energy glut. This scenario entails a significant decrease in profit margins for manufacturers due to the resultant price reductions produced by the surplus of solar energy, hence diminishing the incentive for future investments. The complexity level of administrative procedures is significantly elevated. The limitations identified in Spain encompass several key aspects, namely grid limits, inflexible thermal power plants, inadequate legal frameworks for integrating renewable systems, intricate and protracted regulatory procedures, challenges related to spatial planning, and the necessity to enhance collaboration between national and regional government entities.

89 Bertolini, M. and Blasi, S. (2021) 'The role of the DSOs in the energy transition towards Sustainability. A case study from Italy', Sustainable Development Goals Series, pp. 65–77. doi:10.1007/978-3-030-61923-7_5.
90 International Energy Agency (2022) Spain Electricity Security Policy. https://www.iea.org/articles/spain-electricity-security-policy. Accessed 22 January 2023.
91 Castilla, C.A. (2023) Spain: As Renewables Rise, managing supply and demand is the next challenge, Energy Post. https://energypost.eu/spain-as-renewables-rise-managing-supply-and-demand-is-the-next-challenge/. Accessed 26 September 2023.

	With limited interconnection to the rest of continental Europe, Spain remains one of the most electrically isolated nations in Europe. Additionally, the installed interconnection capacity is underutilized to a substantial degree.[92]
Portugal	The process of issuing production licenses and connecting plants to the grid in Portugal is characterized by complexity and numerous challenges. These challenges include the involvement of multiple entities and organizations, the lack of defined timelines for certain procedures, a significant degree of discretion in decision-making by stakeholders, and procedures that are both time-consuming and financially burdensome.[93]. In contrast to other nations that have implemented incentives and streamlined approaches to facilitate the repowering of wind farms, Portugal has not yet conducted extensive research on this particular option. In accordance with legal provisions, the aforementioned circumstance signifies a substantial alteration to the plant, hence requiring the granting of fresh permits for production and exploitation. This undertaking is known to be both laborious and financially burdensome. The existing legislation imposes greater challenges in acquiring grid connection[94] titles, and the issuance of new titles is contingent upon the resolution of pending cases initiated under the old system[95]. Municipalities are engaging in the process of reclassifying geographical zones that have undergone the installation of wind farms. The categorization hinders the progress of repowering and over-equipment initiatives, as they are

[92] Carreño, B. (2023) *Undersea power link between Spain and France to go ahead* . https://www.reuters.com/business/energy/spain-france-reach-cost-sharing-deal-undersea-power-link-2023-03-02/. Accessed 6 March 2023.
[93] Macedo, D.P., Marques, A.C. and Damette, O. (2020) 'The impact of the integration of renewable energy sources in the Electricity Price Formation: Is the merit-order effect occurring in Portugal?', Utilities Policy, 66, p. 101080. doi:10.1016/j.jup.2020.101080.
[94] OIkuski, T. (2023) 'Portugal's energy security in the context of moving away from fossil fuels', Polityka Energetyczna – Energy Policy Journal, 26(3), pp. 65–80. doi:10.33223/epj/168773.
[95]Rocha, I. et al. (2023) Energy Regulation and Markets: Portugal, https://thelawreviews.co.uk/title/the-energy-regulation-and-markets-review/portugal, Accessed 20 June 2023.

	required to comply with increasingly rigorous environmental laws[96]. The Decree-Law 76/2019 stipulates that the issuance of a permission for specific projects is the responsibility of the City Council. However, the legislation does not include explicit details regarding the timeframe or term of the permit, in the event that the project is approved by the City Council.
Belgium	The renewable energy system in Belgium is characterized by its complexity due to the division of energy policy authorities between the federal government and the three regions: Brussels Capital, Flanders, and Wallonia. The responsibility for assuring supply security and providing support for offshore wind lies with the federal government, whilst regional administrations are tasked with organizing support for other forms of renewable technologies.[97]. The areas of disagreement between Brussels Capital, Flanders, and Wallonia pertain to the required proportions of renewable shares[98], the establishment of guaranteed minimum pricing for green certificates, the imposition of penalties for failing to meet renewable quotas (which function as a price cap for the certificates), and the determination of technology-specific banding factors. The pricing structure for RES power plants in Flanders, Belgium, is a challenge to achieving a level playing field, as it results in these plants incurring costs for unloading their generated electricity onto the distribution system. In contrast, most conventional production units are connected to the transmission grid and are able to bypass such fees. The growth rates of solar photovoltaic (PV) installations in the Wallonia region have experienced a significant decline due to the repeated adjustments made to the region's

[96] Gouveia, J.P. et al. (2014) 'Effects of renewables penetration on the security of Portuguese Electricity Supply', Applied Energy, 123, pp. 438–447. doi:10.1016/j.apenergy.2014.01.038.
[97]European Parliament (2016) Solar energy policy in the EU and the Member States, from the perspective of the petitions received. https://www.europarl.europa.eu/RegData/etudes/STUD/2016/556968/IPOL_STU(2016)556968_EN.pdf. Accessed 16 July 2023.
[98] Laes, E., Valkering, P. and De Weerdt, Y. (2019) 'Diagnosing barriers and enablers for the Flemish Energy Transition', Sustainability, 11(20), p. 5558. doi:10.3390/su11205558.

	support scheme and the subsequent decrease in support levels over the past few years. The province of Wallonia exhibits a notable prevalence of intricate procedures and laws. An additional payment for grid usage[99] was proposed to be enforced for "prosumers," referring to individuals who operate small power plants, primarily photovoltaic plants, under the Net-Metering scheme.
Netherlands	At present, the process of acquiring permits in the Netherlands is subject to variation based on the jurisdiction of the region and the scale of the project. The Environment and Spatial Planning Act, scheduled to be implemented on January 1, 2024, supersedes numerous preexisting legislations and introduces a unified authorization process encompassing diverse undertakings, such as projects pertaining to renewable energy. Nevertheless, the level of digitization in the permit application process is currently constrained, and it is expected that some difficulties will be addressed.[100] The profitability and financing of wind generating projects pose a significant challenge. The unpredictability of offshore wind financing availability is significantly influenced by the presence of a zero-subsidy environment. There is a significant level of apprehension within the market regarding the potential reduction in capital availability, which may result in inadequate financing of all tender capacity until the year 2030[101]. Bottlenecks occur when there is a substantial disparity between supply and demand, resulting from prolonged lead times and a scarcity of skilled personnel to facilitate the construction of additional infrastructure [102].

[99] Gautier, A. and Jacqmin, J. (2019) ‘PV adoption: The role of distribution tariffs under net metering’, Journal of Regulatory Economics, 57(1), pp. 53–73. doi:10.1007/s11149-019-09397-6.
[100]International Monetary Fund (2023) Assessing Recent Climate Policy Initiatives in the Netherlands. https://www.elibrary.imf.org/downloadpdf/journals/002/2022/317/002.2022.issue-317-en.pdf. Accessed 2 April 2023.
[101]Tezel, G. (2020) Financing offshore wind - PWC. Available at: https://www.pwc.nl/nl/actueel-publicaties/assets/pdfs/pwc-invest-nl-financing-offshore-wind.pdf. Accessed 4 February 2023.
[102]Latief, Y. (2023) How the Dutch grid is dealing with grid congestion, Enlit World. https://www.enlit.world/smart-grids/grid-management-monitoring/gridlock-how-the-netherlands-hit-capacity/.Accessed 1 November 2023.

	Insufficient grid capacity poses a challenge to the spread of wind energy and photovoltaic systems in locations that lacked electrification during the initial construction of the electric grid. In regions of this nature, it is imperative to undertake the reconstruction and expansion of the grid system. The influence of provincial elections on destination plans is noteworthy, given that the nation's climate plan stipulates that renewable energy initiatives should endeavor to allocate 50 percent of their generated green energy to citizens inside the locality.[103]
Austria	Grid connection costs in Austria are characterized by a high level of expense. Furthermore, the variation in costs for grid connection fees among different states is a significant factor that must be considered by system installers. The escalated expenses and technological limitations present a substantial barrier.[104] There exist significant vulnerabilities in the electrical infrastructure. During periods of maximum production, it is not uncommon for a portion of the surplus electricity generated by renewable sources to be lost. The underlying cause for this predicament is the absence or inadequacy of the grid infrastructure, which hinders the efficient distribution of electrical power.[105] Grid-related charges account for around 20% of the overall investment cost of ground-mounted photovoltaic (PV) installations. The uniformity of the PV installation permit system is lacking. The frequent need for grid extension

[103] Elton, C. (2023) Floating solar and trash mountains: How the Netherlands became Europe's solar power leader, euronews. https://www.euronews.com/green/2023/03/08/floating-solar-and-trash-mountains-how-the-netherlands-became-europes-solar-power-leader. Accessed 24 March 2023.

[104] Resch, G. et al. (2020) 'Assessment of prerequisites and impacts of a renewable-based electricity supply in Austria by 2030', Lecture Notes in Energy, pp. 99–111. doi:10.1007/978-3-030-40738-4_4.

[105] Krone.at (2023) Gewessler will strom- und gasnetze ausbauen, Kronen Zeitung. Available at: https://www.krone.at/3053851. Accessed 20 August 2023.

	necessitates render many projects economically unviable[106]. Despite the fact that Austria offers appropriate feed-in tariffs for renewable energy sources, particularly wind and photovoltaic systems, the administrative processes involved in obtaining subsidies are frequently subject to delays[107]. Wind energy proliferation is hampered by a lack of zoning in individual federal states. Spatial plans are utilized to limit or prohibit wind energy initiatives [108]. The legal certainty of wind energy project developers is compromised as a result of the heightened probability of intervention by local communities [109].
Bulgaria	The urgency of addressing the decarbonization of the energy industry is emphasized by the European Green Deal and REPowerEU initiatives. In the year 2021, the proportion of fossil fuels in Bulgaria's energy composition amounted to 63%, while nuclear energy constituted 22% and renewable energy sources accounted for 15% [110]. In January 2023, the Commission referred Bulgaria to the Court of Justice of the European Union. The petitioner requested the Court to enforce monetary penalties against Bulgaria due to its non-compliance with the integration of the EU Renewable Energy Directive into domestic

[106] European Commission (2022), Directorate-General for Energy, Tallat-Kelpšaitė, J., Brückmann, R., Banasiak, J., et al., Technical support for RES policy development and implementation : simplification of permission and administrative procedures for RES installations (RES simplify) https://data.europa.eu/doi/10.2833/239077

[107] Eclareon.com (2023). Available at: https://www.eclareon.com/sites/default/files/res_simplify_national_report_at_0.pdf . Accessed July 25, 2023.

[108]Wehrle, S. and Schmidt, J. (2023) Inferring local social cost from renewable zoning decisions. evidence from Lower Austria's wind power zoning. [Preprint]. doi:10.5194/egusphere-egu23-4191.

[109] Kapeller, S. and Biegelbauer, P. (2020) 'How (not) to solve local conflicts around alternative energy production: Six cases of siting decisions of Austrian wind power parks', Utilities Policy, 65, p. 101062. doi:10.1016/j.jup.2020.101062.

[110] European Commission (2023) Country Report - Bulgaria 2023. https://economy-finance.ec.europa.eu/system/files/2023-05/BG_SWD_2023_602_en.pdf .Accessed 4 June 2023).

	legislation, as stipulated by Article 260(3) of the Treaty on the Functioning of the European Union. Grid-scale renewable projects are frequently hindered[111] by administrative procedures that are both intricate and time-consuming, resulting in significant delays. The completion of the grid connection procedure is required within a timeframe of six months. However, the presence of additional interdependencies among the stages of the grid connection procedure introduces a heightened level of complexity to the overall process. A delay in the administrative procedure may lead to a subsequent delay in the grid. Investor distrust arises due to the imposition of a limit on the quantity of power procured through the feed-in tariff. The Bulgarian government implemented a policy that limits the quantity of power obtained through feed-in tariffs to the average annual operational hours of the relevant producers. Preferential pricing is applicable solely to quantities that do not exceed the net specific production (NSP).The adoption of the National Security Policy (NSP) has led to a reduction of approximately 33% in revenue compared to the initial projections for the majority of plants. The issue of aging infrastructure in Bulgaria has been noted as a pressing concern that is progressively worsening. In the event of an unfavorable outcome, this circumstance has the potential to hinder developers' capacity to actualize specific undertakings, or alternatively, the distribution system operator may opt to enforce a temporary suspension. The spread of renewable energy sources is impeded by major barriers, primarily stemming from limitations on grid capacity and additional modifications. The RRP encompasses the enhancement of the transmission grid to accommodate a minimum of 4.5 GW of new generation capacities derived from renewable sources. However, it is imperative to make significant enhancements to the

[111] Konidari, P. and Nikolaev, A. (2022) 'Incorporating barriers in scenarios for energy efficiency improvement and promoting renewable energy in the Bulgarian residential sector', Energy Efficiency, 15(7). doi:10.1007/s12053-022-10058-5.

	current grid and establish energy storage facilities to facilitate the seamless integration of additional grid-scale renewable capacity, while avoiding any potential system balancing challenges. The installation of ground-mounted photovoltaic systems is restricted to areas designated as "industrial land,"[112] so constraining the available possibilities for site selection.
Croatia	The primary obstacles to the implementation of renewable energy projects in Croatia are administrative in nature[113]. These obstacles generally manifest in the form of complex permission procedures, which are excessively burdensome even for minor renewable energy projects. Additionally, there is a notable lack of collaboration among various governmental entities involved in the development and implementation of renewable energy legislation in the country. The process of obtaining the qualified electricity producer designation can involve a total of 30 stages for a large renewable energy source (RES) generator, while a smaller RES generator may require 20 steps. It is imperative for Croatia to undertake endeavors aimed at enhancing its electrical infrastructure[114]. Increasing investments in grid upgrade initiatives will facilitate the seamless integration of renewable energy sources, hence enhancing the overall efficiency of the energy system and mitigating energy losses. The presence of legal ambiguity is a significant obstacle to the adoption of residential solar investments, specifically with respect to the potential consequences arising from the

[112] European Commission (2023) Country Report - Bulgaria 2023. Available at: https://economy-finance.ec.europa.eu/system/files/2023-05/BG_SWD_2023_602_en.pdf .Accessed 4 June 2023. European Commission (2023a) EU supports just climate transition in Bulgaria with a budget of €1.2 billion, European Commission - European Commission. Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6756. Accessed 26 December 2023.

[113] Runko Luttenberger, L. (2015) 'The barriers to renewable energy use in Croatia', Renewable and Sustainable Energy Reviews, 49, pp. 646–654. doi:10.1016/j.rser.2015.04.167.

[114] European Commission (2022) , Regulatory barriers in Croatia: findings and recommendations. https://clean-energy-islands.ec.europa.eu/system/files/2022-12/Regulatory%20barriers%20in%20Croatia%20findings%20and%20recommendations%202022 1215.pdf. Accessed 27 September 2023.

	surplus electricity generated by the producer-consumer and then fed back into the grid. A deficiency in human resources for the processing of applications for ground-mounted photovoltaic systems was also noted in Croatia. In recent times, the proficiency of regulatory bodies in their understanding of renewable energy technology has attained a commendable standard. However, the persistent issue of understaffing remains a significant factor contributing to operational delays. In Croatia, the installation of basic structures such as rooftop photovoltaic (PV) systems does not necessitate obtaining a building permit, provided that they are constructed on pre-existing buildings, irrespective of their capacity to transmit energy to the grid. In contrast, according to the 2017 Simple Buildings Regulation, it is stipulated that the developer must provide notification to the competent building authority upon commencement of construction activities.
Czech Republic	The primary obstacles commonly encountered pertain to insufficient political and public engagement in onshore wind initiatives, alongside inert governmental institutions that fail to modify administrative procedures[115]. The presence of confusion or ambiguity within the legislative and administrative framework results in protracted and expensive permitting procedures, so significantly impeding or obstructing the implementation of ground-mounted photovoltaic installations. The incorporation of additional renewable electricity generation and infrastructure entails a substantial level of administrative complexity. An additional concern pertains to the sluggish pace at which novel initiatives, such as transmission lines, are formulated and executed.[116].

[115] European Commission (2019), National Energy and Climate Plan of the Czech Republic, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf. Accessed 5 October 2023.

[116] International Energy Agency (2021) Energy Policy Review, Czech Republic2021. https://iea.blob.core.windows.net/assets/301b7295-c0aa-4a3e-be6b-2d79aba3680e/CzechRepublic2021.pdf. Accessed 5 October 2023.

	There exists a notable administrative cost associated with the implementation of renewable energy self-consumption, as well as a restricted set of processes for small renewable energy producers to enter the grid. While it is theoretically possible for small solar photovoltaic (PV) operators to have the opportunity to connect to the grid, the practical implementation of this policy poses challenges in various distribution zones[117]. In the event that a renewable power plant possesses an installed capacity that exceeds 50 kWp, it is imperative to adhere to specific land use planning and construction-related constraints as mandated by the Building Code [118].
Cyprus	The pace of Cyprus's move towards green energy has been somewhat sluggish, resulting in a failure to fully tap into the country's capacity for expanding renewable energy sources. Solar energy has achieved a 26% share in the thermal sector, however in the electricity sector, oil remains dominant with an 85% share, while renewable energy only represents 15% [119]. To facilitate the seamless integration of more renewable capacity into the network without compromising stability, it is imperative to implement substantial grid upgrades and modernization measures. The implementation of grid-scale energy storage facilities and the integration of small-scale renewable energy generation, such as rooftop solar panels, alongside small-scale storage solutions like batteries, will be necessary. The licensing process for renewable energy sources in Cyprus has been marked by a significant level of

[117] Durcansky, P. et al. (2023) 'Evolution of green energy production in Czech Republic', Applied Sciences, 13(4), p. 2185. doi:10.3390/app13042185. 5

[118] Naatz , O. (2023) Czech Republic: Amendment to the Energy Law and the Building Act accelerates the deployment of renewable energy, https://www.roedl.com/insights/renewable-energy/2023/february/czech-republic-amendment-energy-and-building-act-accelerates-ee. Accessed 07 October 2023.

[119] European Commision (2023) European Economic Forecast Country Report Cyprus. https://economy-finance.ec.europa.eu/system/files/2023-05/SF_2023_Statistical%20Annex.pdf .Accessed 12 September 2023.

	bureaucratic obstacles[120]. Numerous processes and entities are implicated, necessitating the investor's acquisition of a diverse array of permits. As a result, the overall duration needed for the licensing procedure may vary from 18 months (in the case of photovoltaics) to 20 months or beyond (in the context of onshore wind)[121]. Moreover, the significance of considering the uncertainty surrounding acceptance during each stage of the licensing process cannot be overstated, as the potential investment may be put at risk in the event of a rejection of any of the licensing procedures[122]. The lack of comprehensive planning for renewable energy sources has led to considerable uncertainty for developers of such projects, as any governing body retains the power to halt a project at any stage of the permitting process. Insufficient spatial planning is a notable procedural concern that hinders the implementation of onshore wind power. A prevalent issue arises from the absence of adequate spatial planning or the inadequacy of existing plans in accommodating present-day development[123]. Environmental impact analyses are necessary for wind turbines with capacities exceeding 30 kW, solar systems with capacities surpassing 100 kW, and biomass-fueled power plants with capacities more than 20 kW. It is imperative to conclude the requisite legislative and technical preparations in order to establish connectivity between the entirety of the island and a broader European grid through the forthcoming EuroAsia and EuroAfrica Interconnector efforts. In recent years, there has been a noticeable increase in labor shortages in key sectors, primarily due to a

[120]Koroneos, C., Fokaidis, P. and Moussiopoulos, N. (2005) ‘Cyprus energy system and the use of Renewable Energy Sources’, Energy, 30(10), pp. 1889–1901. doi:10.1016/j.energy.2004.11.011..

[121] Taliotis, C. et al. (2017) ‘Renewable Energy Technology integration for the island of Cyprus: A cost-optimization approach’, Energy, 137, pp. 31–41. doi:10.1016/j.energy.2017.07.015.

[122] (2020) Cyprus’ Integrated national energy and climate plan for the period 2021-2030.: https://energy.ec.europa.eu/system/files/2020-02/it_final_necp_main_en_0.pdf. Accessed 15 September 2023.

[123] European Commision (2023) European Economic Forecast Country Report Cyprus. https://economy-finance.ec.europa.eu/system/files/2023-05/SF_2023_Statistical%20Annex.pdf Accessed 12 September 2023.

	deficiency in crucial skills. This has resulted in significant obstacles in the progression towards achieving a net-zero economy. In the year 2022, a notable dearth of labor was identified in Cyprus across 11 occupational domains that necessitated specialized proficiencies or competence in facilitating the move towards environmentally sustainable practices.[124].
Denmark	In order to fulfill the national goals pertaining to the establishment of offshore and onshore wind power generation capabilities, it is imperative to expedite the process of project commissioning and simplify licensing procedures. The process of constructing new high-voltage connections with the capacity to transmit electricity across vast distances often requires a longer duration compared to the construction of a solar photovoltaic (PV) farm that can generate an equivalent quantity of energy as large-scale power plants.[125]. The inclusion of supplementary capabilities, such as energy islands situated in the Baltic and North Seas, will require the implementation of appropriate planning at the transmission and distribution levels in order to facilitate the growth of the grid[126]. There is a pressing need for a comprehensive reconstruction of the electrical grid. Renewable energy will be harnessed offshore or in areas characterized by low electricity demand, where the generated power exceeds the local capacity for consumption. The initial purpose of the power grid in this particular location was to cater to a restricted population rather than facilitate the transmission of substantial quantities of electrical energy.[127].

[124] European Commission (2023) Labour market information: Cyprus, EURES. https://eures.europa.eu/living-and-working/labour-market-information/labour-market-information-cyprus_en. Accessed 17 September 2023.

[125] Renewable energy in the Danish Energy System (2023) Energinet. https://en.energinet.dk/green-transition/renewable-energy-in-the-energy-system/. Accessed 17 September 2023.

[126] Hvelplund, F., Østergaard, P.A. and Meyer, N.I. (2017) ‘Incentives and barriers for wind power expansion and system integration in Denmark’, Energy Policy, 107, pp. 573–584. doi:10.1016/j.enpol.2017.05.009.

[127] European Commision (2023) Council Recommentation on the 2023 National Reform Programme of Denmark. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023DC0604. Accessed 17 September 2023.

	Distribution System Operators (DSOs) are unable to allocate resources towards the expansion of power transmission infrastructure in response to projected future demand due to the constraint imposed by their revenue model, which is mostly determined by historical levels of electricity use. [128] There is a lack of proactive asset management, which encompasses activities such as asset monitoring, maintenance, and investment planning, resulting in inefficient and ineffective utilization of assets. Municipal renewable energy systems planning encompasses a range of concepts that exhibit variances and peculiarities. The design and implementation of energy programs, as well as the subsequent energy transition, are influenced by variations in institutional frameworks [129].
Estonia	The comprehensive development of renewable energy sources is hindered by bureaucratic obstacles. The presence of significant administrative barriers in Estonia has resulted in the effective cessation of project development. The existence of these substantial impediments might be attributed to the protracted procedures involved and the resistance from the public against wind power ventures[130]. The lack of adequate grid capacity to accommodate the integration of additional renewable energy sources is a persistent obstacle to further advancements. Grid restrictions sometimes give rise to cost-related difficulties. One contributing element to the presence of restrictions is

[128] Council of European Energy Regulators (2023) Report on Regulatory Frameworks for European Energy Networks 2022. https://www.ceer.eu/documents/104400/-/-/2a8f3739-f371-b84f-639e-697903e54acb. Accessed 27 September 2023.

[129] Sillak, S. (2023) ‘All talk, and (NO) action? collaborative implementation of the Renewable Energy Transition in two frontrunner municipalities in Denmark’, Energy Strategy Reviews, 45, p. 101051. doi:10.1016/j.esr.2023.101051.

[130] European Commission (2021) Technical support for RES policy development and implementation – Simplification of permission and administrative procedures for RES installations. https://op.europa.eu/o/opportal-service/download-handler?identifier=fd75d26d-a349-11ec-83e1-01aa75ed71a1&format=pdf&language=en&productionSystem=cellar&part= Accessed 2 October 2023.

	the phenomenon wherein developers allocate grid capacities but fail to fully utilize them. The utilization of a substantial number of favorable wind locations for wind energy development in Estonia has been impeded by concerns pertaining to national security. This obstacle has hindered the expansion of wind energy in the country for an extended period of time. The legal authority to impede wind energy projects lies within the purview of the Ministry of Defence[131]. Land-use conflicts pose a substantial impediment. There exists a tension between the objectives of nature conservation and energy development. A significant proportion of Estonia's designated conservation areas consist of islands. Western Estonia, particularly the islands, harbors a substantial avian population. The growth of renewable energy sources in certain locations is hindered by severe constraints[132].
Finland	In order to ensure the non-interference of wind generation projects with military radar systems, the Finnish Defense Forces are required to grant approval for their deployment throughout Finland. Throughout history, the Defense Forces have consistently declined around twenty percent of the projects that have been filed. It is worth noting that there is a notably low rate of project approvals in the regions of eastern and southern Finland, particularly those situated close the border with Russia. Therefore, the predominant concentration of wind power generation is situated in the western region of Finland. The aforementioned situation has raised apprehensions pertaining to the limitations of wind production grids[133]. Despite the rapid expansion of onshore wind as a renewable energy source in Finland, the Transmission

[131] ERR, E.N.| E. (2019) Private sector wind farm developers say defense ministry blocking progress, ERR. https://news.err.ee/1011420/private-sector-wind-farm-developers-say-defense-ministry-blocking-progress.Accessed 2 October 2023.

[132] European Commission (2022) , Regulatory barriers in Estonia: findings and recommendations.https://clean-energy-islands.ec.europa.eu/system/files/2022-12/Regulatory%20barriers%20in%20Estonia%20findings%20and%20recommendations%202022 1215.pdf Accessed 13 October 2023.

[133] Juszczyk, O. et al. (2022) ‘Barriers for renewable energy technologies diffusion: Empirical evidence from Finland and Poland’, Energies, 15(2), p. 527. doi:10.3390/en15020527..

	System Operator (TSO) has not provided sufficient assurance for the timely development of the grid to meet the growing number of wind projects [134]. Onshore wind projects encounter legal challenges either in court or through administrative procedures, leading to substantial obstacles. In specific instances, local authorities have asserted that the implementation of wind farms could potentially influence the values of residential properties[135]. The provision of additional finance for offshore wind remains questionable, as the specific criteria under which such funding would be allocated are still to be determined. Government officials have neglected to engage in consultations with specialists in the field of offshore wind energy to ascertain the necessity of subsidies or other forms of incentives, such as the construction of offshore infrastructure by the Transmission System Operator (TSO), in order to initiate the development of offshore wind projects.[136]. In order to facilitate the anticipated swift growth of renewable energy generation, it is imperative to enhance the capacity and adaptability of the energy infrastructure. This encompasses the integration of new transmission infrastructure and the improvement of substations, along with assistance in the deployment of smart meters and the construction of energy storage systems. Further measures are necessary to guarantee that the legislation governing the electricity market establishes a transparent economic framework that supports investments in renewable energy generation.

[134] International Energy Agency (2023) Finland Energy Policy Review. https://iea.blob.core.windows.net/assets/07c88e41-c17b-4ea1-b35d-85dffd665de4/Finland2023-EnergyPolicyReview.pdf. Accessed 22 October 2023.
[135] Holm, P. (2021) Wind power effect on residential real estate prices in Finland, Finnish Wind Power Association. Available at: https://tuulivoimayhdistys.fi/media/tuulivoima-ja-asuinkiinteistojen-hinnat-2022-1.pdf .Accessed 22 October 2023.
[136] Mikkonen, A. (2023) The offshore wind power in planning will bring billions in tax benefits and thousands of jobs to Finland, Finnish Wind Power Association. https://tuulivoimayhdistys.fi/en/ajankohtaista/press-releases/the-offshore-wind-power-in-planning-will-bring-billions-in-tax-benefits-and-thousands-of-jobs-to-finland. Accessed 22 October 2023.

Sweden	The implementation of wind energy programs is hindered by intricate and time-consuming procedures. In instances of more substantial projects, the process of authorizing designs and implementing wind energy producing facilities encompasses multiple stages[137]. The project's proprietor is required to engage in consultations with various stakeholders, such as local residents, municipal officials, and government representatives from entities including the County Administrative Board, the Department of Defense, and the Aviation and Water Authorities. These consultations aim to address potential impacts on the affected parties and ensure their involvement in the decision-making process[138]. In addition, it is necessary for the project owner to do an environmental impact assessment and afterwards submit a permit application to the County Administrative Board. Furthermore, it is imperative that the local communities in whom the project is intended to be implemented provide their explicit consent in order for the initiative to advance[139]. The Swedish Armed Forces possess the jurisdiction to compel the county administrative board and municipalities to rescind a previously given administrative authorization for a wind power facility, irrespective of the length of time that has elapsed since the permission was originally granted.[140]. Sweden receives a lower amount of solar radiation compared to countries located at more southern latitudes due to the fact that its southernmost region is subject to a maximum insolation angle of only 58 degrees.[141] Data

[137]. Wang, Y. (2006) ‘Renewable electricity in Sweden: An analysis of policy and regulations’, Energy Policy, 34(10), pp. 1209–1220. doi:10.1016/j.enpol.2004.10.018.
[138] Lindgren, O. et al. (2023) ‘Exploring sufficiency in energy policy: Insights from Sweden’, Sustainability: Science, Practice and Policy, 19(1). doi:10.1080/15487733.2023.2212501.
[139] Laktuka, K. et al. (2023) ‘Renewable energy project implementation: Will the baltic states catch up with the Nordic countries?’, Utilities Policy, 82, p. 101577. doi:10.1016/j.jup.2023.101577.
[140] (2016) Sweden denies permit for $7.4B offshore wind farm because the project would interfere with its military. https://nationalpost.com/news/world/sweden-denies-permit-for-7-4b-offshore-wind-farm-because-the-project-would-interfere-with-its-military. Accessed 27 October 2023.
[141] Palm, J. (2018) ‘Household installation of solar panels – motives and barriers in a 10-year perspective’, Energy Policy, 113, pp. 1–8. doi:10.1016/j.enpol.2017.10.047.

	demonstrates unequivocally that the pace of PV expansion varies across Swedish municipalities. The existing tax regulations present challenges for the utilization of self-consumed solar electricity in residential multifamily buildings, hence creating a substantial obstacle for such buildings. Typically, individual apartments within a multifamily building are equipped with separate meters and contractual agreements with grid operators. Conversely, the entire multifamily building is equipped with a different meter and contractual arrangement for the power consumption in shared spaces, including elevators, laundry rooms, and lights. Given this configuration, it is exclusively viable to utilize photovoltaic (PV) electricity sourced from a PV system installed on the building alone for the purpose of common area electricity consumption.[142].
Slovenia	The incorporation of renewable energy sources poses challenges, notably in the realms of environmental and spatial planning. The current legal framework for the designation of priority siting locations for renewable energy systems is still in its nascent phase of formulation. Likewise, the legislative measures pertaining to spatial planning and the structure for carrying out environmental impact assessments are currently in their early stages of development[143]. The processing of applications is often hindered by a lack of competence or capacity on the part of competent authorities[144]. A notable impediment arises from the prevailing prejudice among the general population towards wind

[142] National Survey Report of PV power applications in Sweden (2021) International Energy Agency. https://iea-pvps.org/wp-content/uploads/2021/10/National-Survey-Report-of-PV-Power-Applications-in-Sweden-2020.pdf. Accessed 27 October 2023.
[143] National Reform Programme Slovenia ((2023). https://commission.europa.eu/system/files/2023-05/npr_slovenia_2023_en.pdf. Accessed 27 October 2023.
[144] Kontić, B. et al. (2016) 'Improving appraisal of sustainability of energy options – A view from Slovenia', Energy Policy, 90, pp. 154–171. doi:10.1016/j.enpol.2015.12.022.

	and large-scale solar energy projects. They constructed barriers that presented a particularly formidable challenge to surmount. The aforementioned problems pose significant obstacles since they have the potential to impede the timely completion of the project [145]. The constrained ESCO market presents a significant difficulty. Small national ESCOs in the Slovene market often face challenges in securing financing due to their restricted equity financing sources[146]. These difficulties arise from the constraints imposed by the assets and liabilities stated on their balance sheets, which significantly limit their creditworthiness and hinder their ability to expand their operations [147]. The growth of the Slovenian energy sector is hindered by the prevailing dominance of important firms. Securing project funding remains a challenging endeavor for small developers, as the majority of them have significant difficulties in obtaining sustainable financing due to the perceived lack of feasibility in the process.[148]. Administrative issues are more prevalent compared to concerns related to grid connection and operating procedures. However, it is important to acknowledge that they possess the capacity to exert a substantial

[145] Spasić, V. (2022) Slovenia drafts decree to prevent opposition from local population to wind farms, Balkan Green Energy News. https://balkangreenenergynews.com/slovenia-drafts-decree-to-prevent-opposition-from-local-population-to-wind-farms. Accessed 27 October 2023.
[146] Malinauskaite, J. et al. (2020) 'Energy efficiency in the industrial sector in the EU, Slovenia, and Spain', Energy, 208, p. 118398. doi:10.1016/j.energy.2020.118398.
[147] Country report on the Energy Efficiency Services - Slovenia (2018) QualitEE Project . https://qualitee.eu/si/wp-content/uploads/sites/5/QualitEE_2-04_CountryReport_SI_2018-04-14_rev1.pdf. Accessed 27 October 2023.
[148]Slovenia just below EU average in barriers to wind and solar energy (2022) The Slovenia Times. https://sloveniatimes.com/31434/slovenia-just-below-eu-average-in-barriers-to-wind-and-solar-energy. Accessed 27 October 2023.

	impact and impede the complete implementation of renewable energy[149].
Luxembourg	Due to its reliance on imports and insufficient domestic generation, Luxembourg maintains substantial electrical connectivity facilities with its surrounding countries. [150]. Over 50% of the overall electricity use is attributed to the industrial sector, which mostly relies on a privately owned electricity network that works autonomously from the national grid. While it is technically conceivable to implement large-scale renewable energy systems that may directly cater to industrial consumers on this network, the current limitations and regulations prevent the realization of such projects[151]. The local community members engage in protests against the implementation of wind energy. In several instances, local officials have described planned wind farms as a significant disruption to both the natural environment and the daily lives of individuals, resulting in a considerable level of opposition from the general population[152]. Despite the government's introduction of a new legislation aimed at exempting home self-consumption from grid charges and taxes[153], as well as the implementation of steps to promote self-consumption and renewable energy communities, there appears to be a limited focus on self-consumption schemes pertaining to photovoltaic technology. The spatial distribution of the installed

[149] Spasić, V. (2022) Slovenia maps locations with grid capacity for utility-scale solar power plants, Balkan Green Energy News. https://balkangreenenergynews.com/slovenia-maps-locations-with-grid-capacity-for-utility-scale-solar-power-plants/.Accessed 27 October 2023.
[150] Luxembourg Connection to German Electrical Grid to be Modernised (2020) Chronicle . Available at: https://chronicle.lu/category/energy/33559-luxembourg-connection-to-german-electrical-grid-to-be-modernised. Accessed 1 November 2023.
[151] International Energy Agency (2020) Energy Policy Review Luxembourg 2020. https://iea.blob.core.windows.net/assets/8875d562-756c-414c-bc7e-5fc115b1a38c/Luxembourg_2020_Energy_Policy_Review.pdf Accessed 5 November 2023.
[152] Wind Farm in Mersch: Fischbach opposed to project, other municipalities and operator 'perplexed' (2023) RTL Today.https://today.rtl.lu/news/luxembourg/a/2057468.html.Accessed 7 November 2023.
[153] Arababadi, A. *et al.* (2021) 'Characterizing the theory of Energy Transition in Luxembourg, part Two—on energy enthusiasts' viewpoints', *Sustainability,* 13(21), p. 12069. doi:10.3390/su132112069.

	capacity of these facilities exhibits discrepancies among municipalities and seems to place large cities at a disadvantage[154]. Due to the significant land requirements associated with ground-mounted solar systems, the promotion of such installations in Luxembourg has not been pursued vigorously. Nevertheless, certain obstacles related to inadequate spatial planning have been successfully addressed[155].
Hungary	In 2016, a series of legislation amendments in Hungary had the practical effect of halting the development of wind farms[156]. The technological requirements established were beyond the capabilities of the majority of technologies available in the market, resulting in either insufficient fulfillment or significantly reduced return on investment. According to the revisions, it is prohibited for wind generating plants with a capacity over 50 kVA to be situated on or within a 12-kilometer radius of residential areas. Considering the high population density in Hungary, it may be inferred that there is presently no location inside the country that satisfies this criterion. Moreover, the alterations granted the government, instead of MEKH, the jurisdiction to determine the quantity of official permits issued for the establishment and finalization of wind farms, together with their corresponding capacity.[157].

[154] Obert , M. and Pailler, P. (2022) The large solar panel installations on which Luxembourg Bets, Delano. https://delano.lu/article/the-large-solar-panel-installa. Accessed 7 November 2023.
[155]Koster, D. et al. (2019) 'Short-term and regionalized photovoltaic power forecasting, enhanced by reference systems, on the example of Luxembourg', Renewable Energy, 132, pp. 455–470. doi:10.1016/j.renene.2018.08.005..
[156] Szakály, Z. et al. (2020) 'Attitude toward and awareness of renewable energy sources: Hungarian experience and special features', Energies, 14(1), p. 22. doi:10.3390/en14010022.
[157]Campos, J., Csontos, C. and Munkácsy, B. (2023) 'Electricity scenarios for Hungary: Possible role of wind and solar resources in the energy transition', Energy, 278, p. 127971. doi:10.1016/j.energy.2023.127971..

	The limited accessibility to the grid poses a vulnerability[158]. The current configuration of the Hungarian energy system is characterized by a centralized organization that revolves around prominent power production facilities. The utilization of variable renewable electricity generation, specifically solar photovoltaic (PV), leads to a paradigm shift towards a more decentralized system. The successful incorporation of increasing solar photovoltaic proportions into the energy system will need substantial investments in grid infrastructure, along with more storage capacity and other forms of flexibility, such as demand-side management. The government has set forth a plan to augment the energy storage capacity to a minimum of 1000 MW by the year 2026, while concurrently aiming to enhance the demand-side response capacity to 100 MW by 2030. Nevertheless, the existing regulatory environment in Hungary pertaining to energy storage is inadequate in terms of facilitating substantial market-driven investments in commercial storage. The allocation of tasks related to the development, financing, execution, oversight, and evaluation of energy efficiency policies has been entrusted by the government to various governmental entities and other organizations[159]. One of the primary challenges faced by implementing authorities often pertains to the insufficiency of adequately trained individuals within various ministries, public institutions, and nongovernmental groups. The issue of bureaucratic red tape is a significant challenge. The updating of construction codes, despite its necessity in expediting the approval

[158] Németh, M. (2022) 'Renewable energy production and storage options and their economic impacts in Hungary', Pénzügyi Szemle = Public Finance Quarterly, 67(3), pp. 335–357. doi:10.35551/pfq_2022_3_2.
[159]Rokicki, T. et al. (2022) 'Changes in the production of energy from renewable sources in the countries of Central and Eastern Europe', Frontiers in Energy Research, 10. doi:10.3389/fenrg.2022.993547. .

	process, is currently not taking place. Responsibility for the formulation, funding, implementation, monitoring, and assessment of energy efficiency policies has been transferred by the government to several governmental agencies and other affiliated entities. One of the primary challenges faced by implementing authorities often pertains to the insufficient presence of adequately trained employees within various ministries, public institutions, and nongovernmental groups. [160]. Despite receiving roughly EUR 160 million in European Union funding for renewable energy investments through EU sectorial and territorial operational programs between 2014 and 2020, Hungary's state-funded programs for such initiatives remain inadequate and inconsistent.[161].
Ireland	The taxation framework poses a significant obstacle to the proliferation of wind projects in Ireland. The observed phenomenon can be attributed to an increase in commercial property tax rates, which have experienced a threefold growth in certain instances since the year 2016. The commercial property tax rates were revalued by the Valuation Office, leading to both increases in rates and the revaluation of wind projects. This resulted in the nullification of the decrease in capital expenditures. The escalation of commercial property tax rates by a maximum of 300% has resulted in an increase in the financial burden on wind projects in terms of development costs[162]. The occurrence of project delays can be attributed to the difficulties encountered in obtaining final planning permit approval and grid construction. The recent revisions in the grid connection regulation are expected to streamline and

[160] Tisheva, P. (2023) Photon Energy navigates red tape for growth in Romania's PV market, Renewables Now. https://renewablesnow.com/news/interview-photon-energy-navigates-red-tape-for-growth-in-romanias-pv-market-824355/. .Accessed 12 November 2023.
[161] European Commission (2021) Recovery and Resilience Facility: Hungary submits official recovery and resilience plan. https://ec.europa.eu/commission/presscorner/detail/ro/ip_21_2442 Accessed 15 November 2023.
[162]Martinez, A. and Iglesias, G. (2022) 'Site selection of floating offshore wind through the levelised cost of energy: A case study in Ireland', Energy Conversion and Management, 266, p. 115802. doi:10.1016/j.enconman.2022.115802.

	enhance the process of installing renewable energy systems[163]. The recent enactment of legislation pertaining to offshore wind development in Ireland has effectively terminated the previously implemented open-door policy. This move may pose a significant obstacle for numerous announced projects that now lack the necessary maritime area consents. There exist several projects currently in different phases of construction that lie beyond the purview of the government's plans. The absence of a clear indication from the government regarding its intended support for these projects poses a potential threat to Ireland's long-term offshore wind development pipeline[164]. The issue of onshore and offshore wind farm development in Ireland has long been a subject of concern among local people. The impact of third-party complaints is significant, as they extend beyond the individuals directly affected by wind power installations due to the unrestricted freedom to lodge complaints. Various individuals may employ this strategy to impede the establishment of wind power plants around the nation, driven by a range of motives such as ideological or perhaps monetary considerations[165]. The occurrence of project delays can be attributed to the delays experienced in securing the final planning permit approval and the subsequent grid building process. The recent modifications in grid connection regulations are expected to facilitate the installation of renewable energy sources. The objective is to provide offshore wind power along the southern coast of Ireland that is physically

[163] International Energy Agency (2019) Energy Policy Review Ireland 2019. hhttps://iea.blob.core.windows.net/assets/07adb8b6-0ed5-45bd-b9a0-3e397575fefd/Energy_Policies_of_IEA_Countries_Ireland_2019_Review.pdf. Accessed 15 November 2023.

[164] Buljan, A. (2023) Irish government sets new offshore wind rules, industry warns they could delay projects, Offshore Wind. https://www.offshorewind.biz/2023/03/15/irish-government-sets-new-offshore-wind-rules-industry-warns-they-could-delay-projects/. Accessed 16 November 2023.

[165]Cronin, Y., Cummins, V. and Wolsztynski, E. (2021) ‘Public perception of offshore wind farms in Ireland’, Marine Policy, 134, p. 104814. doi:10.1016/j.marpol.2021.104814.

	interconnected with the pre-existing onshore grid capacity [166].
Latvia	The progress of wind energy development in Latvia has been impeded by various obstacles. In the past decade and a half, there has been considerable fluctuation in the realm of renewable energy legislation. The impediment to wind park growth arises from the challenge of identifying suitable locations for the installation of several turbines, which is further compounded by the question of property rights. The completion of an environmental evaluation is a mandatory undertaking, albeit one that presents significant challenges. Lastly, it is crucial to consider individuals' perspectives. Irrespective of the environmental assessment, these are frequently regarded with disdain[167]. The expansion of wind power is constrained by spatial planning regulations and administrative limitations. Municipalities hinder the implementation of zoning regulations for wind energy projects, so limiting the progress of additional procedural measures and hindering the widespread use of this technology. In the present scenario, compensatory payments to local governments for the establishment of wind farms have been employed as a means of recompense for the adverse effects associated with wind farm construction.[168]. The implementation of renewable energy systems is subject to a restricted lease term, which imposes limitations on the duration of their utilization. According to the legislation titled "The Law on Prevention of

[166] Department of the Environment, Climate and Communications is a department of the Government of Ireland (2023) Minister Ryan announces significant measures to accelerate the roll out of offshore renewable energy.https://www.gov.ie/en/press-release/74bba-minister-ryan-announces-significant-measures-to-accelerate-the-roll-out-of-offshore-renewable-energy/. Accessed 16 November 2023.

[167] Cross, S, Hast, A, Syri, S, Kuhi-Thalfeldt, R & Valtin, J (2013), Progress in development of renewable electricity in Northern Europe in the context of the EU 2020 renewables target. in 10th European Energy Market Conference, EEM13, Stockholm, Sweden, May 27-31 2013. IEEE, pp. 1-8.

[168] Rapacka, P. (2023) Latvian parliament approves regulations to improve RES development, Baltic Wind. https://balticwind.eu/latvian-parliament-approves-regulations-to-improve-res-development/. Accessed 20 November 2023.

	Squandering the Financial Resources and Property of a Public Person," it is stipulated that a property lease agreement is subject to a maximum duration of 30 years, unless otherwise specified by another law or regulation issued by the Cabinet. In the context of a wind park, the implementation of the project typically requires a minimum of five years, hence allowing for a limited operational and electricity production period of 25 years. This temporal constraint persists despite the existence of contemporary technologies that enable electricity generation for a minimum duration of 30 years[169]. The presence of administrative barriers characterized by an excessive amount of paperwork or waiting time that is not commensurate with the size or scope of the project[170]. The local building authority exhibits a lack of cohesive understanding on the coordination of solar rooftop system installations. Furthermore, there is a query regarding their potential involvement in this particular procedure.
Lithuania	One of the main obstacles encountered during the site selection phase for onshore wind projects is the imposition of territorial limitations due to national security concerns. The Lithuanian Armed Forces have implemented a map delineating restricted areas for wind power development, encompassing approximately one-third of the nation's territory. Consequently, various locations have been excluded from consideration within this framework[171]. Although obtaining a grid connection permit is generally considered to be a quick and uncomplicated procedure, the extended statutory timeframe for connecting the power plant to the electricity grid is sometimes perceived as an

[169] Aniskevich, S. et al. (2017) ‘Modelling the spatial distribution of wind energy resources in Latvia’, Latvian Journal of Physics and Technical Sciences, 54(6), pp. 10–20. doi:10.1515/lpts-2017-0037.
[170]Pakere, I. et al. (2022) ‘Spatial analyses of Smart Energy System implementation through system dynamics and GIS modelling. Wind Power Case Study in Latvia’, Smart Energy, 7, p. 100081. doi:10.1016/j.segy.2022.100081.
[171] Jankevičienė, J. and Kanapickas, A. (2022) ‘Projected wind energy maximum potential in Lithuania’, Applied Sciences, 13(1), p. 364. doi:10.3390/app13010364.

	obstacle[172]. In the long run, it is imperative to ensure that the increasing capacity of renewable energy generation is accompanied by adequate grid capacity to anticipate market saturations. Additionally, it is crucial to establish market access guarantees for both energy producers and consumers, as well as for renewable energy communities[173]. Municipalities possess a significant degree of discretion in the context of site selection and procedures related to land use change[174]. To ensure the acquisition of municipal permits, it is advisable to initiate contact with the relevant administration at an early stage of the planning process in order to engage in a discussion regarding the intended project. The issuance of permits and the transparency of administrative procedures at the municipal level exhibit variation across municipalities. In certain cases, namely within the solar business, the project developer may encounter a refusal from the local government to modify the specified land use, without providing explicit justifications for the denial. The current municipal tax structure exhibits a lack of stability and fails to provide adequate support. Municipalities has the authority to exercise their discretion in determining real estate tax rates, which can range from 0.5% to 3%. The Lithuanian Wind Power Association has observed that towns often establish maximum permissible tariffs, notably for producers of wind and solar energy.[175].
Malta	The expansion of large-scale renewable energy systems is considerably hindered by spatial constraints[176]. Due to its compact size and high population density, Malta

[172] Sattich, T., Morgan, R. and Moe, E. (2022) ‘Searching for Energy Independence, finding renewables? energy security perceptions and renewable energy policy in Lithuania’, Political Geography, 96, p. 102656. doi:10.1016/j.polgeo.2022.102656.
[173] European Commission (2023) National Reform Programme of Lithuania 2023 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023SC0615 Accessed 21 November 2023.
[174] Edita, A. and Dalia, P. (2022) ‘Challenges and problems of agricultural land use changes in Lithuania according to territorial planning documents: Case of vilnius district municipality’, Land Use Policy, 117, p. 106125. doi:10.1016/j.landusepol.2022.106125.
[175] Ministry of Finance of the Republic of Lithuania (2023) Real Estate Tax. https://finmin.lrv.lt/en/competence-areas/taxation/main-taxes. Accessed 21 November 2023.
[176] Micallef, A., Spiteri Staines, C. and Licari, J. (2022) ‘Renewable energy communities in islands: A Maltese case study’, Energies, 15(24), p. 9518. doi:10.3390/en15249518.

	encounters spatial limitations that restrict the potential for the execution of solar energy programs[177]. The influence of administrative hurdles on rooftop and ground-mounted solar power systems varies, with ground-mounted photovoltaic (PV) installations encountering notably greater hindrances compared to rooftop PV systems. This phenomenon can be attributed, in part, to the streamlined administrative procedures sometimes implemented for smaller facilities.[178]. The conversion of two- or three-story structures into multi-story apartment buildings resulted in an augmented extent of shading imposed on adjacent lower rooftops. The implementation of this technology could potentially render existing rooftop photovoltaic systems inoperable[179]. Insufficient capacity and limited flexibility of the power grid provide challenges to the integration of renewable energy sources and hinder efforts to enhance supply efficiency, reliability, and security. Infrastructure modernization investments are required in order to meet the current needs and demands[180]. The entirety of expenses related to establishing a connection between an installation and the grid are exclusively shouldered by the developer. In certain instances, this factor may present an obstacle due to the fluctuating costs associated with the proximity to the electrical grid and the potential need for infrastructure enhancements to establish a connection with the nearest viable point[181]. Consequently, the financial burden of grid

[177] Franzitta, V. et al. (2016) 'Assessment of renewable sources for the energy consumption in Malta in the Mediterranean Sea', Energies, 9(12), p. 1034. doi:10.3390/en9121034.

[178] Waste of sun and land as government shuns mass solar panel plan, claims CEO (2023) Times of Malta. https://timesofmalta.com/articles/view/waste-sun-land-government-blocks-solar-panel-installations-claims-ceo.1016748. Accessed 22 November 2023.

[179] Arena, J. (2023) Solar panels could be required on every new building from 2024, Times of Malta. https://timesofmalta.com/articles/view/solar-panels-required-every-new-building-2024.1038600. Accessed 22 November 2023.

[180] European Commission (2023) National Reform Programme of Poland 2023 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=COM:2023:621:FIN Accessed 22 November 2023.

[181]Kotzebue, J.R. and Weissenbacher, M. (2020) 'The EU's Clean Energy Strategy for islands: A policy perspective on Malta's spatial governance in energy transition', Energy Policy, 139, p. 111361. doi:10.1016/j.enpol.2020.111361.

	connectivity can render solar energy implementation unfeasible for developers, thereby impeding its deployment. Neither onshore nor offshore wind energy is included in the Maltese National Energy and Climate Plan (NECP) as viable alternatives for renewable technology that can assist Malta in achieving its renewable energy objectives for the European Union's 2030 target. Nevertheless, there is currently a law under deliberation in the Maltese Parliament that aims to streamline the process of conducting the nation's inaugural offshore wind purchase.[182].
Poland	Poland's most substantial administrative obstacle to onshore wind energy was undoubtedly the implementation of the 10H rule[183]. As per this regulation, it was mandated that the minimum separation distance between a wind farm and residential structures must be no less than ten times the height of the turbine. The 10H rule-imposed restrictions on the expansion of onshore wind power within the national energy portfolio, as it presented significant challenges in identifying suitable locations for wind energy projects that complied with the 10H rule. The liberalization of the 10H rule, which was initially established by the Distance Law of 2016, has been officially concluded by the Polish government.[184]. The amendment to the windmill statute was signed by the Polish president on March 13, 2023. After the stage of obtaining administrative permits, the physical implementation of the grid connection is too time-consuming [185]. Although there are legal deadlines for issuing grid connection conditions, there are insufficient legal instruments available when the physical

[182] Buljan, A. (2023) Malta planning its first offshore wind tender, Offshore Wind. https://www.offshorewind.biz/2023/07/10/malta-planning-its-first-offshore-wind-tender/ Accessed 22 November 2023.

[183] Juszczyk, O. et al. (2022) 'Barriers for renewable energy technologies diffusion: Empirical evidence from Finland and Poland', Energies, 15(2), p. 527. doi:10.3390/en15020527.

[184] Ptak, A. (2023) Polish parliament approves law to unblock building of onshore wind farms, Notes from Poland. https://notesfrompoland.com/2023/02/09/polish-parliament-approves-law-to-unblock-building-of-onshore-wind-farms/.Accessed 24 November 2023.

[185] Paska, J. et al. (2020) 'Electricity generation from renewable energy sources in Poland as a part of commitment to the Polish and EU Energy policy', Energies, 13(16), p. 4261. doi:10.3390/en13164261.

	implementation of the grid connection is persistently delayed[186]. The network instability is a result of the presence of microinstallations. The grid operators are experiencing delays in the physical installation of grid connection due to concerns regarding the destabilization of the network caused by renewable energy microgeneration devices. Solar systems with an electricity capacity of less than 50 kW are exempt from the requirement of obtaining a building permit or providing notification to the architectural and building administration. Nevertheless, it is imperative to obtain validation from a fire safety expert regarding compliance with fire safety standards for photovoltaic systems over 6.5 kW in installed capacity. The interpretation of the Property Tax Law for PV projects gives rise to various difficulties, resulting in the imposition of additional costs. The tax code has a high degree of complexity and undergoes continuous evolution. Furthermore, it is worth noting that a lack of uniformity exists in the interpretation of tax laws by tax authorities and administrative tribunals, leading to differing viewpoints on various matters. When considering property tax, taxpayers encounter challenges in discerning the categorization of various components inside a photovoltaic installation, specifically distinguishing between buildings and structures. This distinction has significant relevance in accurately computing property tax liabilities.[187].
Romania	A particular obstacle arises from the frequent revisions made to the primary legislation governing Renewable Energy. The dearth of information and transparency exhibited by authorities, coupled with a deficiency in expertise among government personnel[188] in the realm of renewable energy, often hinders and dissuades prospective

[186] European Commission (2023) National Reform Programme of Poland 2023 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=COM:2023:621:FIN Accessed 22 November 2023.
[187] Kałążny, A. and Morawski, W. (2021) 'Taxation of assets used to generate energy—in the context of the transformation of the Polish energy sector from coal energy to low-emission energy', Energies, 14(15), p. 4587. doi:10.3390/en14154587.
[188] Cîrstea, Ş. et al. (2018) 'Current situation and future perspectives of the Romanian Renewable Energy', Energies, 11(12), p. 3289. doi:10.3390/en11123289.

	developers from implementing further renewable energy capacity within the power sector. The adoption of renewable energy is impeded by limitations inside the electrical system [189]. The current transmission and distribution systems impose constraints on the potential of emerging renewable energy sources. The insufficient allocation of national funds towards utility infrastructure has resulted in the incapacity of key regions for renewable energy sources development [190] to effectively incorporate new capacities, mostly due to their limited ability to integrate emerging technologies. The aforementioned circumstance has hindered the successful implementation of photovoltaic and wind energy projects in the industrial sector. The little expertise possessed by the staff members responsible for grid administration poses challenges in acquiring licenses for power production and permits for grid connections[191]. The regional spatial planning documents in Romania have been subject to numerous legal challenges, which seem to be based on arbitrary reasons, leading to a range of concerns. In instances where project developers advise authorities of their goal to construct a renewable energy installation at a designated location, it is important to note that there may not be an established and functional urban plan in place that can offer preliminary insights into the project's feasibility. The Romanian Parliament passed a new legislation on May 11, 2023, which involves modifications and additions to two existing laws: Law No. 350/2001 concerning spatial planning and urbanism, and Law No. 50/1991 on the authorization of construction project execution [192].

[189] Popescu, C. and Radu, V. (2023) Romanian Competition Council identifies barriers to market entry of renewable electricity producers: Romanian Lawyers Week, Romanian Lawyers Week |. https://rlw.juridice.ro/22804/romanian-competition-council-identifies-barriers-to-market-entry-of-renewable-electricity-producers.html. Accessed 24 November 2023.
[190] Aceleanu, M.I. et al. (2017) 'Renewable energy: A way for a sustainable development in Romania', Energy Sources, Part B: Economics, Planning, and Policy, 12(11), pp. 958–963. doi:10.1080/15567249.2017.1328621.
[191] Ban, O.-I. et al. (2023) 'Romania residents' attitude investigation toward the transition to renewable energy sources through importance-performance analysis', Sustainability, 15(20), p. 14790. doi:10.3390/su152014790.
[192] PL-X Nr. 110/2023 - cdep.ro.
https://www.cdep.ro/pls/proiecte/upl_pck2015.proiect?idp=20701 Accessed 24 November 2023.

	Securing funding poses a significant challenge [193]. Currently, Romania lacks a specific assistance program for renewable energy projects. The former green certificates scheme, which was relevant for projects commissioned through the end of 2016, is no longer in effect. Renewable energy initiatives have the potential to qualify for European Union funding through several programs, such as the Recovery and Resilience Plan.
Slovakia	There is a dearth of tax incentives or benefits that are currently accessible for renewable energy plants. The assistance schemes lack complementarity, as observed in the case of the decarbonisation scheme. Additionally, the extent of support provided by private finance and financial instruments is minimal [194]. The TPS levy is responsible for the increment of electricity costs in both residential and commercial sectors. The taxation policy under consideration serves as a crucial means of funding the production of electricity derived from renewable energy sources and combined heat and power systems. The annual determination of the final power price includes the involvement of the Regulatory Office for Network Industries (RSO).[195]. In April 2021, the government of Slovakia implemented a policy change by rescinding the prohibition on the integration of newly established renewable energy sources into the national power system. Nonetheless, the implementation of a process that ensures the provision of clear and reliable information regarding the ability to

[193] Bâra, A., Oprea, S.-V. and Oprea, N. (2023) 'How fast to avoid carbon emissions: A holistic view on the res, storage and non-res replacement in Romania', International Journal of Environmental Research and Public Health, 20(6), p. 5115. doi:10.3390/ijerph20065115.
[194] European Commission (2022) National Reform Programme of Slovakia 2022 https://commission.europa.eu/system/files/2022-05/2022-european-semester-csr-slovakia_en.pdf Accessed 24 November 2023.
[195] Giovanni Sgaravatti Giovanni works at Bruegel as an Energy and climate research analyst. He studied Economics (BSc) at University of Venice - Ca' Foscari - including one semester at the University of Melbourne et al. (2023) National fiscal policy responses to the energy crisis, Bruegel. https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices. Accessed 24 November 2023.

	integrate new intermittent renewable energy sources into the power grid remains necessary.[196]. There are several elements that contribute to the unsatisfactory state of land access in Slovakia. The predominant portion of the nation's land area comprises little parcels of land that are privately owned by a multitude of individuals. As a result, the process of obtaining larger property parcels presents significant challenges and requires a substantial investment of time [197]. The overriding public interest principle pertains to the prioritization and preferential treatment of renewable energy projects within the context of permits and land-use planning procedures. In the context of Slovakia, it can be observed that the prioritization of renewable energy sources is not primarily determined by considerations of public interest or national significance [198].

Chapter 3: Barriers impeding the deployment of wind and PV plants in Greece.

Delays in licensing, permits, and grid connection are major hurdles for Greece's renewable energy industry[199]. In the past few years, a large number of investors have focused on the Greek renewable energy source market, and an abundance of new projects have been developed throughout the country – to the point where one might presume that the Greek distribution network has an excess capacity. The occupancy of grid space has been very loosely regulated for a considerable amount of time, and final grid connection offers (FGCOs) have been granted to licensed

[196] European Commission (2023) Recovery and resilience plan for Slovakia 2023 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52023PC0375 Accessed 24 November 2023.
[197] Lazíková, J. and Bandlerová, A. (2022) 'Land lease in Slovakia in the light of the New Legal Regulations', Przegląd Prawa Rolnego, (1(30)), pp. 125–143. doi:10.14746/ppr.2022.30.1.9.
[198] European Commission (2022), Directorate-General for Energy, Tallat-Kelpšaitė, J., Brückmann, R., Banasiak, J., et al., Technical support for RES policy development and implementation : simplification of permission and administrative procedures for RES installations (RES simplify) https://data.europa.eu/doi/10.2833/239077 Accessed 24 November 2023.
[199] Manolopoulos, D. et al. (2016) 'The evolution of renewable energy sources in the electricity sector of Greece', International Journal of Hydrogen Energy, 41(29), pp. 12659–12671. doi:10.1016/j.ijhydene.2016.02.115.

producers primarily on a first-come, first-served basis, with no specific priority requirements. As a consequence, the IPTO has been overburdened with providing connection offers for new wind power plants and reviewing connection offers for ones that have been redesigned. The same was true for PV installations, particularly small clusters of ground-mounted PV systems below 1 MW. IPTO and HEDNO were inundated [200] with new connection requests, causing further bottlenecks, because of significant delays in the preceding stages of the permitting procedure. According to data from the Association of PV Energy Producers, in 2021, HEDNO declined 80% of connection term requests, up from 40% in 2018-2020.

The average time between signing a connection contract with the Hellenic Energy Regulatory Authority and semi-loading a unit increased from 6.7 months in 2019 to 7.4 months in 2020, and 8.8 months in 2021. The entire duration from the final connection offer to semi-loading, on the other hand, showed a consistent, if not decreasing trend: from 13.1 months in 2019 to 12 and 12.7 months in 2020 and 2021, respectively.

Obtaining approval for an Environmental Impact Assessment (EIA) can be a further obstacle for onshore wind developments. Environmental licensing[201] can cause multi-year delays in project commencement. Environmental permitting can necessitate multiple rounds of evaluations and authorization from multiple authorities, and by the time the license is granted, the project is obsolete and must be restarted with current technology.

Appeals and legal proceedings are also factors that contribute to project delays and cancellations. Since the implementation of Law No. 3468/2006 on the Promotion of RES in Greece (including its later changes), a substantial number of cases have been filed with the State Council (High Court) seeking the cancellation of RES licenses (Installation License, Operation License, EIA Approval). This was due to local communities' and public authorities' (municipalities') reluctance to the deployment of new renewable energy projects. This impediment has a detrimental influence on the project's legal, technical, or operational levels. Because of the complaint proceedings, the project implementation process is delayed because the licensing process is suspended until the Court examines the annulment request. This impediment also affects operational renewable energy projects.

Aside from grid[202] and environmental and legal process constraints, the spatial planning framework also stifles the growth of renewable energy sources. It is a

[200] Loumakis, S., Giannini, E. and Maroulis, Z. (2019) ‘Renewable energy sources penetration in Greece: Characteristics and seasonal variation of the electricity demand share covering’, Energies, 12(12), p. 2441. doi:10.3390/en12122441.
[201] Seiradakis, Y. and Stazilova, E. (2023) Energy laws and regulations: Greece , GLI - Global Legal Insights - International legal business solutions. https://www.globallegalinsights.com/practice-areas/energy-laws-and-regulations/greece. Accessed 9 December 2023.
[202] Liaggou, C. (2023) The RES expansion headache, eKathimerini.com. https://www.ekathimerini.com/economy/1212156/the-res-expansion-headache/. Accessed 2 July 2023.

reform that has been in the works for 5 years. The Ministry of Environment and Energy announced a modification to the RES Special Spatial Plan in 2018. The change is designed to impose tougher regulations, especially affecting onshore wind and small hydropower installations. The new RES Special Spatial Plan has not yet been completed as of today[203]. On the other hand, the RES industry is concerned that this paper will lack precise planning rules. They are concerned, on the other hand, about the impact of the modified RES Special Spatial Plan on the subordinate regional spatial plans, and, in particular, that certain environmental groups may use this to stymie RES deployment.

In Greece, the consistency of financing the energy transition, particularly renewable energy sources, also poses a challenge. The Special Account for Renewable Energy Sources[204] is the primary source of funding for renewable energy subsidies. The account is funded by the Greenhouse Gas Emissions Reduction Special Duty, which is levied on all electricity consumers, ETS allowance auction revenues, and excess revenues earned by renewable suppliers receiving support through the FiP mechanism.

The majority of RES production in Greece is governed by fixed price contracts (FiT/FiP). Under the FiP mechanism, RES projects receive a premium in the form of a variable (progressive) premium in addition to their market revenues. During 2021, the proportion of FiT increased by only 5.6%, translating to a gradual shift away from state protection schemes in the RES market. Under the declining FiP framework, renewable energy producers receive a premium equal to the difference between the Reference Price and the monthly Reference Market Price per technology. Due to the significant increase in the Reference Market Price in 2021, RES producers were required to refund the difference between the Reference Market Price and their Reference Price to the RES Special Account.

In the year 2021, Greece implemented notable modifications to the distribution of Emissions Trading Scheme revenues. Specifically, a substantial portion of ETS revenues was redirected from the Special Account for Renewable Energy Sources, which finances subsidies for renewable energy initiatives, to the Energy Transition Fund[205], which provides direct payments to consumers and businesses to mitigate the impact of high energy prices. The majority of ETS revenues now go to the Energy Transition Fund (75 percent in 2022)[206]. This allocation falls short of the EU requirement that fifty percent of ETS revenues be spent on modernizing the energy system and reducing greenhouse gas emissions. Greece is required by law

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[203] Energypress (2023) New Res Spatial Plan to include stricter installation rules. https://energypress.eu/new-res-spatial-plan-includes-stricter-installation-rules/ Accessed 17 November 2023.

[204] Regulatory Authority for Energy (2023) Regulatory Authority for Energy Official Website. https://www.rae.gr/special-account-for-res-and-chp/?lang=en. Accessed 7 October 2023.

[205] Energypress (2022) Permanent Energy Transition Fund - How will it work, who will it subsidize, what income will it have. https://energypress.gr/news/monimo-tameio-energeiakis-metavasis-pos-tha-leitoyrgei-poioys-tha-epidotei-ti-esoda-tha-ehei. Accessed 8 October 2023.

[206] Vlachou, A. and Pantelias, G. (2022) ‘Energy transitions: The case of greece with a special focus on the role of the EU ETS’, Science & Society, 86(4), pp. 516–545. doi:10.1521/siso.2022.86.4.516.

to spend all ETS revenues on domestic climate change and energy initiatives. Nonetheless, the allocation of the revenues is determined annually, and no national law mandates that a minimum proportion be spent in accordance with EU requirements. This is notably problematic due to the increasing importance of ETS revenues in financing climate policy, as a result of high allowances.

Beyond the aforementioned challenges, there exist additional issues that are anticipated to emerge in the coming years. Interconnections that are not commercialized in a timely manner affect the renewable energy sector. Greece's wholesale power supply is substantially reliant on cross-border interconnections. Electricity traders can acquire long-term physical transmission rights to utilize cross-border interconnections through auctions conducted by the TSO. A portion of transmission capacity is reserved for the day-ahead market, which handles electricity imports.[207].

The European XBID initiative launched continuous intraday trading on the Greek-Italian and Greek-Bulgarian borders in November 2022[208]. This system permits continuous cross-border trade by market participants in proximity to delivery time, thereby optimizing market schedules and reducing imbalance costs. Attempted by Greece are substantial investments aimed at enhancing interconnection capacity[209] in order to improve integration with the European electricity market and assist the country's objective of becoming a net electricity exporter.

The government has announced its intention to construct an interconnection with Egypt, increase the capacity of interconnections with Albania, Bulgaria, Italy, and North Macedonia by twofold, and construct an interconnection with Italy. Greece and other member states of the region have reached a consensus to initiate construction of the EuroAsia Interconnector[210], an extensive undertaking that aims to link these countries via two DC subsea cables.

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[207] European Commission (2021) Market reform plan for Greece.https://energy.ec.europa.eu/system/files/2021-08/greece_market_reform_plan_0.pdf. Accessed 9 October 2023.

[208] Energypress (2022) Cross-border intraday XBID continuous market ready. https://energypress.eu/cross-border-intraday-xbid-continuous-market-launch-tomorrow/. Accessed 10 October 2023.

[209]Aposporis, H. (2023) Greece’s ipto working on interconnections with all neighboring countries, Balkan Green Energy News. https://balkangreenenergynews.com/greeces-ipto-working-on-interconnections-with-all-neighboring-countries/. Accessed 10 October 2023.

[210] Energypress (2023) IPTO in advanced talks for EuroAsia Interconnector Helm. https://energypress.eu/ipto-in-advanced-talks-to-take-charge-of-euroasia-interconnector/ Accessed 11 October 2023.

Chapter 4: Policy choices for addressing the challenges - The Greek case.

4.1 The political decision to alter the connection priority.

As previously stated, the enormous volume of applications for Final Connection Offers (FGCOs) to RES stations had resulted in an extraordinarily burdensome situation for the Operators[211]. The Greek government decided to cut rather than dissolve the "Gordian Link" and to end the "first-come, first-served" policy.

The Ministry of Environment and Energy published a new decision on the priority framework for granting Final Connection Offers to RES stations in August 2022[212], following a long-standing unofficial suspension to the approval of new applications for FGCOs. The legislative provisions of the ministerial decision are crucial for renewable energy investment projects because they determine the order of priority in which pending requests for the granting of final grid connection offers of connection conditions will be reviewed, thereby having a significant impact on the timeline for obtaining a compensation price for mature RES projects.

RES projects are grouped into six priority categories (further subdivided into subcategories), and applications for granting FGCOs are processed by the competent independent power transmission operator (IPTO) in each category, beginning with Group A (which relates primarily to the largest projects, strategic investments, and plants close to the borders) and ending with Group F (Chart 1). Significantly distinguishing the decision from all previous administrations is the restriction on the unrestricted licensing of RES projects through the allocation of a maximum capacity power limit per group/subgroup by the competent IPTO.

The change in connection terms drove numerous energy producers and Greek opposition parties to talk about “tailor-made guidelines”. They argued that the ministerial decision hinders mature investments in the RES market by altering the grid connection priority regime, and that the sole reason for the Ministry of Environment and Energy to establish these priorities was the size of the projects and the installation area, which served specific business interests[213]. For its part, the government argued that the new system gives all stakeholders access to a trustworthy priority framework that makes an effort to regulate the previously strict procedures for RES licensing and operation, speeds up the implementation of mature RES projects that have been waiting in line for a while, and makes it easier to integrate upcoming ambitious RES projects.

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[211] Makrygiorgou, J.J. et al. (2023) ‘The Electricity Market in Greece: Current status, identified challenges, and arranged reforms’, Sustainability, 15(4), p. 3767. doi:10.3390/su15043767.
[212] Ministerial Decision ΥΠΕΝ/ΓΔΕ/84014/7123 (Government Gazette 4333 Β’ 2022) https://www.nomotelia.gr/photos/File/4333b-22.pdf Accessed 1 October 2023.
[213] Energypress (2022) Perka: With the decision of the Ministry of Internal Affairs to change the connection conditions of RES projects, the scandal of the ND regarding the available electrical space to selectively serve large interests was achievedhttps://energypress.gr/news/perka-me-tin-apofasi-toy-ypen-gia-tin-allagi-ton-oron-syndesis-ton-ergon-ape-oloklirothike. Accessed 1 October 2023.

Six months after[214] the decision was issued, on January 20, 2023, a second ministerial decision was published, amending the first by increasing the regulated capacity of Group B from 1.5 gigawatts to 4 gigawatts, without materially affecting the maximum regulated capacity of all other priority groups. The primary objective of the amendment act was to facilitate the production of renewable energy sources (RES) in facilities designed to produce based on power purchase agreements.

Group B consists exclusively of plants designated for concluding PPAs. As with the majority of priority groups, a 20% "deviation" is provided, indicating that, at the discretion of the IPTO, the final decision issuing FGCOs to any such project may reduce the plant's regulated capacity by up to 20% compared to the producer's license. In this case, producers must have concluded PPAs with suppliers or industrial consumers for at least 80% of their production or demonstrate that they will do so promptly. In addition, producers must submit a letter of guarantee to the relevant IPTO for EUR 100,000 per megawatt. Despite the fact that a first reading of the requirement might imply that the provision is intended to favor large investors, it simultaneously ensures that, contrary to past practices, only financially sustainable projects will be considered and given the opportunity to occupy vital space on the grid.

Group D projects, which include standalone battery projects and RES[215] plants with internal storage facilities, have presumably received a significant priority boost, as their respective grid connection applications will be evaluated concurrently with Group B applications. It should be noted that the first tender for such projects in Greece, with a capacity of up to 1 gigawatt, is scheduled for the end of the first quarter of 2023. This should pique the interest of investors, particularly in light of the National Energy and Climate Plan's target of 8 gigawatts of storage capacity within the next ten years, with battery installations anticipated to reach up to 5.6%.

The criticism persisted even after this second modification to the ministerial decree. Businesses who were negatively impacted by the government's decision claimed that the Ministry of Environment and Energy failed to address the main issue of inadequate electrical capacity in the network and failed to guarantee the advancement of mature projects. They claimed that the government is favoring political allies who hurried to secure terms of connection in order to sell the licenses and make enormous profits. For example, a renewable energy license for photovoltaics without FGCOs has a value of no more than 10,000 euros per 1 MW. Nonetheless, if FGCOs are granted, this license could be worth between 85,000 and 150,000 euros per 1 MW (depending on connection costs))[216].

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[214]Chatzigiannidou, S. and Makri, A. (2023) Greece enacts changes in the recently established Grid Connection Offers Priority Regime. https://www.zeya.com/sites/default/files/2023-01/energy_newsletter_eng_30012023.pdf_0.pdf Accessed 11 October 2023.
[215] Katsantonis, A. (2023) Greece: New Grid Connection Priority Framework Favors ppas and Energy Storage. Available at: https://drakopoulos-law.com/2023/05/17/greece-new-grid-connection-priority-framework-favors-ppas-and-energy-storage/. Accessed 12 October 2023.
[216] Newsbomb,(2023) The manner in which the Mitsotakis administration provides millions to its own in photographic terms associated with the RES.

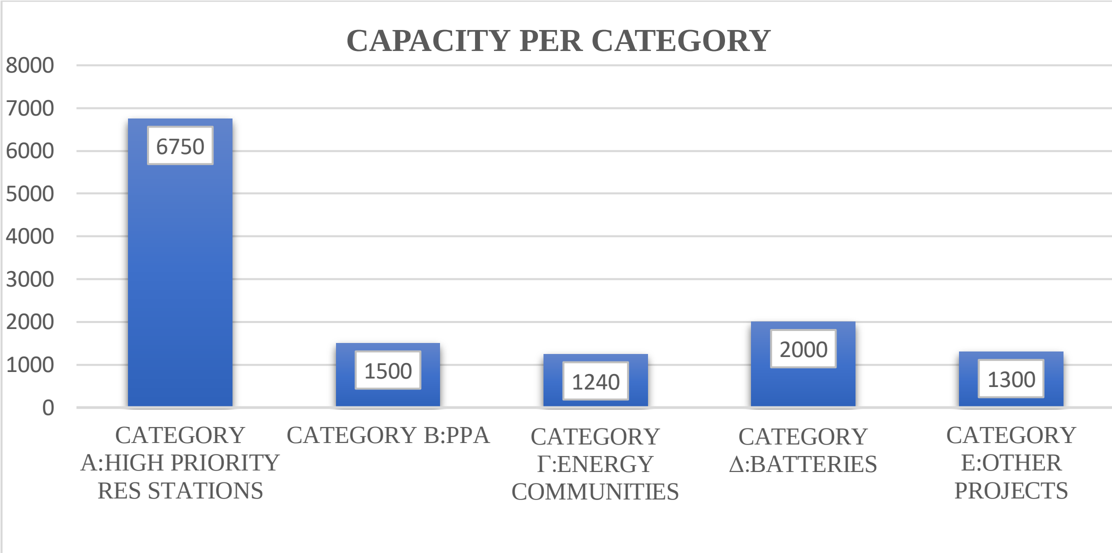

Figure 3 Projects that may be eligible- Open-source data calculation 2023

The Greek government implemented an additional unforeseen adjustment to the grid-connection priority in March 2024[217].

Law 5095/2024 granted RES producers who have entered into green-energy PPAs with domestic energy-intensive industrial producers and farmers, in addition to RES projects for which PPAs will be established subsequent to the ratification of the legislative revision, absolute grid-connection priority[218].

The criterion for determining which RES projects are eligible for expedited grid access will be established by a ministerial decision that the energy ministry will publish sixty days subsequent to the ratification of the legislative revision. The residual grid capacity allocated to wind and solar energy projects that fail to obtain expedited grid access will be significantly diminished. It is anticipated that this reduced capacity will recommence once measures aimed at liberating grid capacity have been executed.

On account of the legislative revision, RES projects with a combined capacity of up to 1,600 MW may be able to secure grid connection terms more quickly, according to estimates.

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https://www.newsbomb.gr/bomber/apokalypseis/story/1395019/pos-i-kyvernisi-mitsotaki-dinei-ekatommyria-se-imeterous-me-fotografikoys-orous-syndesis-stis-ape. Accessed 11 October 2023.

[217217] Law 5095/2024, (2024)“Strengthening of jurisprudence: Regulations for inheritances, acceptances and renunciations of inheritances, registrations and eliminations of consensual mortgage notes and affidavits and for the Fund Financing of Court Buildings and the payment of legal aid cases and other urgent arrangements”. (Government Gazette A’ 40/15-3-2024).

[218] Iefimerida.gr, N. (2024) Πήρε ΦΕΚ η ρύθμιση μείωσης του ενεργειακού κόστους για αγρότες και βιομηχανία, iefimerida.gr. Available at: https://www.iefimerida.gr/oikonomia/pire-fek-i-rythmisi-meiosis-toy-energeiakoy-kostoys-gia-agrotes-kai-biomihania (Accessed: 16 March 2024).

4.2 Priorities for IPTO's Final Connection Offer

In accordance with the new framework, the RES and HECHP stations that are granted a Final Connection Offer by the System Operator are classified into the following categories and reviewed sequentially or concurrently, as specified.

Group A includes the following stations (Chart 2)

SUB-GROUP A1

A1. Stations that are installed exclusively within the boundaries of regions that are up to 30 km from the border, according to the Production License, Producer Certificate, or Special Projects Certificate, and that are related to individual requests for granting final connection offers for stations with a maximum production capacity greater than or equal to 200MW.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 800 MW of installed capacity.

2. Capacity deviation: 20%.

SUB-GROUP A2

A2. Stations that have been designated as "strategic investments" by the Interministerial Committee for Strategic Investments (DESE) in accordance with the provisions of Laws 3894/2010, 4608/2019, and 4864/2021, and for which requests or joint requests for granting final connection offers have been submitted.

Special Terms and Conditions:

1. The maximum capacity limit of the connection is 1600 MW, of which up to 1250MW is made accessible in the Regions of Western Macedonia, Thessaly, and Central Greece, while the remaining capacity is made available in the rest of the country.

2. Capacity deviation: 20%.

SUB-GROUP A3

A3. The stations that are exclusively located within the geographical boundaries of the Western Macedonia region, as indicated by the Production License, Producer Certificate, or Special Projects Certificate, and for which requests or joint requests for a final connection offer have been submitted, are those belonging to the same holder of the Production License, Producer Certificate, or Special Projects

Certificate. These stations must have a request capacity, total joint request capacity, or total capacity of all requests from the same holder, which must be equal to or greater than 100MW.

Special Terms and Conditions:

1. The maximum capacity limit for connection offers is 1500 MW of installed capacity, of which up to 1100 MW are made available in the Regional Unit of Kozani, up to 150 MW in the Regional Unit of Florina, and up to 250 MW in the Regional Unit of Grevena.

2. Capacity deviation: 20%.

SUB-GROUP A4

A4. Stations with a Special Projects Certificate that fall under subparagraphs (g) and (h) of paragraph 5 of article 10 of Law 4685/2020 and for which requests or joint requests for granting final connection offers have been submitted or will be submitted after the publication of this document, with a request capacity or total joint request capacity greater than or equal to 150 MW.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 850 MW of installed capacity.

2. Capacity deviation: 20%.

SUB-GROUP A5

A5. Stations with a producer certificate that have submitted requests or joint requests for granting a final connection offer, with request capacity or total joint request capacity greater than or equal to 300MW, and with an integrated storage unit with energy storage capacity of at least 250MWh per station in accordance with the environmental licensing decision.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 500MW maximum production capacity.

2. Capacity deviation: 0%.

3. The owners of the stations included in this sub-group must submit the necessary technical information regarding the storage technology's ability to absorb power

within two months of the publication of the aforementioned MD; failing to do so will result in a limit on the absorption power of no more than 50%.

4. Producers must agree to being included in this sub-group and the decreased maximum production capacity of the station within twenty days after receiving the pertinent communication from the System Operator. The following is the maximum production capacity restriction, which is determined by the technological features of the integrated storage facility: 43% if the storage's power absorption capacity in relation to the station's installed capacity is greater than or equal to 20%. 33% if the storage's power absorption capacity in relation to the station's installed capacity is up to 20%.

5. To enable the offer to be issued, owners of stations in this subgroup must possess a Producer Certificate in accordance with paragraph 11a of Article 10 of Law 4685/2020 up until the final connection offer is approved.

6. The storage station specified in the application for a final connection offer should be put into service at the same time as the RES station by the owners of the stations in this sub-group. To this aim, the connection offer included a particular requirement.

SUB-GROUP A6a

A6a. Wind power plants that have a Production License or Producer Certificate and for which requests or joint requests for final connection offers have been made.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 600 MW of installed capacity.

2. Capacity deviation: 20%.

SUB-GROUP A6b

A6b. Wind power stations that, according to the Production License, Producer Certificate, or Special Projects Certificate, are installed exclusively within the geographical boundaries of areas located up to 30 kilometers from the borders and for which requests or joint requests for granting final connection offers have been or will be submitted, with a request capacity or total joint request capacity greater than or equal to 200MW.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 250 MW of installed capacity.

2. Capacity deviation: 20%.

SUB-GROUP A7

A7. Stations that, according to the Production License, the Producer Certificate, or the Special Projects Certificate, are installed exclusively within the geographical boundaries of the "Megalopolis Lignite Phase-out Zone" (Megalopolis ZAP in accordance with articles 155 and 156 of Law 4759/2020) and for which requests or joint requests for granting final connection offers have been submitted.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 500 MW of installed capacity.

2. Capacity deviation: 0%.

SUB-GROUP A8

A8. Stations that have been installed exclusively within the boundaries of the Epirus Region, as specified by the Production License, Producer Certificate, or Special Projects Certificate, and for which requests or joint requests for the granting of final connection offers have been made, with a request capacity or total joint request capacity of greater than or equal to 50 MW.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 150 MW of installed capacity.

2. Capacity deviation: 20%.

SUB-GROUP A9

A9 Stations for which requests or joint requests for granting final connection offers for photovoltaic stations have been submitted with a request capacity or total joint request capacity greater than or equal to 50 MW, and which are installed exclusively within the geographic boundaries of the Epirus Region and the Regional Units of Aetoloakarnania and Fokida, according to the Production License, Producer Certificate, or Special Projects Certificate. Additionally for wind power plants having a request capacity or total joint request capacity greater than or equal to 20 MW.Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 400 MW of installed capacity is the maximum capacity allowed by connection offers, of which no more than 200 MW may be devoted to photovoltaic technology and the remaining to wind technology.

2. Capacity deviation: 20%.

SUB-GROUP A10

A10 Stations that, according to the Production License or the Producer Certificate or the Special Projects Certificate, are exclusively installed within the geographical boundaries of the Region of Eastern Macedonia and Thrace and for which requests or joint requests for granting final connection offers for photovoltaic stations have been submitted with a request capacity or total joint request capacity greater than or equal to 50 MW, and for wind power stations with a request capacity or total joint request capacity greater than or equal to 20 MW.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 550 MW of installed capacity is the maximum capacity limit for connection offers, of which no more than 450 MW may be devoted to photovoltaic technology and the remaining to wind technology.

2. Capacity deviation: 20%.

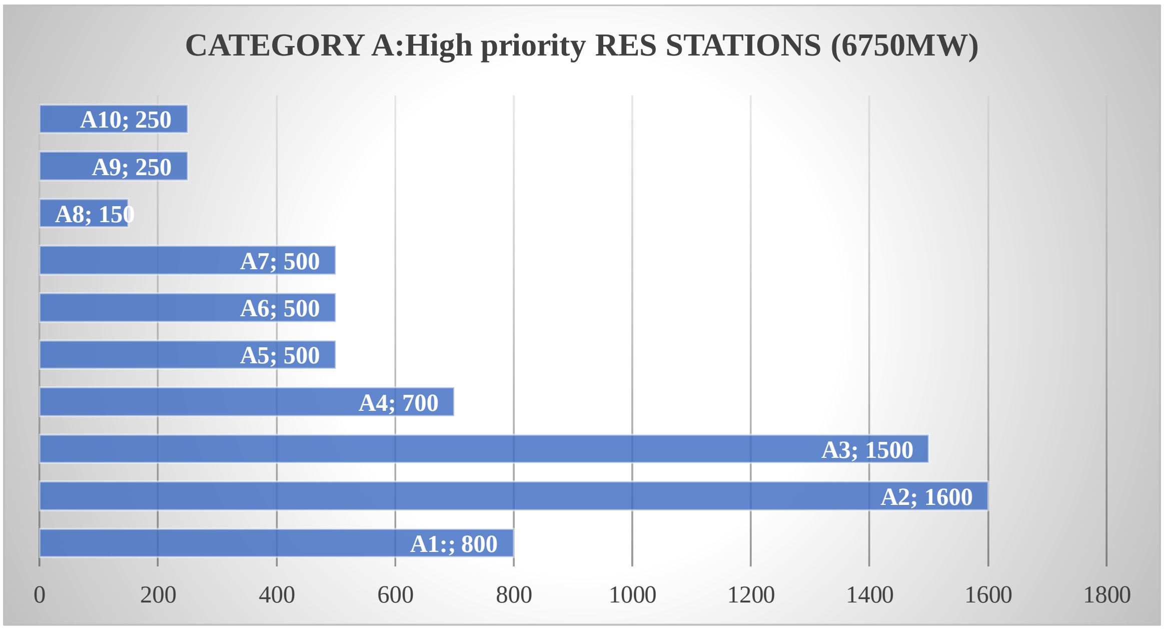

Figure 4 Projects that may be eligible- Open-source data calculation 2023

GROUP B

Group B includes the following stations:

Power plants made of RES and HECHP for which the Producer has signed or intends to sign a bilateral electrical power purchase agreement with a final non-household customer or with an electricity supplier, and for which requests or joint requests for granting final connection offers have been made.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 4000 MW of installed capacity.

2. Capacity deviation: 20%.

3. If there is a bilateral agreement with an electricity supplier, the supplier should agree to sign a pertinent supply contract with a final consumer or final consumers who are not households. The bilateral agreement need not specify how the produced energy will be delivered physically. A customer who is based inside the Greek Territory is referred to as an end customer.

4. Producers who wish to join this group must do the following within two months of the MD's taking effect:

a) submit to the Operator a letter of guarantee (bilateral agreement letter of guarantee) in an amount equal to the maximum production capacity of the station, taking into account the reduced capacity in accordance with the deviation rate specified for this group, which is specifically 100,000 euros per MW.(b) present the appropriate document, depending on what is suitable: (ba) a declaration on honor that they will enter into a bilateral power purchase agreement (or bilateral agreements), along with the understanding outlining its key provisions; or (bb) the bilateral agreement(s) that has(have) been reached.

5. Producers commit to submitting the duly executed bilateral power purchase agreement to the Operator no later than six months following the issuance of the Final Offer. If that happens, the Final Connection Offer will immediately no longer be valid.

6. The details of the end customer, the installed capacity of the station, the agreed-upon amount of energy to be consumed by the end customer or purchased by the supplier, and the duration of the power purchase agreement, which should be at least eight years, must all be included in the bilateral power purchase agreement that must be submitted. According to the energy analysis for the station's produced power and the expected consumption by the end user, the bilateral agreement should cover at least 80% of the electricity generated by the RES or HECHP station. Conditions

guaranteeing that it is matched with end customers should be included in the bilateral agreement between a producer and a supplier.

7. A new agreement with an end customer must be reached within two months or matched via a supplier in the event that a bilateral agreement with the end customer with whom it was signed or with whom it was matched via a supplier is terminated.

GROUP C

Group C the includes the following stations:

SUB-GROUP C1

Exempt Stations for which joint petitions for granting final connection offers have been submitted or will be presented by 10.12.2022 exclusively by 'Energy Communities' of Law 4513/2018, with participation from first and second tier local government organizations.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: The utmost installed capacity of connection offers is 200 MW, with a maximum of 50 MW per Regional Unit.

2. Capacity deviation: 20%.

3. The relevant first or second tier local government organizations must be a member of the 'Energy Community' prior to submitting a proposal.

SUB-GROUP C2

Exempt Stations that are to be installed solely within the boundaries of the Regional Units of Kozani and Florina, for which joint requests for granting final connection offers have been submitted or will be submitted by 10.12.2022, and which are being developed solely by 'Energy Communities' of Law 4513/2018 with a total joint request capacity greater than 100MW.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: The connection's maximum capacity limit is 400 MW of installed capacity.

2. Capacity deviation: 20%.

SUB-GROUP C3

Wind power stations that are exempt or hold a Production License or Producer Certificate with a maximum production capacity of less than or equal to 6MW (6MW) and for which requests have been submitted or will be submitted by April 10, 2023, and are developed solely by "Energy Communities" as defined by Law 4513/2018.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: The connection offers have a 120 MW maximum production capacity cap, with a 6 MW cap per "Energy Community" as the upper limit.

2. Capacity deviation: 0%.

3. The 'Energy Communities' that have filed or will submit requests must have been created before the Ministerial Decision was published.

SUB-GROUP C4

Exempt Stations that will be installed solely within the boundaries of the Regional Units of Kozani and Florina, for which joint requests for granting final connection offers have been submitted or will be presented by 10.12.2022, with a total joint request capacity of more than 100 MW. At least 70 distinct legal companies or natural people are involved in the development of the stations listed in the joint request.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: The connection's maximum capacity limit is 400 MW of installed capacity.

2. Capacity deviation: 20%.

SUB-GROUP C5

Exempt Stations that are to be installed solely within the boundaries of the Region of Eastern Macedonia and Thrace and the Region of Serres, for which joint requests for granting final connection offers have been submitted or will be submitted by 10.12.2022 solely by 'Energy Communities' of Law 4513/2018.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: The maximum installed capacity for connection proposals is 150 MW.

2. Capacity deviation: 20%.

SUB-GROUP C6

Exempt Stations that are to be installed solely within the geographical boundaries of the Epirus Region and the Regional Units of Aetoloakarnania and Fokida, and for which joint requests for granting final connection offers have been or will be submitted solely by "Energy Communities" under Law 4513/2018 by 10.12.2022.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: The connection's maximum capacity restriction is 250MW of installed capacity.

2. Capacity deviation: 20%.

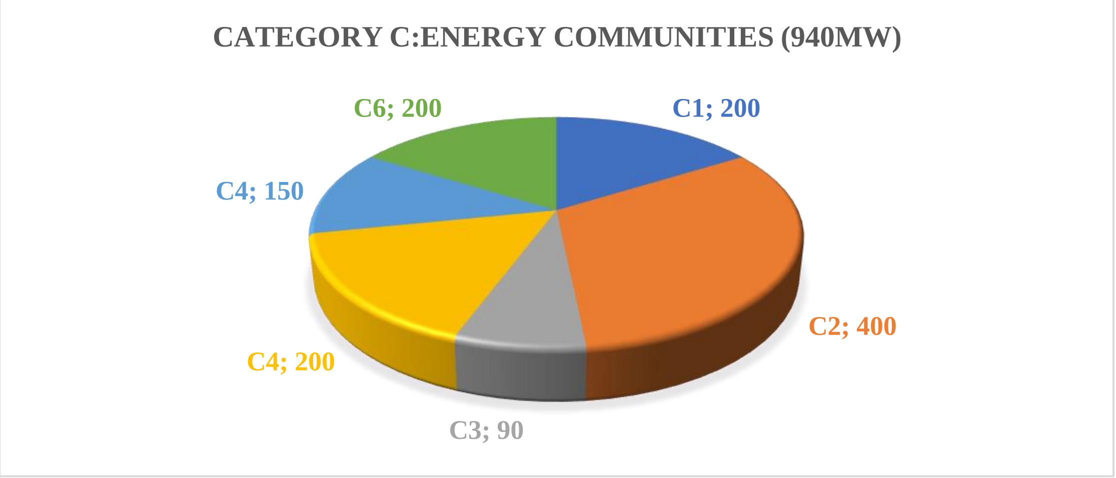

Figure 5 Projects that may be eligible- Open-source data calculation 2023

GROUP D

RES stations with integrated storage or a combination of RES stations and storage stations with restricted operational capacity. Group D consists of the subsequent subdivisions of stations:

SUB-GROUP D1

D1 RES stations with storage that do not draw power from the grid.

a) RES stations with storage of paragraph 11A of article 1 of Law 4685/2020 with a Producer Certificate for which requests or joint requests for connection of RES stations to a common connection point are submitted, with an aggregate capacity of 100MW or larger.

b) The sub-group also includes RES stations for which requests or joint requests for connection to a common connection point have been submitted, with a total capacity greater than 100MW, that may work in tandem with storage stations to fill the storage systems with which they are connected on a common connection point of the System, provided that the total maximum injection capacity into the System does not exceed the maximum injection capacity of the storage station.

To include a station described in this subparagraph (b) in subgroup D1, interested parties must submit the following with their request: (bb) a statement/commitment that it accepts the imposition of up to 100 percent injection operational restrictions by the storage station during periods of high RES generation penetration.

The limitation of subparagraph (ba) is incorporated into the project connection terms and connection agreements. The implementation of the agreed-upon restriction will be monitored in real time.

Special Terms and Conditions:

1. Maximum capacity limit of connection offers: 1000 MW of installed capacity of RES Stations, with a maximum limit of 250 MW per request or joint request.

2. Capacity deviation: 20%.

3. The maximum injection capacity of the RES stations within this sub-group may not exceed the maximum injection capacity of the storage station/systems after the capacity deviation has been applied.

The duration of storage should be a minimum of two hours at the utmost injection capacity of the storage station.

5. Station owners should commission the storage station described in the application for a final connection offer simultaneously with the RES station. To this purpose, the final connection offer stipulates a specific condition.

SUB-GROUP D2

RES stations with storage of paragraph 11B of article 1 of Law 4685/2020 and a Producer Certificate, for which requests or joint requests for RES station connection to a common connection point are submitted. RES stations that have storage capable of absorbing network energy.

Terms and Conditions:

1. Maximum capacity limit of connection offers: The utmost capacity limit of connection offers is 1,000 MW of installed capacity of RES Stations, with a per-station maximum of 250 MW.

2. . Capacity deviation: 20%.

3. The storage systems' maximum injection capacity may not be greater than the maximum injection capacity of the stations in this subgroup.

4. At the station's maximum injection capacity, storage time should be at least two hours.

GROUP E

Group E' contains requests or joint requests for stations that have been submitted or will be submitted after the publication of the said Ministerial Decision and fall into the following categories:

E1. HECHP power plants
E2. Biomass and biogas
E3. Small Hydroelectric Power Plants
E4. Geothermal Power Plants
E5. Wind Power Plants
E6. Photovoltaic power plants built in buildings or other structures.
E7. Auto-producers
E8. Offshore Wind Farms

Special Terms and Conditions

1. Maximum capacity restrictions for connection offers are as follows: (a) 1000 MW installed capacity for stations in sub-group E5; (b) 300 MW installed capacity for stations in sub-group E6.

2. Capacity deviation: 0%

GROUP F

Group F covers all RES and HECHP stations that do not fit under Groups A, B, C, D, or E.

4.3 Priorities for HEDNO's Final Connection Offer

The Network Operator reviews applications submitted by RES and CHP stations for a final connection offer if they belong to any of the following categories:

GROUP A

Group A includes the following station categories:

- Power plants powered by gases emitted by landfills and biological treatment plants, as well as biogas derived from anaerobic digestion of the biodegradable waste fraction and organic sewage sludge/mud from biological treatment operations, to be operated by Solid Waste Management Bodies (FODSA) or legal persons to whom FODSA powers have been delegated under a program agreement and/or a Public Private Partnership (PPP) or other type of pubic-private partnership.

- Pilot Marine Floating Photovoltaic Stations.

GROUP B

Group B includes the following station categories:

- Biomass stations, as defined in Law 3874/2010, are establishments or legal entities that are registered in the Register of Farmers and Agricultural Holdings. These stations have an operational capacity of no more than 3 MW and must be situated within the Regional Unit where their agricultural holdings are situated.

- Biogas stations with a maximum capacity of less than or equal to 3 MW.

- Innovative projects implemented in the scope of research programs by the Centre for Renewable Energy Sources and Saving (CRES), universities, research institutes, and private sector research organizations or agencies.

- Auto-producer power plants with net metering, in compliance with Article 14A of Law 3468/2006.

- Auto-producer power stations with virtual net metering, in compliance with Article 14A of Law 3468/2006.

- Power stations affiliated with 'Energy Communities' that use virtual net metering in compliance with Article 11 of Law 4513/2018.

- Small hydroelectric stations having a maximum output capacity of 500 kW or less, located in water, irrigation, or sewerage networks and geothermal energy power plants.

GROUP C

Group C includes the following station categories:

• RES power plants to be operated by General Land Reclamation Organizations (GOEV), Local Land Reclamation Organizations (TOEV), or Crete Development Organization S.A. (OAK S.A.).

• Photovoltaic power stations installed into houses or other structures.

• All RES and HECHP power stations, except wind and solar power stations, belong to 'Energy Communities'.

• Small hydroelectric power plants.

• Small HECHP plants have been having a maximum capacity of less than or equal to 3 MW.

• Biomass power plants with a maximum output capacity of less than or equal to 3 MW.

• HECHP stations, the thermal energy generated by which is either employed in the production of agricultural goods or made available through the city's district heating network.

• Wind and photovoltaic power stations belonging to 'Energy Communities' that expressly state in their articles of association that they will not distribute any financial year surplus to their members, in accordance with paragraph 2 of Article 6 of Law 4513/2018, or to 'Energy Communities' in which first or second tier local government organizations participate, or to 'Energy Communities' with more than 60 members, at least 50 of whom are natural persons.

• Auto-producer RES and HECHP stations connected to a low voltage network.

GROUP D

Group D consists of wind and solar generating facilities that are members of "Energy Communities," who, in accordance with Section 4 of Article 6 of Law 4513/2018, pay any financial year surplus to their members after deducting the statutory reserve amount.

GROUP E

The types of RES and HECHP stations that do not come into Groups A, B, C, and D are included in Group E.

4.4 Enhancing and streamlining Net-Metering

Net-Metering is one of the most essential ways for encouraging self-production and use of renewable energy sources[219]. Net-Metering allows consumers to cover a large portion of their own demand while also using the network for indirect energy storage. Recognizing the importance of Net-Metering, the Greek government has set aside 2.5 GW of grid capacity for roof-mounted photovoltaics Net-Metering projects. This reservation is estimated to allow for the installation of roughly 250,000 solar energy systems of up to 10 KW in the categories of households, small businesses, and agricultural. [220] . According to Hellenic Association of Photovoltaic Companies (HELAPCO) data, Net-Metering installations increased significantly in 2022, reaching a total capacity of 110 MW, roughly three times that of 2021, when the installed Net-Metering capacity totaled 38 MW[221].

In response to industry and producer requests, the Greek government implemented several measures in 2023 to reform[222] the legal framework for Net-Metering and Virtual Net-Metering and to introduce new Net-Metering and Virtual Net-Metering capacity limitations. Law 5037/2023 sets the Net-Metering capacity limit for residential customers at 10.8kW and for nonresidential customers at 100kW, as opposed to the previous limit of 3MW. In addition, the maximum Virtual Net-Metering capacity for power plants with agricultural use is 100kW.

Concurrently, several modifications occurred[223]. Virtual Net-Metering is set to be available to high-voltage consumers, in contrast to the previous framework, under which self-consumers could only connect to low or medium voltage networks.
Virtual Net Metering may be implemented by local governments (OTA), farmers, and Energy Communities (i.e., existing Energy Communities, new Renewable Energy Communities, and Citizen Energy Communities) for the sole purpose of satisfying the requirements of their domestic members. Non-profit and private law entities and other enterprises can no longer implement Virtual Net-Metering, contrary to previous provisions that permitted Virtual Net-Metering for any Energy Community, regardless of the nature of its members. New Renewable Energy Community can register for Virtual Net-Metering from RES stations (not CHP units), and RES stations with storage, (not just storage units).

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[219] Ministerial Decision No. E/EK/15084/382/19.2.2019 Government Gazette B 759/5.3.2019. https://www.kodiko.gr/nomothesia/document/774282/yp.-apofasi-ypen-dapeek-15084-382-2019 Accessed 12 October 2023.
[220] Energypress (2023) Grid capacity for net metering, Energy Community Projects. https://energypress.eu/grid-capacity-reserved-for-net-metering-energy-community-projects/. Accessed 13 October 2023.
[221] Energypress (2023) Record-level solar panel installations in 2022 reach 1,362 MW https://energypress.eu/record-level-solar-panel-installations-in-2022-reach-1362-mw/. Accessed 13 October 2023.
[222] Law 5037/2023 (Government Gazette 78/28.03.2023) https://www.taxheaven.gr/law/5037/2023 . Accessed 13 October 2023.
[223]Energypress (2023) The new legislation on self-consumption, net metering and net billing: A first legal assessment. https://energypress.gr/news/oi-nees-nomothetikes-rythmiseis-gia-tin-aytokatanalosi-net-metering-kai-net-billing-mia-proti Accessed 12 October 2023.

For the implementation of Virtual Net-Metering by all categories of Energy Community, self-production facilities may be established in any region, regardless of the location of the self-consumption site and the registered office of the Community, subject to proximity requirements. Under the previous rule, the production facility and the self-consumption facility had to be located in the same region. Any excess energy remaining at the conclusion of a three year Net-Metering period is injected into the network without compensation to the selfconsumer, following energy clearing.

Self-consumption without injection into the grid is implemented through the installation of Net-Metering equipment on land parcels and areas only; installation on industrial areas or rooftops is no longer permitted.

According to Law 5037/2023 the Virtual Net Metering production and consumption facilities may be represented by various suppliers[224]. The previous framework stipulated that both generation and consumption facilities must be represented by the same supplier, except for Net-Metering by Energy Communities connected to Non interconnected Islands. Applications for the issuance of Final Grid Connection Offers (FGCO) for Virtual Net-Metering are subject to the new provisions of the Law 5037/2023 as of 1 July 2023, and Existing Energy Communities cannot submit such applications after 1 November 2023.

Regarding the implementation of Net-Billing and Virtual Net-Billing, the new framework addressed several deficiencies[225]. Net-Billing and Virtual Net-Billing provide for simultaneous consumption n and production in real time and enable self-consumers to sell excess energy at prices determined by fixed tariffs or auctions. All consumers are eligible to register independently or through aggregators for the implementation of a Net-Billing or Virtual Net-Billing facility. Businesses can specifically apply for Virtual Net-Billing but not Virtual Net - Metering. Self-consumers are eligible for operating assistance for the total capacity of excess energy. Until now, operating aid was provided for up to 20% of the total annual electricity production and for up to 75% of the energy produced by PV systems with agricultural use. In contrast with the Net-Metering scheme, there is no capacity limitation per supply consumption in Net-Billing.

Collective Self-Consumption is yet another area where the government has modified the law[226]. Two or more self-consumers (residential or commercial self-consumers) in the same building can now participate in Self-Consumption. The new Collective s Self-Consumption schemes require self-consumes to appoint a

[224] Seiradakis, Y. (2023) Energy briefing special edition, Bernitsas Law. https://bernitsaslaw.com/2023/04/07/energy-briefing-special-edition Accessed 11 October 2023.

[225] HELAPCO (2023) The new regulations of Law 5037/2023 for photovoltaic, self-consumption and Energy Communities. https://helapco.gr/wp-content/uploads/HELAPCO_NewLaw_29Mar2023-2.pdf Accessed 13 October 2023.

[226] RESCHOOL (2023) Empowering communities through collective energy: Coen's first PV Park and energy sharing model, Reschool project. https://www.reschool-project.eu/empowering-communities-through-collective-energy-coens-first-pv-park-and-energy-sharing-model/ Accessed 14 October 2023.

representative and enter into an agreement, the terms of which regulate specific activities such as entry and departure requirements, the required age of majority, and financial matters. Also, the new Collective Self-Consumption schemes can encompass the consumption requirements of a building's common areas.

Lastly, Law 5037/2023 clarified the essential component of Final Grid Connection Offers (FGCO). Under the new framework competent operators may grant FGCOs for Net-Metering and Virtual Net-Metering initiatives a maximum power capacity of 2 GW. No such restriction existed previously. Subject to certain exemptions, the provisions of the Law 5037/2023 apply to pending applications for the issuance of a FGCO, as well as to extant FGCOs and Connection Agreements.

Municipalities, farmers[227], and all Energy Communities who applied for Net-Metering or Virtual Net-Metering prior to 30 June 2023 will either be subject to the new law or exempt upon submission of a relevant declaration to the competent operator, either the Independent Power Transmission Operator (IPTO) or the Hellenic Electricity Distribution Network Operator (HEDNO). All applications that have been submitted after July 1, 2023 shall be subject to Law 5037/2023.
Finally, producers of RES or HECHP with pending or existing FGCOs may amend their Production License, Producer's Certificate, or FGCO, as applicable, to implement a (Virtual) Net-Billing or (Virtual) Net-Metering scheme. The limit is set at 100 percent of the sum of all the mitigating consumptions.

4.5 A clearer route for energy storage projects

As the proportion of renewable energy sources in the energy mix rises the need for energy storage to maintain a balance between the supply and demand of electricity generated by RES also rises. Energy storage will enable better portfolio utilization and predictability for wholesale market participation for investors who generate significant amounts of energy from renewable sources, while also providing greater flexibility in entering into green bilateral agreements (PPAs) with large consumers or electricity suppliers. In this respect, the storage transition is a one-way path for investors who have already built substantial RES portfolios.

Energy storage will also provide a solution to the operators of Greece's and Europe's power systems, who are increasingly experiencing network overload due to excess energy. To avoid overloading the networks, operator either disconnect energy production units[228] or suspend power imports during periods of low demand, such as weekends and holidays, when the production of wind and photovoltaic plants boosts due to weather conditions. This challenge will be

[227] Metaxas & Associates (2023) The New Legislative Provisions on Self-Consumption, Net Metering, and Net Billing: An Initial Legal Assessment. https://www.metaxaslaw.gr/quot-the-new-legislative-provisions-on-self-consumption-net-metering-and-net-billing-an-initial-legal-assessment-quot/ Accessed 12 October 2023.
[228] Fintikakis, G. (2023) We throw away 50% of green energy!, https://energypress.gr/news/petame-sta-skoypidia-50-tis-prasinis-energeias Accessed 12 October 2023.

mitigated to a large part if efficient technologies of energy storage are developed, as well as initiatives to modernize infrastructure.

Initially, the development of renewable energy sources in Greece was not tied to the necessity of energy storage. In recent years, this has changed, initially due to provisions of European law that lead to a corresponding amendment of the Greek legal framework. By passing Law 4685/2020 on May 5, 2020, the Greek government took the first step toward reforming environmental legislation and the RES licensing procedure. A second decisive step was taken with the adoption of Law 4951/2022 modernizing phase B' of the RES. By amending the pertinent provisions of Laws 4001/2011 and 4067/2012, Law 4951/2022 incorporated the provisions of Directive (EU) 2019/944 on the storage of electricity.

Law 4951/2022[229] introduced significant provisions for energy storage projects, reforming the existing regulatory framework and addressing regulatory voids for projects that combine electricity generation and energy storage. The economic feasibility of energy storage initiatives was deemed of the utmost importance, and solutions to problems such as balancing and the management of congested networks were sought. Storage, according to the new paradigm, is defined as the postponement of the final use of electric energy to a time after its production by converting it into a form of energy that can be stored. Storage of such energy and subsequent conversion of said energy into electricity, which is currently considered a type of electricity activity, is subject to RAE license.

The provisions of Law 4951/2022 apply to projects used exclusively for energy storage[230], as well as projects that combine energy storage with the production of electricity from RES or CHP.

Specifically, the activity of electricity storage is permitted for natural or legal persons who have been granted an electricity storage license or who have been legally exempted from this requirement, such as injection power storage stations with a capacity of less than one megawatt (1 MW). The electricity storage permit is granted by RAE for a period of up to twenty-five (25) years and may be extended for an equal period under the terms and conditions outlined in this document and the Storage Permits Regulation. Specifically for pumped storage stations, the storage permit may be issued for up to thirty-five (35) years.

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[229] Law 4951/2022 "Modernization of the licensing process for Renewable Energy Sources -Phase B', Licensing of electricity production and storage, framework for the development of Pilot Marine Floating Photovoltaic Plants and more specific provisions for energy and the protection of the environment" (Government Gazette 129/A/04-07-2022). https://www.taxheaven.gr/law/4951/2022 Accessed 14 October 2023.

[230] Mitsios, S. (2022) Law 4951/2022 - modernization of the licensing process for RES projects & licensing of Energy Storage. Available at: https://www.ey.com/en_gr/tax/tax-alerts/law-4951-2022-modernization-of-the-licensing-process-for-res-projects-and-licensing-of-energy-storage Accessed 10 October 2023.

The law requires Network Operators[231] to treat requests for a final connection offer for stations used primarily for energy storage separately, ensuring that connection conditions are delivered as soon as possible. It, however, continues beyond. Integrated electricity storage stations are further divided into two categories: those capable of storing and utilizing network electricity, and those incapable of doing so. It is explicitly stated that energy storage stations are not authorized to participate in the Electricity Markets or engage into Operating Aid agreements. As mandated by Law 4951/2022, RAE is obligated to uphold an Electronic Energy Storage Register (E.M.A.P.E.) wherein data, applications, procedures, and particulars pertaining to the issuance of electricity storage permits and as specified in the Storage Permits Regulation are recorded.

Documents required for the issuance of storage licenses in accordance with the new legislation must be submitted by holders of valid electricity production licenses within three months of the relevant list being published by RAE. Failure to do so will result in the revocation of the corresponding licenses.Additionally, the new legislation provided increased adaptability. In accordance with the regulations, individuals who are in possession of valid Producer Certificates, Special Projects Certificates, or Electricity Production Licenses issued by RES and CHP and desire to incorporate electricity storage or explore the possibility of storing electricity absorbed by the transmission system or the electricity distribution network may do so in accordance with the standard amendment procedure or the procedure outlined in article 42 of Law 4951/2022. This procedure also applies to the installation of a storage system.[232].

Simultaneously, with the legal amendments came financial incentives for individuals who invest in energy storage. The Greek government submitted a proposal to the European Commission[233], which was approved, and which calls for the construction of multiple electricity storage facilities with a combined capacity of up to 900 megawatts and connection to the high-voltage grid. According to this plan, the projects will be selected through a transparent and non-discriminatory bidding procedure, contracts will be awarded to the selected projects by the end of 2023, and the storage facilities will be finished by the end of 2025.

The aid will be granted cumulatively in the form of an investment grant, which will be paid during the construction phase of all supported projects, and annual support, which will be paid during the operation phase of the projects for a period of 10

[231] HEDNO (2022) 3rd Hedno announcement in Application of Law 4951/2022 (GG 129/A/04.07.2022). https://deddie.gr/en/themata-stathmon-ape-sithia/sundeseis-stathmwn-ananewsimwn-pigwn-energeias-ape/anakoinwseis/3i-anakoinosi-se-efarmogi-fek/ Accessed 11 October 2023.

[232] Dagoumas, A. (2022) Legal and Regulatory Developments on Energy Storage. https://www.iene.eu/articlefiles/inline/dagoumas%20e%20&%20a%202023.pdf. Accessed 14 October 2023).

[233]European Commission (2022) State aid: Commission approves Greek scheme under Recovery and Resilience Facility to support development of electricity storage facilities, European Commission - European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_4582. Accessed 09 October 2023.

years. According to the Greek plan[234], the total quantity of annual support per beneficiary will be determined through a competitive bidding process and adjusted through a claw-back mechanism if the project generates excess market revenues during the operations phase.

4.6 An entirely novel model for offshore wind farm development

Following the energy crisis triggered by Russia's invasion of Ukraine, countries in the EU and throughout the world are increasing their efforts to safeguard their energy capacity while minimizing their dependency on external sources. According to the Global Wind Energy Council (GWEC), cumulative installed offshore wind capacity will top 205 GW globally in 2030 [235], from 110 GW in 2023[236]. Offshore wind energy is receiving international attention due to its high capacity and low-cost technologies. And the benefits of this technology are numerous. At sea, the winds are blowing forcefully and continually. Implementing windfarms at sea, away from the coast and away from any wind interference, means more generation capacity. It also has a lower environmental impact because wind farms are being placed further and further away from the horizon line.Offshore wind solutions can thus fulfill rising electricity demand and are viewed as important to the energy transition to a carbon-neutral economy.

The European Union[237] has committed to a fivefold increase in offshore wind energy production by 2030. The EU strategy calls for elevating Europe's offshore wind capacity from 12 GW to at least 60 GW by 2030 and 300 GW by 2050. This ambitious expansion will be based on the huge potential of all of Europe's sea basins, as well as the sector's global leadership position held by EU enterprises.
With 15,147 kilometers of coastline, Greece had no alternative but to participate in this undertaking. In the past three years, the Greek government has demonstrated its support for offshore wind to play a significant role in the energy transition and to prevent repeating past mistakes (Greece has no offshore wind generation at present)[238]. Estimates show that Greece's offshore wind energy goals will bring in

[234] European Commission (2022b) State Aid SA.64736 – RRF - Greece - Financial support in favour of electricity storage facilities. https://ec.europa.eu/competition/state_aid/cases1/202240/SA_64736_400E7A83-0000-C599-B417-2392BF680950_60_1.pdf . Accessed 09 October 2023.
[235] Liu, M. et al. (2022) 'Towards resilience of offshore wind farms: A Framework and application to Asset Integrity Management', Applied Energy, 322, p. 119429. doi:10.1016/j.apenergy.2022.119429.
[236] Whitlock, R.E.M. (2023) Bloomberg reports global wind installations to sustain double-digit growth in 2024-26. https://www.renewableenergymagazine.com/wind/global-wind-installations-to-sustain-doubledigit-growth-20230712. Accessed 15 October 2023.
[237] European Commission (2020) Boosting Offshore Renewable Energy for a Climate Neutral Europe, European Commission - European Commission. https://ec.europa.eu/commission/presscorner/detail/en/IP_20_209. Accessed 15 October 2023.
[238] International Energy Agency (2023) Energy Policy Review, Greece 2023. https://iea.blob.core.windows.net/assets/7b570018-82d5-4ea3-b1ad-806234b7b184/Executivesummary-WorldEnergyOutlook2023.pdf. Accessed 01 July 2023.

6 billion (EUR 28 billion by 2050) in private investments and create more than 8000 new direct and indirect jobs by 2030[239].

In August 2022[240], the Greek parliament approved the country's first Offshore Wind Law, which aims for 2 GW of offshore wind capacity by 2030. The law appoints the state-owned exploration company Hellenic Hydrocarbons and Energy Resources Management Company (HEREMA) [241] to lead site investigation, allocation and concession development and makes the electricity TSO responsible for providing the onshore and offshore grid infrastructure to support offshore wind deployment.

Under the law, the Ministry of Environment and Energy will adopt a series of decrees to fully define offshore deployment locations and the process for selecting projects and awarding funding. As part of this work, the government will commission environmental impact assessments to define broad offshore wind development areas and will then assign installation zones within these areas. Holders of an Offshore Wind Farm Exploration License may conduct research, technical studies, and measurements required for the design, development, installation, and operation of Offshore Wind Farm Projects (OWF) in each OWF Organised Development Area (OWFODA).These zones will be defined in consultation with key stakeholders, including the military[242], fisheries, the tourism industry and the public Project developers will be able to apply for non-exclusive research permits for the broader offshore wind development areas to undertake resource assessments and seabed surveys. Within the Offshore Wind Farm Organised Development Areas (OWFODA), the Hellenic Republic is solely responsible for the exploration, search for, and identification of Offshore Wind Farm Organized Development Areas and OWF Installation Areas, as well as the concession of exploration and exploitation rights for OWF Projects.

The first round of applications for these permits should take place from 2023 to 2024. Only developers with a research permit will be eligible to bid in offshore wind auctions, with the first auctions potentially taking place in 2025 or 2026. Law 4964/2022 mandates that, within two years of the conclusion of the first round of OWF Exploration License applications, the OWF Body shall hold public consultations on the OWF Installation Areas of each OWF Organised Development Area. Within four months of the decision on the allocation of the OWF Installation Areas within the Offshore Wind Farm Organised Development Areas (OWFODA) for which OWF Exploration Licenses have been issued, and on

[239] Delagrammatikas, G. and Roukanas, S. (2023) 'Offshore Wind Farm in the Southeast Aegean Sea and energy security', Energies, 16(13), p. 5208. doi:10.3390/en16135208.
[240] Law 4964/2022 (Government Gazette A' 150/30.07.2022) https://www.kodiko.gr/nomothesia/document/811946/nomos-4964-2022 Accessed 10 October 2023.
[241] Liaggou, C. (2023) Where will the first offshore wind farms be built? https://www.kathimerini.gr/economy/562411642/poy-tha-ginoyn-ta-prota-yperaktia-aiolika-parka/. Accessed 16 October 2023.
[242] Floudopoulos , H. (2023) EDEYEP study: Offshore wind farms are coming, Capital.gr. https://www.capital.gr/oikonomia/3716700/meleti-edeuep-erxontai-ta-offshore-aiolika/. Accessed 16 October 2023.

the maximum capacity of OWF Projects estimated for each one, the Regulatory Authority for Energy will launch a competitive bidding process for the granting of operating aid to OWF Projects to be developed within the OWF Installation Areas defined by the aforementioned decision.

Selected bidders will acquire an exclusive right to construct and operate an offshore wind farm in the auctioned zone. The criterion for selecting the OWF Investor is the lowest offer price in euros per megawatt-hour for the compensation of the electricity produced by the OWF Project developed within the particular OWF Installation Area. RAE will decide on the competitive tendering procedure in order to define and further specify the participation and evaluation criteria. OWF Projects included in a support framework in the form of Operating Aid will enter into a Sliding Premium Operating Aid Contract governed by the Reference Tariff (RT) resulting from the corresponding bid submitted in a competitive procedure for the selected OWF Installation Area. The duration of the Sliding Premium Operating Aid Agreement is twenty years.

Law 5037/2023[243] made additional modifications and enhancements to the legal framework for offshore wind farms by delineating their initial growth area. In particular, Article 164 of law 5037/2023 states, "The marine territory that extends south of the coastline of the Evros Regional Unit and north-northeast of Samothraki is defined as an OWP pilot project development area, for OWPs projects with a total capacity of up to 600 MW. A portion of the area is designated as an Area of Organized Development OWPs, while another portion is designated as a First Choice Area (i.e., in accordance with the European directives for the "go-to-areas" for the rapid deployment of new installations for the production of energy from renewable sources. In addition, the law provides that, "the estimated maximum power of OWPs Projects that can be installed in each OWF installation area cannot be less than 200 MW". Given that most Greek waters have depths greater than 50 meters, a significant proportion of the offshore wind development in the Area of Organized Development OWPs will require floating wind turbines.[244].

4.7 Modest developments in renewable hydrogen production

The "Fit for 55" European climate-neutrality policy, which aims to reduce CO2 emissions by 55 percent by 2030, identifies renewable hydrogen and low-emissions hydrogen as crucial means of gradually replacing fossil natural gases in the European energy mix. To attain these objectives, the European Commission proposed a "Hydrogen and decarbonized gas package"[245] in December 2021. In

[243] Delagrammatikas, G. and Roukanas, S. (2023) 'Offshore Wind Farm in the Southeast Aegean Sea and energy security', Energies, 16(13), p. 5208. doi:10.3390/en16135208.
[244] Liaggou, C. (2022) Floating wind turbines to be made in Greece, eKathimerini.com. https://www.ekathimerini.com/economy/1184147/floating-wind-turbines-to-be-made-in-greece/. Accessed 16 October 2023.
[245] European Commission (2021) Proposal for a Directive of the European Parliament and of the Council on common rules for the internal markets in renewable and natural gases and in hydrogen. https://eur-

typical European Commission fashion, the document states that "all decarbonisation scenarios show that clean hydrogen, in particular renewable, will play an important role in the not too distant future – it is thus not a question of whether but a question of when precisely this will happen".

In this context the European Commission's package aims to establish a hydrogen market with adequate infrastructure and cross-border cooperation, including interconnectors, via which hydrogen can be channeled at a low cost. It is anticipated that existing gas networks can be partially modified to carry hydrogen[246], saving significant money over the building of new infrastructure. National regulators will play a critical role in the development of this internal market, as they will be tasked with promoting cross-border hydrogen flows. The adoption of basic regulatory concepts comparable to those in the gas market but adapted to the hydrogen market is a critical element guiding the design of hydrogen markets. As a result, a hydrogen network operator, a hydrogen storage operator, and a hydrogen terminal operator should be appointed.

The European Commission made efforts to speed up procedures. With the adoption of two Delegated Acts, as mandated by the Renewable Energy Directive, the Commission has proposed in February 2023[247] specific rules to define what constitutes renewable hydrogen in the EU. The purpose of these Acts was to assure that all RFNBOs[248] (renewable fuels of non-biological origin) are produced from renewable electricity. According to the designers of these policies, the two Acts are interdependent and required for the fuels to be counted towards the renewable energy objective of Member States. In accordance with the REPowerEU Plan, the objective of the intervention is to provide regulatory certainty to investors as the EU strives to attain 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of renewable hydrogen imports. In June 2023[249], following the conclusion of the period of scrutiny by the European Parliament and Council, the Commission formally published two Delegated Acts outlining detailed regulations on the EU definition of renewable hydrogen.

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lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ%3AL%3A2011%3A304%3A0018%3A0063%3AEN%3APDF. Accessed 17 October 2023.

[246] Findlay, C. (2020) Can gas lines and other existing infrastructure handle hydrogen? https://www.siemens-energy.com/global/en/news/magazine/2020/repurposing-natural-gas-infrastructure-for-hydrogen.html. Accessed 15 October 2023.

[247] European Commission (2013) Commission sets out rules for renewable hydrogen. https://ec.europa.eu/commission/presscorner/detail/en/IP_23_594. Accessed 16 October 2023.

[248] European Commission (2023) Questions and Answers on the EU Delegated Acts on Renewable Hydrogen. https://ec.europa.eu/commission/presscorner/detail/en/qanda_23_595 Accessed 16 October 2023.

[249] European Commission (2023) Renewable hydrogen production: new rules formally adopted. https://energy.ec.europa.eu/news/renewable-hydrogen-production-new-rules-formally-adopted-2023-06-20_en. Accessed 16 October 2023.

The first Delegated Act[250] specifies the conditions under which hydrogen, hydrogen-based fuels, and other energy carriers may be regarded as RFNBOs. The Act clarifies the principle of "additionality" for hydrogen as outlined in the Renewable Energy Directive of the European Union. Hydrogen-producing electrolyzers must be connected to new renewable electricity generation[251]. This principle seeks to ensure that the production of renewable hydrogen increases the amount of renewable energy available to the grid. In this way, the production of hydrogen will aid in decarbonization and complement electrification efforts, while alleviating pressure on the generation of electricity. The Commission has estimated that approximately 500 TWh of renewable electricity is required to achieve the REPowerEU goal of producing 10 million tonnes of RFNBOs by 2030[252]. The 10 Mt target for 2030 is equivalent to 14% of the total EU electricity consumption. This aspiration is reflected in the Commission's proposal to increase the renewable energy objective for 2030 to 45 percent. Nonetheless, the Commission offered flexibility. The Delegated Act specifies various methods for producers to demonstrate that the renewable electricity used for hydrogen production complies with regulations. It also establishes criteria to ensure that renewable hydrogen is produced only “when and where sufficient renewable energy is available”[253].

To accommodate existing investment commitments and permit the sector to adjust to the new framework, the rules will be phased in gradually and tailored to become increasingly stringent over time. Specifically, the rules provide for a transitional phase of "additionality" requirements for hydrogen programs that begin operations before January 1, 2028. This transitional period corresponds to the time when electrolysers will be commercialized and scaled up. However, beginning on 1 July 2027, Member States will have the option to implement stricter rules regarding temporal correlation. In addition, until January 1, 2030, hydrogen producers will be able to match their monthly hydrogen production with their contracted renewables.The second Delegated Act proposes a technique for calculating RFNBOs' life-cycle greenhouse gas emissions[254]. The methodology takes into account greenhouse gas emissions throughout the fuel's entire lifecycle, including upstream emissions, emissions from acquiring power from the grid, emissions from processing, and emissions from delivering these fuels to the end user. Furthermore, the approach explains how to calculate the greenhouse gas emissions

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[250] European Commission (2023) Lex - 32022R0720 - en - EUR-Lex. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022R0720. Accessed 16 October 2023.
[251] International Energy Agency (2023) Electrolysers . https://www.iea.org/energy-system/low-emission-fuels/electrolysers. Accessed 17 October 2023.
[252] Spasić, V. (2023) EU opens door for putting low-carbon label on hydrogen produced from Nuclear Power, Balkan Green Energy News. https://balkangreenenergynews.com/eu-opens-door-for-putting-low-carbon-label-on-hydrogen-produced-from-nuclear-power/. Accessed 17 October 2023.
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of renewable hydrogen or its derivatives when produced in conjunction with fossil fuels.

Greece acted fast to align with EU policies. Specific targets for the generation of green hydrogen were set in the Ministry of Environment and Energy's National Energy and Climate Plan, which was unveiled in January 2023[255]. By 2030, 1.2 GW of electrolysis capacity is expected to create 205,000 tons of green hydrogen. In 2035, electrolysis capacity will expand to 2.4 GW, and hydrogen output will climb to 0.5 Mt. The goal is to increase electrolysis capacity to 6 GW by 2040 and hydrogen output to 1 Mt. The strategy will be founded on five pillars, beginning with the production and distribution of hydrogen and renewable gases, moving on to the utilization of hydrogen and biogas, and concluding with the regulatory framework. There will also be provisions for research and development. Additionally, the strategy will be divided into three phases: Phase A relates to the period 2022-2027, during which state aid will be required for the development of hydrogen infrastructure; Phase B relates to the period 2027-2030, during which pilot projects will begin to be implemented in Greece[256], with the State maintaining a central role with an emphasis on incentives (tax and aid); and Phase C relates to the period after 2030, during which private initiative will play a role

Five[257] Greek initiatives have been selected as "Hydrogen" Important initiatives of Common European Interest (IPCEI) as early as 2021. The following are the projects:

- Blue Med[258]: The project entails the production of blue hydrogen and green hydrogen with extremely low carbon emissions by 2025. The initiative calls for the establishment of a blue and green H2 integrated production cycle cluster for transportation, distribution, and use in industry and transportation (buses and ships). In addition to Motor Oil, DESFA, and PPC, Greek research institutions are anticipated to participate in the endeavor.

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[258] Kalogirou, A. (2021) Motor Oil: Hydrogen at the heart of its strategy - Plans for Blue Med. https://www.imerisia.gr/epiheiriseis/24586_motor-oil-ydrogono-sto-epikentro-tis-stratigikis-tis-ta-shedia-gia-blue-med. Accessed 18 October 2023.

- Green HIPo [259]: Project of Advanced Energy Technologies (Advent Technologies) to construct an innovative electrolytes and fuel cell production facility. Advent intends to manufacture CHP fuel cells for Project White Dragon. The production will occur on the company's Western Macedonia production line.
- White Dragon: Cluster of initiatives for the production of green hydrogen in Western Macedonia via electrolysis of solar energy and distribution via the DESFA network and TAP pipeline. Participating in the initiative are DEPA Commercial S.A. (as coordinator), Advent Technologies S.A., COPELOUZOS GROUP (Damco ENERGY S.A.), Corinth Pipeworks S.A., TAP AG, DESFA, TERNA Energy SA, Hellenic Petroleum, MOTOR-OIL Group, and PPC. However, the €8 billion proposal was eliminated from European projects in June 2022[260].
- H2CAT TANKS[261]: Is an initiative of B&T Composites (TIRIAKIDIS VASILEIOS AETE) for the construction of innovative high-pressure tanks made of composite materials and carbon fibres to store hydrogen for the transportation industry.
- H2CEM - TITAN[262]: This project entails the production, storage, and use of green hydrogen for combustion to generate energy in kilns in an effort to decarbonize TITAN's cement plants.

The objective of Greece's participation in the first wave of IPCEI "Hydrogen" is to mark the commencement of a local hydrogen economy by implementing qualifying projects and linking them to an expanding pan-European hydrogen value chain[263]. This will be achieved by simultaneously constructing industrial-scale hydrogen production, processing, storage, and transport facilities and generating internal demand, commencing with energy-intensive industrial consumers and progressing to the transportation and marine sectors.

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[261] Mason, H. (2022) B&T Composites joins R&D project to develop novel composite hydrogen storage tanks. https://www.compositesworld.com/news/bt-composites-joins-rd-project-to-develop-novel-composite-hydrogen-storage-tanks. Accessed 17 November 2023.

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Chapter 5: Thesis conclusions

Over the past decade, there has been a significant increase in the adoption of renewable energy sources across the European Union. This growth can largely be credited to the enforcement of governmental legislation at both national and European levels[264], as well as huge expenditures from both public and private entities. However, the distribution of its expansion continues to exhibit inequality. This matter is linked to other consequential variables, which can be classified into two distinct domains: political and economic. From a political perspective, the presence of narrow-minded, often fragmented, and complex policies might pose difficulties in the decision-making process, thereby discouraging possible investors and prospective stakeholders.

From an economic standpoint, the presence of economic issues and the Covid-19 pandemic has led to a slowdown in incentives and investments[265]. However, there is prevalent a broad acknowledgment of the importance of renewable energy sources, both in the domain of politics and within corporate entities. There exists a collective recognition of the imperative to optimize existing legal frameworks and regulatory measures, alongside fostering the broad adoption and dissemination of cutting-edge, technologically sophisticated solutions that are economically viable and operationally effective.

This Master Thesis provides evidence that the European Union has the capacity to achieve energy self-sufficiency by improving and expanding its energy infrastructure, as well as adopting plant conversion techniques. The analysis provides evidence that directing resources towards renewable energy sources leads to favorable effects in the realms of social and employment.

This investment enables the expansion of ecologically sustainable employment options, hence offering substantial potential for economic growth in rural areas that often face challenges related to population decline and limited work alternatives. However, a significant issue revolves around the source of finance and the challenges associated with obtaining it. Undoubtedly, the implementation of a new energy infrastructure requires significant initial investments, which are then recovered over a prolonged period through the process of amortization. In this context, it is crucial for policymakers to aggressively endorse the expansion of renewable communities as a strategy to promote empowerment and enhance awareness.

The desired outcome can be attained by employing tax incentives, feed-in tariffs, and regulatory actions. Furthermore, another noteworthy aspect concerns investments in research and development (R&D) and the necessity of promoting and facilitating the

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[265] Adedoyin, F.F. et al. (2023) 'Energy policy simulation in times of crisis: Revisiting the impact of renewable and non-renewable energy production on environmental quality in Germany', Energy Reports, 9, pp. 4749–4762. doi:10.1016/j.egyr.2023.03.120.

widespread adoption of economically viable, highly effective, readily deployable, low-maintenance, and significantly improved electrical capacity technologies. The measures that policy makers prioritize in their efforts to promote the transition towards a low-carbon future and achieve the lofty targets set by the European Union[266] are the key areas of focus.

In conclusion, the analysis provides significant insights that could potentially guide policymakers in their decision-making pursuits. Firstly, this study provides actual evidence that supports the economic and societal benefits that result from devoting resources towards renewable energy. This serves as a justification for further investments in this field. Furthermore, this highlights the intricate nature of obtaining sufficient financial resources and highlights the imperative role of government interventions in facilitating the expansion of renewable communities through focused strategies that are both effective and influential. Furthermore, it emphasizes the importance of dedicating resources to research and development initiatives to promote the progress and widespread adoption of cost-effective and highly efficient technologies. The adoption of renewable energy sources is often impeded by the slow progress associated with the technological complexities of new patents, which requires a substantial time commitment before they can achieve optimal functionality.

The analysis revealed that the progress of renewable energy development and the factors hindering this progress differ among various regions within the European Union, indicating that it is not suitable to view the European Union as a uniform territory in this context. The results of the analysis showed that there was no statistically significant correlation between the presence of barriers to the growth of renewable energy sources in the European Union and the fluctuations in the share of renewables in energy consumption[267].

When examining long-term trends, limitations including political, administrative, commercial, and economic hurdles significantly impacted the ability of renewable energy sources to contribute to energy consumption. After examining specific countries, substantial correlations and implications of the restraints on the progress of renewable energy sources were identified.

To accelerate the use of renewable energy, it is crucial to simplify administrative procedures, enhance environmental planning, and lower costs in these sectors. Renewable energy sources have faced challenges in their development within the electricity system, especially in regions like Southern-Central Europe and Greece[268].

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[267] Shivakumar, A. et al. (2019) 'Drivers of renewable energy deployment in the EU: An analysis of past trends and projections', Energy Strategy Reviews, 26, p. 100402. doi:10.1016/j.esr.2019.100402.

[268] Alexandros Nikas, Vassilis Stavrakas, Apostolos Arsenopoulos, Haris Doukas, Marek Antosiewicz, Jan Witajewski-Baltvilks, Alexandros Flamos, Barriers to and consequences of a

Obstacles included sluggish progress in building grid infrastructure, intricate procedures for grid connection, and exorbitant connection prices. It is crucial to tackle these issues in order to fully realize the promise of renewable energy in these regions.

In addition to improved support systems for creators, increased public funding for research and development will be essential for fostering innovation in renewable energy technology and promoting sustainable economic growth across the European Union. Administrative procedure constraints exert a substantial influence on the adoption of renewable energy sources in the majority of European Union member states, with limitations spanning from moderate to extreme. The influence of social development levels on the share of renewable energy sources in overall energy consumption is substantial, given the limitations imposed by market economics. Social development that was inadequate impeded progress[269].

Administrative barriers significantly impacted the economics of less prosperous European Union member states. Countries where a significant or swiftly growing portion of their energy supply was obtained from renewable sources were profoundly impacted by the surplus capacity in the renewable market[270]. The grid infrastructure in Southern-Central European countries, particularly Greece, presents substantial obstacles to the advancement of renewable energy sources[271]. The hurdles consist of slow advancement in infrastructure construction, intricate processes for linking renewable energy sources to the grid, and expensive grid connection charges.

From this research, various practical suggestions have arisen for policymakers to advance renewable energy and address the challenges. Promoting socioeconomic progress should be accorded considerable importance, specifically by addressing the eradication of administrative barriers and the stimulation of economic development in less developed economies. This can be accomplished through the optimization and duration reduction of environmental planning procedures. It is crucial that developed nations give utmost importance to the mitigation of excess capacity within the renewable energy industry.

An additional conclusion can be made regarding the lack of comprehensive research conducted on the condition of barriers across all member states of the European Union, which would have facilitated the tracking of developments in this field of study. The existing body of literature does not adequately address the substantial impact that socioeconomic factors exert on the progress of renewable energy sources

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and the degree of achievement that member states attain in meeting target indicators. The statistical analysis of the aforementioned obstacles in RES underscores the significance of taking into account the variations and requirements of distinct country groups during the formulation of strategies to surmount these challenges.
Barriers to the development of a diverse energy system are eliminated in accordance with the implementation of renewable energy source legislation in EU member states. Although EU regulations govern the entire European Union, the analysis revealed that obstacles to the development of renewable energy sources vary by region within the EU[272]. Distinct hurdles or causes that hinder the advancement of renewable energy sources are specific to particular areas or nations within Europe. More focus should be placed on the barriers that impede the progress of renewable energy infrastructure and technology when creating specific regulations.

The endeavors initiated in recent times signify a significant progression towards the intended goal. Nevertheless, their influence on climate policy[273] will remain constrained until significant obstacles are successfully eliminated in subsequent periods. In order to attain optimal results, it is imperative to consistently execute energy sector reform initiatives and augment public expenditure on research and development, which should encompass domestic funds as well. Furthermore, it is critical to further enhance the resources available to innovators and implement the insights obtained from recent past endeavors. This research endeavor, similar to others, is bound by certain limitations.

Along with the constraints connected with data accessibility, the primary limitation is the annual monitoring of barriers to the penetration of renewable energy sources in EU member states, which is necessary for further evaluation. This also pertains to Greece, where the difficulties have been occasionally exacerbated by the legacies of high emission intensity, constrained fiscal space, rent-seeking practices, and limited private financing.

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