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Strategic Analysis of Offshore Wind Farm Development versus Hydrocarbon Extraction South of Crete: A Comparative Study for Greece's Sustainable Energy Strategy

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Konstantinos Gkaidatzoglou

Abstract

The global transition towards low-carbon energy systems has intensified the debate regarding the optimal allocation of resources between renewable energy technologies and conventional hydrocarbon development. This dissertation examines this strategic dilemma through a comparative analysis of two alternative energy development pathways in the offshore area south of Crete: offshore wind farm development and hydrocarbon extraction. The study is conducted within the broader context of Greece's energy transition, European climate policy objectives, and the increasing importance of energy security following recent geopolitical developments.

The research adopts a qualitative comparative approach based exclusively on secondary data obtained from academic literature, international energy organisations, European Union policy documents, and national energy planning frameworks. Offshore wind and hydrocarbon development are evaluated using a common analytical framework, incorporating technical, economic, environmental, and strategic dimensions. SWOT and PESTEL analyses are employed to provide a structured comparison of the opportunities, challenges, strengths, weaknesses, and external factors associated with each development pathway.

The findings indicate that offshore wind development offers strong long-term advantages in terms of sustainability, alignment with European decarbonisation targets, reduced greenhouse gas emissions, and enhanced energy independence. The analysis also highlights the significant offshore wind potential of the region, particularly through the application of floating wind technologies suitable for the deep-water conditions south of Crete. Conversely, hydrocarbon extraction may provide short- to medium-term economic benefits, strengthen domestic energy production, and contribute to energy security. However, it is associated with considerable environmental risks, long-term regulatory uncertainty, and limited compatibility with future climate objectives.

The study concludes that offshore wind development represents the most sustainable and strategically consistent option for Greece's long-term energy future. While hydrocarbons may play a transitional role in supporting energy security, offshore renewable energy offers

greater potential to support economic development, environmental sustainability, and compliance with European energy and climate policies.

Keywords

Offshore Wind Energy, Hydrocarbon Extraction, Energy Transition, Energy Security, South of Crete, Sustainable Development.

Στρατηγική Ανάλυση της Ανάπτυξης Υπεράκτιου Αιολικού Πάρκου έναντι Εξόρυξης Υδρογονανθράκων Νότια της Κρήτης: Συγκριτική Μελέτη για τη Βιώσιμη Ενεργειακή Στρατηγική της Ελλάδας

Κωνσταντίνος Γκαϊδατζόγλου

Περίληψη

Η παγκόσμια μετάβαση προς ενεργειακά συστήματα χαμηλών εκπομπών άνθρακα έχει εντείνει τη συζήτηση σχετικά με τη βέλτιστη αξιοποίηση των διαθέσιμων ενεργειακών πόρων μεταξύ των ανανεώσιμων πηγών ενέργειας και της συμβατικής εκμετάλλευσης υδρογονανθράκων. Η παρούσα μεταπτυχιακή εργασία εξετάζει αυτό το στρατηγικό δίλημμα μέσω μιας συγκριτικής ανάλυσης δύο εναλλακτικών ενεργειακών αναπτυξιακών σεναρίων στην υπεράκτια περιοχή νότια της Κρήτης: της ανάπτυξης υπεράκτιων αιολικών πάρκων και της εξόρυξης υδρογονανθράκων. Η μελέτη πραγματοποιείται στο ευρύτερο πλαίσιο της ενεργειακής μετάβασης της Ελλάδας, των ευρωπαϊκών κλιματικών πολιτικών και της αυξανόμενης σημασίας της ενεργειακής ασφάλειας λόγω των πρόσφατων γεωπολιτικών εξελίξεων.

Η έρευνα ακολουθεί ποιοτική συγκριτική προσέγγιση και βασίζεται αποκλειστικά σε δευτερογενή δεδομένα που προέρχονται από επιστημονική βιβλιογραφία, διεθνείς ενεργειακούς οργανισμούς, έγγραφα πολιτικής της Ευρωπαϊκής Ένωσης και εθνικά ενεργειακά σχέδια. Τα δύο ενεργειακά σενάρια αξιολογούνται μέσω ενός κοινού αναλυτικού πλαισίου που περιλαμβάνει τεχνικές, οικονομικές, περιβαλλοντικές και στρατηγικές διαστάσεις. Επιπλέον, εφαρμόζονται οι αναλύσεις SWOT και PESTEL για τη συστηματική αξιολόγηση των πλεονεκτημάτων, αδυναμιών, ευκαιριών, απειλών και εξωτερικών παραγόντων που επηρεάζουν κάθε αναπτυξιακή επιλογή.

Τα αποτελέσματα δείχνουν ότι η ανάπτυξη υπεράκτιων αιολικών πάρκων παρουσιάζει σημαντικά μακροπρόθεσμα πλεονεκτήματα όσον αφορά τη βιωσιμότητα, τη συμβατότητα με τους ευρωπαϊκούς στόχους απανθρακοποίησης, τη μείωση των εκπομπών αερίων του

θερμοκηπίου και την ενίσχυση της ενεργειακής ανεξαρτησίας. Παράλληλα, αναδεικνύεται το σημαντικό δυναμικό υπεράκτιας αιολικής ενέργειας της περιοχής, ιδιαίτερα μέσω της αξιοποίησης πλωτών τεχνολογιών κατάλληλων για τα μεγάλα θαλάσσια βάθη νότια της Κρήτης. Αντίθετα, η εκμετάλλευση υδρογονανθράκων ενδέχεται να προσφέρει βραχυπρόθεσμα και μεσοπρόθεσμα οικονομικά οφέλη, να ενισχύσει την εγχώρια παραγωγή ενέργειας και να συμβάλει στην ενεργειακή ασφάλεια. Ωστόσο, συνοδεύεται από σημαντικές περιβαλλοντικές προκλήσεις, υψηλό βαθμό αβεβαιότητας και περιορισμένη συμβατότητα με τους μακροπρόθεσμους κλιματικούς στόχους.

Η μελέτη καταλήγει στο συμπέρασμα ότι η ανάπτυξη υπεράκτιας αιολικής ενέργειας αποτελεί τη βιωσιμότερη και στρατηγικά πιο συνεπή επιλογή για το μακροπρόθεσμο ενεργειακό μέλλον της Ελλάδας. Παρότι οι υδρογονάνθρακες ενδέχεται να διαδραματίσουν έναν μεταβατικό ρόλο στην ενίσχυση της ενεργειακής ασφάλειας, οι ανανεώσιμες πηγές ενέργειας προσφέρουν μεγαλύτερες προοπτικές για οικονομική ανάπτυξη, περιβαλλοντική βιωσιμότητα και συμμόρφωση με τις ευρωπαϊκές ενεργειακές και κλιματικές πολιτικές.

Λέξεις – Κλειδιά

Υπεράκτια Αιολική Ενέργεια, Υδρογονάνθρακες, Ενεργειακή Μετάβαση, Ενεργειακή Ασφάλεια, Νότια Κρήτη, Βιώσιμη Ανάπτυξη.

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List of Abbreviations & Acronyms

Abbreviation	Definition
CAPEX	Capital Expenditure
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EU	European Union
GDP	Gross Domestic Product
GW	Gigawatt
GWEC	Global Wind Energy Council
HCMR	Hellenic Centre for Marine Research
HEREMA	Hellenic Hydrocarbons and Energy Resources Management Company
HOU	Hellenic Open University
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPTO	Independent Power Transmission Operator
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
LNG	Liquefied Natural Gas
LCOE	Levelized Cost of Electricity
MW	Megawatt
NECP	National Energy and Climate Plan
NPV	Net Present Value
OWFODA	Offshore Wind Farm Organised Development Areas
PAHs	Polycyclic Aromatic Hydrocarbons
PESTEL	Political, Economic, Social, Technological, Environmental and Legal Analysis
RES	Renewable Energy Sources

Abbreviation	Definition
REPowerEU	Recovery and Resilience Plan for European Energy Independence
RCREEE	Regional Centre for Renewable Energy and Energy Efficiency
SEIA	Strategic Environmental Impact Assessment
SPA	Special Protection Area
SWOT	Strengths, Weaknesses, Opportunities and Threats
TFB	Thrust and Fold Belt
TPH	Total Petroleum Hydrocarbons
TWh	Terawatt-hour

1. Introduction

1.1 Global Energy Transition

The global energy landscape is currently experiencing a significant transformation, characterized by a transition from reliance on fossil fuels to the adoption of renewable and low-carbon energy sources. This shift is primarily driven by pressing concerns related to climate change and the imperative for sustainable development. In addition, the rising levels of carbon dioxide in the atmosphere, primarily resulting from extensive fossil fuel consumption, have increased awareness of the risks associated with global warming. These environmental issues carry far-reaching economic and social implications, underscoring the need for a sustainable energy future. As a result, governments and international organizations have placed decarbonisation at the center of energy policy and long-term development strategies (IEA, 2023). Decarbonisation is the gradual reduction of carbon intensity in energy systems through the transition from fossil fuels to low-carbon and renewable alternatives. This transition is strongly supported by international agreements, such as the Paris Agreement, and by regional policy frameworks, including the European Green Deal, which aims to achieve climate neutrality by 2050 (European Commission, 2020b; Faraggiana et al., 2024).

Within this context, renewable energy sources such as wind, solar, and hydropower are expected to play a pivotal role in shaping future energy systems, gradually replacing traditional hydrocarbons as the primary sources of electricity generation. Among these, offshore wind energy has gained increased significance as a key component of the global energy transition. Offshore wind development, in particular, offers several advantages, including stronger and more consistent wind resources compared to onshore sites, as well as the potential for large-scale energy output with minimal land footprint. Recent technological innovations, such as floating wind turbines, have expanded the geographic applicability of offshore wind projects, making them feasible in deeper waters. This advancement enhances their strategic importance for nations with limited shallow coastal zones, positioning offshore wind as an integral element of sustainable energy strategies (Barooni et al., 2023; IRENA, 2021; WindEurope, 2023).

Furthermore, offshore renewable energy plays a significant role not only in reducing emissions but also in enhancing energy security and diversification. By decreasing reliance on imported fossil fuels, nations can improve the resilience of their energy systems while advancing environmental and sustainability goals. As global energy demand continues to escalate, offshore wind energy is increasingly acknowledged as a scalable and dependable solution that supports both economic development and climate objectives (IEA, 2023; IRENA, 2021).

1.2 Greece's Energy Framework and Strategic Challenges

At the European level, the transition toward a low-carbon energy system is guided by comprehensive policy frameworks such as the European Green Deal, which aims to achieve climate neutrality by 2050 (European Commission, 2020b). This strategy is supported by intermediate targets under the "Fit for 55" package, which seeks to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels (European Commission, 2021). Within this policy environment, renewable energy deployment—particularly in the power sector—has become a central priority, with offshore energy identified as a key pillar for achieving large-scale decarbonisation across Member States.

Greece has made notable progress in the development of renewable energy over the past decade, particularly in onshore wind and solar photovoltaic installations. According to recent national energy planning documents, the share of renewables in electricity generation has increased significantly, contributing to a long-term reduction in lignite-based power production (Ministry of Environment and Energy, 2024). The recent energy crisis, triggered by the COVID-19 pandemic and ongoing geopolitical instability in energy markets, has temporarily increased the reliance on lignite. This shift reflects Greece's efforts to bolster energy security and decrease its dependence on imported natural gas.

Despite this progress, Greece remains partly dependent on energy imports, particularly for fossil fuels, exposing the country to price volatility and external supply risks. At the same time, offshore wind development in Greece is still at an early stage, with most projects currently under planning or licensing phases rather than in operation (Ministry of Environment and Energy, 2024). This section underscores the discrepancy between Greece's substantial offshore renewable energy potential and the limited extent of its actual deployment. Such a gap emphasizes the critical need for strategic decision-making concerning future energy investments. As the energy landscape continues to evolve, countries like Greece are compelled to assess alternative development pathways that can effectively balance economic performance, energy security, and environmental sustainability (IEA, 2023).

1.3 Topic Selection and Focus on South of Crete

Despite the increasing emphasis on renewable energy and long-term decarbonization targets, a fundamental strategic dilemma remains: how to optimally allocate resources between low-carbon technologies and traditional energy sources. This issue is particularly pronounced in countries like Greece, where energy policy must navigate the competing demands of environmental commitments, economic considerations, and energy security. The coexistence of offshore wind development and hydrocarbon reserves creates a complex decision-making environment, reflecting divergent development pathways. Offshore wind energy represents a development pathway aligned with European climate objectives and long-term decarbonisation goals. However, its deployment remains associated with significant investment requirements and technological challenges, particularly in deep-water environments. (European Commission, 2021; IEA, 2023).

The contrasting strategies of hydrocarbon extraction and renewable energy development present a complex decision-making landscape for Greece. Hydrocarbon extraction is regarded as a traditional energy pathway, offering potential short- to medium-term economic benefits, increased domestic energy production, and enhanced energy security. However, this approach is fraught with significant environmental risks, susceptibility to global fuel price fluctuations, and mounting regulatory pressures driven by climate policies aimed at reducing reliance on fossil fuels. The central challenge of this thesis involves evaluating these divergent strategies within the same geographical and policy framework.

This dilemma reflects a broader tension between short-term energy security priorities and long-term decarbonisation goals—an issue at the heart of current energy policy debates. The offshore area south of Crete offers a particularly pertinent case study for exploring Greece's future energy direction. This region combines substantial renewable energy potential with the possibility of hydrocarbon extraction under a shared regulatory environment.

Such a dual-resource setting makes it ideally suited for a comparative analysis of alternative development pathways. From a renewable perspective, the southern Cretan offshore zone benefits from advantageous wind conditions and presents considerable opportunities for offshore wind deployment, especially through floating turbine technologies that are well-suited to the region's deep-water bathymetry. These characteristics position the area as one of the most promising locations for large-scale offshore wind development in Greece, in line with broader European efforts to expand offshore renewable capacity (IRENA, 2021; European Commission, 2020).

At the same time, the region has attracted considerable interest for hydrocarbon exploration, as preliminary geological studies indicate the possible presence of natural gas reserves in offshore blocks south of Crete. This has led to licensing activities and partnerships with international energy companies, highlighting the economic and strategic importance of the area within Greece's energy planning framework (Ministry of Environment and Energy, 2024).

The coexistence of offshore wind potential and hydrocarbon prospectivity within the same geographical region creates a strategic dilemma for policymakers. Since both development pathways are technically feasible, the area provides an appropriate case study for comparative analysis.

1.4 Research Aim and Questions

This dissertation aims to perform a comprehensive comparative analysis of offshore wind farm development and hydrocarbon extraction south of Crete, with an emphasis on their technical, economic, environmental, and policy dimensions within the context of Greece's evolving energy strategy. The primary objective is to determine which pathway aligns more closely with long-term sustainability goals, while also considering immediate concerns related to energy security and economic viability.

To achieve this, the study investigates several interrelated research questions. Initially, it examines the key technical and economic characteristics associated with both offshore wind and hydrocarbon development in the region south of Crete. Subsequently, it explores the environmental and social impacts linked to each development option. The analysis continues with a comparison of the strategic value, economic feasibility, and concordance with

European and national energy policies of both pathways. Ultimately, the research intends to identify the development approach most suitable for securing Greece's long-term energy future.

1.5 Structure of the Dissertation

The dissertation comprises five main chapters. Chapter 1 introduces the research topic, outlines the broader context, and defines the aim and research questions. Chapter 2 reviews the relevant literature on the energy transition, offshore wind energy, hydrocarbon extraction, and the Greek energy policy framework. Chapter 3 describes the research methodology and analytical approach used in the study. Chapter 4 presents the results of a comparative analysis of offshore wind energy and hydrocarbon extraction south of Crete. Finally, Chapter 5 discusses the findings and provides conclusions and strategic recommendations.

2. Literature Review

2.1 Energy Strategy and Sustainable Development

Energy strategy and sustainable development have become closely interconnected concepts within contemporary economic and policy discussions. Growing concerns about climate change, environmental degradation, and long-term energy security have significantly shaped how governments and international organisations approach energy planning and infrastructure investment (Kaya et al., 2025). Traditionally, energy strategies were primarily focused on ensuring a stable energy supply and supporting economic growth. However, the growing environmental impacts associated with fossil fuel consumption have shifted attention towards the development of more sustainable and low-carbon energy systems (IRENA, 2023).

The concept of sustainable development was formally introduced in the Brundtland Report, which defined it as development that meets present needs without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987).Within the energy sector, sustainable development involves balancing economic growth, environmental protection, and social well-being, often referred to as the "three pillars" of sustainability. Consequently, modern energy strategies are increasingly evaluated not only in terms of economic performance but also by their environmental and social implications (Michailidis et al., 2025).

The transition toward low-carbon energy systems has emerged as a central objective of global energy policy (Tsiara et al., 2025). Decarbonisation strategies aim to reduce greenhouse gas emissions by gradually replacing fossil fuels with renewable energy sources and cleaner technologies. International agreements such as the Paris Agreement, along with policy initiatives including the European Green Deal, have accelerated this transition by setting long-term climate targets and encouraging investment in renewable energy infrastructure (European Commission, 2020b; United Nations, 2015).

At the same time, energy security remains a fundamental component of national energy strategies. Energy security generally refers to the uninterrupted availability of energy sources at affordable prices (IEA, 2023). Recent geopolitical developments, including the energy market instability following the COVID-19 pandemic and the war in Ukraine, have highlighted the vulnerability of countries heavily dependent on imported fossil fuels. As a result, many governments have sought to diversify their energy mix and increase domestic energy production in order to reduce exposure to external supply disruptions and price volatility (Islam et al., 2026; Koirala et al., 2025).

In this context, renewable energy technologies have gained strategic importance for their ability to support decarbonisation, strengthen energy security and reduce dependence on imported hydrocarbons (IRENA, 2023).

The transition to sustainable energy systems presents numerous challenges. Renewable energy projects often require substantial investments, infrastructure upgrades and extended development timelines, while issues related to intermittency, storage and grid integration remain important considerations. At the same time, fossil fuel extraction may generate economic benefits and support domestic energy production, but it faces increasing criticism due to its environmental impacts and limited compatibility with long-term climate objectives. Consequently, policymakers must balance energy security, economic competitiveness and environmental sustainability when designing future energy strategies.

2.2 Offshore Wind Energy: Global and European Experience

2.2.1 Global Development of Offshore Wind

Offshore wind energy has emerged as one of the fastest-growing renewable energy technologies worldwide and is increasingly regarded as a central component of the global energy transition. Compared to onshore wind farms, offshore installations benefit from stronger and more consistent wind speeds, which can lead to higher electricity generation efficiency and improved capacity factors (IRENA, 2021). In addition, offshore wind projects reduce many of the land-use limitations associated with onshore renewable energy development, making them particularly attractive for densely populated regions and countries with extensive coastlines.

Over the last two decades, offshore wind capacity has grown significantly due to technological advances, declining costs, supportive policy frameworks and increasing commitments to climate action. EU has historically led offshore wind development, with countries such as the United Kingdom, Germany, Denmark and the Netherlands investing heavily in offshore renewable infrastructure (Crown Estate Scotland, 2018; WindEurope, 2023). The European Union has identified offshore wind as a key component of its decarbonisation and energy-security strategy (European Commission, 2020a).

Recent studies focusing on the Eastern Mediterranean further highlight the growing strategic importance of offshore wind development in the region (IRENA, 2021; WindEurope, 2023). Climate and wind-resource assessments indicate favourable conditions for large-scale offshore renewable energy deployment, particularly in the Aegean Sea and surrounding offshore areas, where strong and persistent wind regimes have been identified (Logothetis et al., 2026).

Offshore wind has also attracted growing interest across the wider Mediterranean and North African region due to favourable wind conditions, extensive coastlines and rising energy demand. Morocco possesses significant offshore wind potential along its Atlantic coastline and the Strait of Gibraltar (World Bank, 2019), while Egypt has increasingly promoted renewable energy expansion in both the Red Sea and Mediterranean regions as part of its long-term energy strategy (GWEC, 2023). Furthermore, the deep-water conditions characterising much of the Mediterranean basin have increased interest in floating offshore wind technologies as a future pathway for regional offshore renewable energy development (RCREEE, 2024).

2.2.2 Fixed-Bottom and Floating Offshore Technologies

The evolution of offshore wind technologies has progressed significantly in recent years. Initially, most offshore wind projects relied on fixed-bottom foundations, such as monopiles and jackets, which are particularly suitable for shallow-water environments. These solutions continue to dominate in regions with relatively shallow seabeds, including parts of Northern Europe. However, fixed-bottom systems become technically and economically challenging in deeper waters, where installation complexity and construction costs increase substantially (Musial et al., 2022). The Mediterranean region presents additional challenges due to steep seabed gradients and limited continental shelf areas, making conventional fixed-bottom technologies less suitable in many offshore locations.

In response to these limitations, floating offshore wind technology has emerged as a viable alternative for offshore renewable energy deployment. Floating platforms enable turbine installation in water depths exceeding 60 metres, expanding offshore wind potential to areas previously considered unsuitable for conventional offshore installations (IRENA, 2021).

While fixed-bottom turbines are generally more suitable for water depths below 60 metres, floating systems can operate efficiently in much deeper waters using advanced mooring and anchoring technologies to ensure structural stability. This development is particularly relevant for countries such as Greece, where steep seabed bathymetry limits the applicability of fixed-bottom foundations.

Several advantages of floating offshore wind systems are highlighted in the literature. Compared to fixed-bottom foundations, floating platforms tend to reduce the need for direct seabed intervention during installation and offer increased flexibility in turbine placement. Furthermore, floating systems facilitate the assembly of turbines closer to shore, which can then be towed to their operational sites. This approach has the potential to simplify offshore construction processes and decrease maintenance requirements, thereby optimizing project feasibility. Floating wind farms present additional engineering challenges, including mooring stability, dynamic cable behavior, anchoring systems, and the influence of metocean conditions. Consequently, site investigation and geotechnical assessment become essential components in the planning and development stages of floating offshore wind projects, ensuring that technical and environmental factors are thoroughly considered (IRENA, 2021; Musial et al., 2022).

Floating platforms can be classified into three primary types: spar-buoy, semi-submersible, and tension-leg platforms. Each type exhibits distinct technical characteristics, stability behaviors, installation procedures, and economic considerations. Among these, semi-submersible platforms are particularly prominent in current discussions, largely owing to their relative ease of installation and compatibility with existing port infrastructure (WindEurope, 2023). Despite significant technological progress, floating offshore wind remains less commercially mature than fixed-bottom technology and is still associated with higher investment costs and greater technical uncertainty.

The Mediterranean basin, including Greece, is therefore frequently identified as a promising future market for floating offshore wind development. Continued technological advances are expected to further expand the geographical applicability of offshore renewable energy across Southern Europe.

2.2.3 Economic Characteristics and Investment Trends

The economic competitiveness of offshore wind has improved substantially over the past decade. Technological advances, economies of scale, larger turbine capacities, and improved installation methods have contributed to a gradual reduction in the levelized cost of electricity (LCOE) for offshore wind projects (IRENA, 2023). Modern offshore wind turbines increasingly surpass capacities of 12–15 MW, enabling higher electricity output per installation and enhancing overall project efficiency. Several studies suggest that costs associated with floating offshore wind are likely to decrease further as deployment expands and supply chains become more mature. Consequently, offshore wind is increasingly recognized not only as an environmentally sustainable solution but also as a competitive long-term energy investment.

The economic viability of floating offshore wind projects is influenced by a range of technical and geographical factors, including water depth, wind conditions, proximity to shore, infrastructure availability, and installation complexity. Economic assessments frequently utilize metrics such as Net Present Value (NPV), Internal Rate of Return (IRR), and Levelized Cost of Electricity (LCOE). Research on deep-water offshore wind development indicates that floating wind systems currently entail higher capital expenditures compared to fixed-bottom alternatives. This is primarily due to costs related to platform manufacturing, anchoring systems, and specialized installation procedures.

The literature further indicates that increasing turbine size and expanding deployment can reduce long-term electricity-generation costs. In addition, the development of dedicated supply chains, port infrastructure, maintenance capabilities and grid-integration systems is considered critical for improving project efficiency and reducing operational expenses. Industry reports also highlight broader economic benefits associated with floating offshore wind, including job creation, industrial investment and regional economic growth, particularly in coastal areas with suitable offshore conditions.

However, large-scale offshore wind projects demand significant investments in transmission infrastructure, grid integration, and port facilities. These requirements can notably impact project timelines and overall feasibility, necessitating careful planning and resource allocation.

2.2.4 Environmental and Industrial Implications

In addition to economic considerations, offshore wind energy is associated with a range of environmental and social implications. Compared to fossil fuel-based electricity generation, offshore wind contributes significantly lower greenhouse gas emissions during operation and supports broader climate mitigation objectives. However, the literature also identifies concerns related to marine ecosystems, underwater noise during installation, impacts on fisheries, and visual effects in coastal areas (European Commission, 2020a). Effective spatial planning, environmental assessment, and stakeholder engagement are widely recognized as critical components in the development of offshore wind projects.

Floating offshore wind technology also presents important industrial and economic opportunities. The development, fabrication, installation and maintenance of floating platforms require advanced engineering skills and specialized offshore infrastructure, creating opportunities for industries with expertise in offshore construction, shipbuilding and oil and gas operations.

Studies indicate that countries with established offshore industrial sectors may benefit from floating offshore wind through the development of supply chains, employment opportunities and the export of technical services and engineering expertise. Consequently, floating offshore wind is increasingly viewed not only as a means of supporting the energy transition but also as a strategic industrial-development opportunity. The integration of floating wind systems with existing offshore infrastructure has also attracted growing interest, particularly in regions where mature offshore hydrocarbon sectors can support a gradual transition toward lower-carbon energy systems.

2.2.5 Strategic Importance of Offshore Wind

Offshore wind contributes to energy security, renewable electricity generation and reduced dependence on imported fuels. Following the energy-market disruptions associated with COVID-19 and the war in Ukraine, offshore wind has become increasingly important within European energy strategies (IEA, 2023). The literature widely identifies offshore wind as a strategic technology capable of supporting decarbonisation, energy security, industrial development and long-term economic competitiveness. Although significant technical, financial and regulatory challenges remain, particularly for floating offshore systems, the continued expansion of offshore wind capacity demonstrates its growing importance within modern energy strategies and international climate-policy frameworks.

2.3 Hydrocarbon Extraction and Energy Security

2.3.1 Global Importance of Hydrocarbons

Hydrocarbons continue to play a central role in the global energy system despite the growing international emphasis on renewable energy and decarbonisation policies. Oil, natural gas and coal remain the dominant primary energy sources supporting industrial production, electricity generation, transportation and economic development worldwide. Projections indicate that hydrocarbons are expected to account for approximately 76% of global primary energy consumption by 2035, demonstrating that the transition toward alternative energy systems will be gradual rather than immediate (Litvinenko, 2020).

The importance of hydrocarbons is strongly connected to their high energy density, mature infrastructure networks and ability to support modern industrial economies. Oil remains essential for transportation and industry, while natural gas plays a major role in electricity generation, industrial production and residential heating (IEA, 2023). In addition, hydrocarbons constitute critical feedstocks for petrochemical industries and are widely used in the production of plastics, fertilizers, synthetic materials, lubricants and chemical products. Consequently, modern industrial systems remain deeply interconnected with hydrocarbon supply chains and related infrastructure.

The literature further demonstrates that hydrocarbons remain closely linked to geopolitical stability and national energy security. Energy security generally refers to the uninterrupted availability of energy resources at affordable prices and constitutes a central objective of national energy strategies. Competition for access to hydrocarbon reserves continues to influence international relations, while disruptions in hydrocarbon supply chains may significantly affect global markets and economic stability. Litvinenko (2020) argues that hydrocarbons increasingly function not only as energy resources but also as geopolitical assets with strategic importance for both exporting and importing countries.

The COVID-19 pandemic, followed by the war in Ukraine, exposed the vulnerability of countries highly dependent on imported fossil fuels and intensified concerns regarding supply diversification and energy independence (IEA, 2023). In response, many governments have increasingly prioritized domestic energy production, strategic reserves, and alternative supply routes in order to reduce exposure to external market disruptions and price volatility.

2.3.2 Hydrocarbons, Energy Security and Geopolitical Risks

Energy security has emerged as a critical aspect of modern energy policy, closely linked to the availability, affordability and reliability of hydrocarbon resources. For countries heavily dependent on imported fossil fuels, disruptions in international hydrocarbon markets may affect economic stability, industrial productivity and long-term strategic planning (IEA, 2023). European nations, including Greece, have historically relied on imported hydrocarbons, making their energy systems vulnerable to geopolitical instability, price volatility and supply-chain disruptions. As a result, energy diversification and the strengthening of domestic energy production have become important priorities in European energy policy (European Commission, 2020b)

The strategic importance of hydrocarbons became particularly evident during recent global crises. The COVID-19 pandemic caused major disruptions across global energy markets, affecting hydrocarbon demand, supply chains and pricing mechanisms. The subsequent economic recovery increased energy demand and placed additional pressure on hydrocarbon markets, reinforcing concerns regarding energy affordability and long-term supply security (IEA, 2023). The conflict in Ukraine further intensified concerns regarding European energy security. The decline in Russian natural gas exports exposed vulnerabilities among countries heavily dependent on imported hydrocarbons and triggered significant increases in energy prices. In response, European countries accelerated efforts to diversify supply sources, expand renewable energy infrastructure, develop strategic reserves and strengthen long-term energy resilience. The European Commission's REPowerEU strategy further emphasized diversification, renewable energy expansion and energy efficiency improvements as key mechanisms for enhancing European energy security (European Commission, 2022)

Price volatility in the hydrocarbons sector poses considerable challenges for both importing and exporting nations. Sudden fluctuations in the prices of oil and natural gas can significantly influence inflation, industrial competitiveness, transportation costs, electricity prices, and household energy affordability. Recent energy crises in Europe, for instance, have intensified economic and political pressures, bringing long-term issues related to energy resilience and market stability into sharp focus.

For Greece, energy security is especially critical given the country's longstanding dependence on imported fossil fuels and its strategic position within the Eastern Mediterranean. The nation's heavy reliance on imported hydrocarbons for electricity generation, transportation, and industry renders it highly susceptible to international market fluctuations. Meanwhile, the Eastern Mediterranean region has gained prominence as a key geopolitical energy corridor following the discovery of offshore natural gas reserves and growing regional competition over energy infrastructure and maritime boundaries.

Efforts to develop domestic hydrocarbon resources are often motivated by the desire to improve national energy security and decrease long-term import reliance. Proponents argue that increasing domestic natural gas output can diversify supply sources, bolster economic growth, and advance energy independence. Additionally, offshore exploration and extraction have the potential to enhance Greece's strategic position within regional energy networks and contribute to European energy security frameworks.

Nevertheless, hydrocarbon development entails significant strategic and environmental considerations. While boosting domestic production may enhance short- to medium-term energy security, it also risks conflicting with broader European decarbonization efforts and climate objectives. Balancing the imperatives of energy security with environmental sustainability and the transition toward renewable energy sources remains a complex policy challenge.

Overall, the literature underscores the intricate relationships among hydrocarbons, energy security, geopolitical stability, and economic resilience. Despite the rapid expansion of renewable technologies, hydrocarbons continue to play a pivotal role in current energy-security strategies, especially in regions marked by import dependence and geopolitical uncertainty.

2.3.3 Environmental and Strategic Challenges of Hydrocarbon Development

Despite their continued importance within the global energy system, hydrocarbons are increasingly associated with environmental, social and strategic challenges. Growing concerns regarding climate change and sustainability have intensified debates over the compatibility of hydrocarbon development with long-term decarbonisation objectives.

A primary environmental concern associated with hydrocarbon extraction is greenhouse-gas emissions generated throughout extraction, transportation, refining and end-use stages. Fossil fuels remain the largest contributor to global carbon dioxide emissions and are widely recognized as a major driver of climate change (IEA, 2023). Consequently, international initiatives such as the Paris Agreement and the European Green Deal promote a gradual reduction in fossil-fuel dependence and support the transition toward lower-carbon energy systems (European Commission, 2020b; United Nations, 2015).

Beyond atmospheric emissions, hydrocarbon extraction may generate significant local and regional environmental impacts. Oil spills, drilling discharges and accidental releases can affect marine ecosystems, groundwater systems, coastal environments and soil quality. Hydrocarbon contaminants, including PAHs, TPH and associated heavy metals, may persist in ecosystems for extended periods and negatively affect biodiversity, ecosystem stability, groundwater quality and public health (Alaidaroos, 2023; Alao et al., 2025).

The environmental risks linked to offshore hydrocarbon development have gained heightened importance following major international oil spill incidents. The Deepwater Horizon spill in the Gulf of Mexico highlighted the potentially severe ecological and economic repercussions of offshore hydrocarbon accidents. This event caused an increase in regulatory scrutiny, concerning safety protocols for offshore drilling, environmental monitoring practices, and emergency response preparedness. As a result, contemporary offshore hydrocarbon projects often undergo comprehensive environmental impact assessments, adhere to more stringent operational standards, and face rising public opposition, particularly in ecologically sensitive regions.

Domestic production can reduce import dependence, strengthen energy security and generate economic benefits, particularly during periods of geopolitical instability. At the same time, climate commitments require a gradual transition toward renewable and low-carbon energy systems. This tension became particularly visible in Europe following the COVID-19 recovery period and the war in Ukraine, when concerns regarding energy affordability and supply security temporarily increased fossil-fuel reliance despite long-term decarbonisation objectives (IEA, 2023).

Hydrocarbon projects typically entail long investment horizons and significant capital expenditures, often resulting in oil and gas infrastructure remaining operational for several decades. Critics warn that this can lead to "carbon lock-in", whereby economies remain structurally dependent on fossil-fuel systems and the transition toward climate-neutral energy frameworks is delayed. As a result, the long-term strategic value of new hydrocarbon developments remains a focal point of debate within academic circles and international energy policy discussions.

Beyond direct pollution, hydrocarbons are associated with air pollution, methane emissions, groundwater contamination, habitat fragmentation and impacts on fisheries and tourism. These effects often generate broader socio-economic consequences and may create conflicts with tourism, fisheries and marine conservation activities. Such challenges are particularly relevant in sensitive regions such as the Mediterranean, where environmental vulnerability and economic dependence on coastal activities intersect.

Nevertheless, some scholars and policymakers maintain that hydrocarbons may serve a transitional role within the global energy landscape over the coming decades. This is especially relevant in sectors where rapid decarbonization presents substantial technological or economic challenges. Natural gas, in particular, is often characterized as a "transition fuel" capable of bolstering energy security while offering lower emissions compared to coal. However, this perspective faces significant scrutiny due to concerns about methane leakage, persistent fossil fuel reliance, and potential delays in renewable energy deployment.

In summary, hydrocarbon development remains closely linked to energy security and economic competitiveness, but faces growing environmental and regulatory challenges. As climate policies become increasingly ambitious and renewable-energy deployment expands, the long-term role of hydrocarbons is being reassessed within broader sustainability and decarbonisation frameworks.

2.4 The Greek Energy Policy Context

2.4.1 Greece's Energy Transition

Greece's energy transition aligns with the broader European objective of achieving climate neutrality by 2050 and involves a gradual shift away from lignite and imported fossil fuels. The revised National Energy and Climate Plan outlines a pathway toward net zero that adopts a phased approach: initial efforts focus on decarbonising electricity generation, followed by the electrification of final energy use, and ultimately, the decarbonisation of hard-to-abate sectors through the deployment of alternative fuels, green hydrogen, and synthetic fuels.

According to (IPTO, 2021), renewable energy sources accounted for approximately one-third of Greece's electricity generation in 2021, reflecting the ongoing transformation of the national energy system. At the same time, IPTO identifies island interconnections and transmission-grid expansion as critical components of Greece's transition process, as they enhance energy security, facilitate greater integration of renewable energy sources and reduce dependence on isolated fossil-fuel-based electricity generation systems (IPTO, 2021).

During the period 2025–2030, the main priority is the rapid expansion of renewable energy generation, supported by investments in transmission networks, interconnections, energy-storage systems and pumped-storage projects. These investments are considered essential for integrating larger shares of renewables and enhancing energy security.

A central element of Greece's transition is the gradual reduction and final phase-out of lignite in electricity generation. The revised NECP links the decarbonisation of the power sector with the planned cessation of lignite use by the end of 2028, in line with the National Climate Law. This represents a major structural shift for the Greek energy system, as lignite historically played an important role in domestic electricity production and regional employment. The transition therefore also requires measures for district heating, regional adjustment and replacement technologies, including natural gas in the short term and heat pumps or other climate-neutral solutions in the medium to long term.

The Greek energy transition also includes the electrification of final energy consumption. In the period 2030–2040, the NECP expects wider deployment of electric vehicles, heat pumps, smart meters and demand-response systems, supported by charging infrastructure and network upgrades. This phase is expected to accelerate the reduction of fossil fuel use in transport, buildings and industry. The NECP also projects increasing use of renewable gases and hydrogen over the period to 2050, with hydrogen production expected to rise from 1.2 TWh in 2030 to 20.2 TWh in 2050, while biomethane production is expected to increase from 2.1 TWh in 2030 to 4.6 TWh in 2050 (Ministry of Environment and Energy, 2024).

Offshore wind is also introduced as an emerging component of Greece's long-term transition strategy. Although its development is expected to begin gradually due to high initial costs and infrastructure requirements, it is considered strategically important because it may support domestic value creation through port infrastructure, shipyards, cables and related supply chains. This is particularly relevant for Greece, where deep-water conditions increase the importance of floating offshore wind technologies.

However, the revised NECP does not present the transition as an immediate replacement of all fossil fuels. Natural gas is still expected to play a transitional role in maintaining electricity system stability, especially during the period of rapid renewable penetration. At the same time, Greece's energy dependence is projected to decline substantially, from around 66% in 2030 to 21% in 2050, mainly due to high renewable penetration and improvements in energy efficiency.

Greece's energy transition can therefore be viewed as a staged process combining renewable expansion, lignite phase-out, electrification, storage and interconnections rather than an immediate departure from conventional energy sources.

2.4.2 Offshore Wind Policy in Greece

Offshore wind energy has recently emerged as an important component of Greece's long-term energy transition strategy. Although Greece has achieved substantial growth in onshore renewable energy generation, offshore wind development remains at an early stage compared to Northern European markets. Nevertheless, the Greek government increasingly considers offshore wind as a strategic technology capable of supporting decarbonisation, energy security, industrial development and long-term energy diversification. According to HEREMA, Greece aims to develop at least 2 GW of offshore wind capacity by 2030 as part of the National Energy and Climate Plan (NECP).

The strategic importance of offshore wind in Greece is closely linked to the geographical characteristics of the country's maritime environment. Greece's maritime environment is characterised by steep seabed gradients and deep-water conditions located relatively close to the coastline. As a result, conventional fixed-bottom offshore wind technologies are often less suitable, increasing the relevance of floating offshore wind systems (Zountouridou et al., 2015).

Zountouridou et al. (2015) demonstrated the potential of floating offshore wind around Santorini, while other studies identify the Aegean Sea and surrounding offshore regions as areas with favourable wind conditions for large-scale offshore electricity generation (HEREMA).

The institutional framework for offshore wind development in Greece was significantly strengthened with the adoption of Law 4964/2022, which established the first dedicated legal framework for offshore wind farm development in the country. Under this framework, HEREMA was assigned responsibility for identifying, exploring and managing Offshore Wind Farm Organised Development Areas (OWFODA), while also participating in licensing, environmental assessment and spatial planning procedures (HEREMA). This legislation represents a major step toward the formal integration of offshore wind into Greece's national energy strategy and provides the regulatory basis for future offshore renewable investments.

Despite these developments, offshore wind deployment in Greece remains largely at the planning and licensing stage, with no commercial offshore wind farms currently in operation. Existing efforts primarily focus on spatial planning, environmental studies, regulatory preparation and pilot project development. According to HEREMA, the first pilot offshore wind projects are expected to be developed in the Thracian Sea, while future expansion may also involve maritime zones between Crete and Kassos.

The literature further indicates that offshore wind development in Greece may create broader industrial and economic opportunities beyond electricity production alone. Offshore wind projects require substantial investment in ports, shipyards, subsea cables, offshore engineering services and transmission infrastructure, potentially contributing to the development of domestic supply chains and specialised technical expertise (HEREMA). In this context, offshore wind is increasingly viewed not only as a renewable energy technology but also as a potential driver of industrial development and technological innovation.

At the same time, several technical and regulatory challenges remain. Offshore wind site selection in Greece is influenced by multiple factors, including water depth, wind velocity, military zones, seismic activity, environmental restrictions, distance from ports and proximity to electricity transmission infrastructure (Spyridonidou et al., 2020; Spyridonidou & Vagiona, 2020). Furthermore, the high initial investment costs associated with floating offshore wind systems, combined with the limited operational experience in the Mediterranean region, continue to create uncertainty regarding large-scale commercial deployment. Nevertheless, the revised National Energy and Climate Plan identifies offshore wind, storage systems and electricity-grid expansion as key pillars of Greece's future low-carbon energy system (Ministry of Environment and Energy, 2024). Offshore wind is therefore expected to play an increasingly important role in Greece's decarbonisation, energy-security and economic-development objectives.

2.4.3 Hydrocarbon Exploration in Greece

Hydrocarbon exploration in Greece has re-emerged as an important component of the country's energy and geopolitical strategy within the evolving Eastern Mediterranean energy landscape. Major offshore gas discoveries in Egypt, Israel and Cyprus demonstrated the hydrocarbon potential of the Eastern Mediterranean and increased interest in evaluating Greece's offshore geological resources (Telemenis et al., 2025)

Recent geological and geochemical studies have strengthened interest in hydrocarbon exploration south of Crete and Gavdos. Research by Telemenis et al. (2025) identified geological characteristics associated with gas-prone source rocks and highlighted similarities with hydrocarbon-producing regions elsewhere in the Eastern Mediterranean. The study also suggested that Gavdos may serve as a useful geological analogue for offshore exploration south of Crete.

Figure 1 presents the main offshore hydrocarbon concession areas and regional energy infrastructure in Greece and the Eastern Mediterranean. The map illustrates the strategic position of the offshore blocks south and west of Crete within the broader network of existing and proposed natural gas corridors.

Figure 1. Offshore hydrocarbon concession areas and major energy infrastructure in Greece and the Eastern Mediterranean. Source: HELLENiQ ENERGY (2026).

At the institutional level, Greece has gradually strengthened its hydrocarbon exploration framework through the establishment of regulatory authorities and offshore licensing procedures. The Hellenic Hydrocarbon and Energy Resources Management Company (HEREMA) has played an increasingly important role in coordinating offshore exploration activities, environmental assessment procedures and concession agreements. International energy companies including ExxonMobil, Chevron and HELLENiQ ENERGY have shown growing interest in Greek offshore blocks, particularly in ultra-deepwater areas south and west of Crete.

A major recent development was the signing of offshore concession agreements between the Hellenic Republic, Chevron and HELLENiQ ENERGY concerning exploration blocks south of Crete and the Peloponnese. According to HELLENiQ ENERGY (2026), the offshore blocks “South Crete 1”, “South Crete 2”, “South of Peloponnese” and “Block A2” cover approximately 47,000 km^2 and are located in ultra-deepwater environments exceeding 1,500 m water depth. The agreements involve multi-phase exploration programmes aiming to assess the hydrocarbon potential of these offshore regions. These developments demonstrate that Greece is increasingly viewed as a potentially important frontier area for offshore natural gas exploration in the Eastern Mediterranean.

Despite growing interest, hydrocarbon exploration in Greece remains associated with substantial technical, environmental and economic uncertainty. Offshore drilling in ultra-deepwater environments requires advanced technology, large-scale investment and long development timelines, while future profitability remains uncertain within an increasingly decarbonized European policy framework. Nevertheless, supporters argue that domestic natural gas production could reduce import dependence, strengthen energy security and enhance Greece's geopolitical position within regional energy networks. Potential hydrocarbon revenues could also support future investments in renewable energy infrastructure and energy-transition policies.

2.4.4 Strategic Challenges for Greece

Despite the significant progress achieved in renewable energy development and energy-transition planning, Greece continues to face multiple strategic challenges regarding the future structure of its energy system. One of the most important challenges concerns the balance between long-term decarbonisation objectives and short-term energy security needs. On the one hand, Greece is committed to European climate targets and the gradual reduction of greenhouse gas emissions through the expansion of renewable energy systems. On the other hand, recent geopolitical instability and fluctuations in international energy markets have highlighted the importance of maintaining reliable and secure energy supplies, particularly in countries with relatively high dependence on imported fuels (IEA, 2023).

Energy import dependence remains a significant issue for the Greek economy, particularly regarding natural gas and petroleum products. Although renewable energy penetration has increased considerably, imported fossil fuels continue to play an important role in electricity generation, transport and industry, leaving Greece exposed to international price volatility and supply-chain disruptions, as demonstrated during the energy crisis following the COVID-19 pandemic and the war in Ukraine (European Commission, 2020a).

At the same time, the expansion of large-scale energy projects often generates environmental and social concerns, particularly in regions strongly dependent on tourism and coastal economic activity. Offshore wind farms and hydrocarbon exploration projects may raise concerns about landscape impacts, marine ecosystems, fisheries, and tourism-related activities, especially in environmentally sensitive island and coastal regions. Consequently, spatial planning, environmental assessment and stakeholder acceptance remain critical aspects of future energy development strategies in Greece.

Economic uncertainty also represents an important challenge. Offshore wind projects require substantial investment, advanced infrastructure and long development periods, while hydrocarbon exploration in ultra-deepwater environments involves high exploration risk and uncertain long-term profitability. Consequently, both pathways involve considerable financial and strategic uncertainty.

Finally, infrastructure limitations continue to affect the pace of Greece's energy transition. Grid reinforcement, island interconnections, storage systems and port infrastructure are essential for supporting large-scale renewable and offshore energy development. The updated National Energy and Climate Plan identifies investments in transmission networks, storage technologies and interconnection systems as essential for achieving Greece's long-term decarbonisation objectives (Ministry of Environment and Energy, 2024). Consequently, Greece's future energy strategy will largely depend on its ability to balance energy security, economic competitiveness and environmental sustainability within a rapidly evolving geopolitical and energy landscape.

2.5 Comparative Perspectives: Renewable Energy versus Hydrocarbons

The comparison between offshore renewable energy development and hydrocarbon extraction has become increasingly important within international energy policy, particularly in regions such as the Eastern Mediterranean, where both resources coexist within the same geographical and geopolitical environment. Offshore wind energy and hydrocarbon development represent fundamentally different energy pathways, each associated with distinct economic, environmental, strategic and geopolitical characteristics. While renewable energy technologies are strongly aligned with long-term decarbonisation objectives and climate policies, hydrocarbons continue to play a central role in energy security, industrial activity and regional geopolitical dynamics. Consequently, the literature increasingly approaches the relationship between these two sectors not as a simple competition between "old" and "new" energy systems, but rather as a broader strategic dilemma involving sustainability, supply security, economic development, and geopolitical stability.

2.5.1 Economic Perspectives

From an economic perspective, offshore wind energy and hydrocarbon extraction differ significantly in terms of investment structure, operational characteristics, revenue generation and industrial maturity. Offshore hydrocarbon development remains associated with a mature global industry supported by decades of technological development, established infrastructure and extensive international investment networks. Oil and gas projects often provide relatively rapid monetisation opportunities once commercially exploitable reserves are confirmed, particularly in regions with existing export infrastructure and strong market demand (BP, 2023). In the Eastern Mediterranean, hydrocarbon discoveries have attracted interest partly because of their potential to generate state revenues, foreign direct investment and export opportunities.

At the same time, hydrocarbon projects are characterised by substantial geological uncertainty, exploration risks and exposure to international commodity price volatility. The profitability of offshore hydrocarbon extraction is highly dependent on global oil and gas prices, production costs, geopolitical stability and long-term market demand. The Eastern Mediterranean experience demonstrates that even major discoveries may face delays due to regulatory uncertainty, geopolitical tensions and infrastructure limitations (Tagliapietra, 2017). Furthermore, increasing climate policies and global decarbonisation efforts create uncertainty regarding the long-term economic viability of new hydrocarbon investments.

In contrast, offshore wind energy is closely associated with long-term infrastructure investment and gradual cost reductions driven by technological innovation and economies of scale. Although offshore wind projects typically involve high initial capital expenditure (CAPEX), operational costs are generally lower once infrastructure becomes operational because no fuel extraction or transportation is required. Recent technological developments, particularly in floating offshore wind systems, are expected to further improve economic competitiveness over the coming decades (IRENA, 2021). Several studies indicate that larger turbine capacities, improved installation methods and more mature supply chains have contributed to substantial reductions in offshore wind electricity costs (IRENA, 2023).

The economic benefits of offshore wind extend beyond electricity generation itself. The sector may support industrial development through shipbuilding, cable manufacturing, offshore engineering services, port infrastructure and maintenance activities. Countries with existing maritime and offshore industrial capabilities may therefore benefit from the creation of domestic value chains and employment opportunities. Similar arguments are also presented for hydrocarbon development, particularly in offshore regions where energy projects may stimulate broader industrial activity. However, renewable energy projects are generally considered more compatible with long-term European industrial transition strategies and climate-neutral economic planning.

Consequently, the literature increasingly presents offshore wind and hydrocarbon development as two fundamentally different investment models. Hydrocarbons may offer faster short- to medium-term economic returns under favourable market conditions, while offshore renewable energy is more strongly associated with long-term infrastructure transformation and sustainable industrial development.

2.5.2 Environmental Perspectives

Environmental considerations represent one of the clearest distinctions between offshore renewable energy development and hydrocarbon extraction. Offshore wind is widely regarded as a low-carbon electricity-generation technology that supports greenhouse-gas reductions and international climate objectives (European Commission, 2020a)

Nevertheless, offshore wind projects are not environmentally neutral. The literature identifies several environmental concerns associated with offshore renewable energy infrastructure, including impacts on marine ecosystems, underwater noise during installation, fisheries disruption, seabird interactions and visual impacts in coastal areas. These impacts are particularly relevant in environmentally sensitive and tourism-dependent regions such as the Mediterranean. However, most studies conclude that the long-term environmental footprint of offshore wind remains considerably lower than that of fossil fuel extraction and combustion.

Hydrocarbon extraction presents different environmental challenges. The combustion of oil and natural gas remains a major contributor to greenhouse-gas emissions and climate change (IPCC, 2021). Offshore drilling is also associated with risks including oil spills, methane leakage, marine pollution and ecosystem disturbance. Although natural gas is often described as a transition fuel, it remains a fossil fuel contributing to long-term carbon emissions.

In the Eastern Mediterranean, environmental concerns are particularly important due to the ecological sensitivity of the region and the economic importance of tourism and coastal activities. Large-scale offshore hydrocarbon extraction could potentially generate tensions between energy development objectives and environmental protection priorities. At the same time, offshore renewable energy projects may also face local opposition related to landscape alteration, tourism concerns and marine spatial planning conflicts.

The central environmental and policy dilemma arises from the coexistence of climate-neutrality objectives and continuing hydrocarbon demand. While renewable energy supports long-term decarbonisation pathways, hydrocarbons continue to contribute to energy security and system stability during the transition period. Consequently, energy development in the Eastern Mediterranean requires a broader strategic approach that balances sustainability objectives, energy-security needs and regional economic realities (Tagliapietra, 2017).

2.5.3 Energy Security and Strategic Perspectives

Energy security remains a central aspect of the comparison between offshore renewable energy and hydrocarbons. Recent crises, including the COVID-19 pandemic and the war in Ukraine, exposed vulnerabilities in international energy systems and reinforced the importance of supply diversification and domestic energy production.

Hydrocarbons continue to play an important role in energy security due to their dispatchability and flexibility in supporting electricity generation, industry and transportation. Domestic hydrocarbon production may reduce import dependence, improve trade balances and strengthen geopolitical influence. In the Eastern Mediterranean, recent gas discoveries have raised expectations regarding regional energy diversification and cooperation.

Within European policy discussions, Eastern Mediterranean gas resources are often viewed as a supplementary supply source capable of supporting diversification objectives and reducing dependence on external suppliers. The European Parliament has highlighted their potential contribution to the EU's broader Energy Union strategy (Tagliapietra, 2017).

Hydrocarbons remain closely associated with geopolitical instability and market uncertainty. Fluctuations in oil and gas prices are heavily influenced by geopolitical events, conflicts, sanctions, and shifts in international markets. Additionally, infrastructure projects related to hydrocarbons often depend on long-term political stability and extensive international cooperation. The Eastern Mediterranean exemplifies these issues, as ongoing maritime disputes, regional rivalries, and diplomatic tensions continue to shape offshore energy development.

In contrast, offshore wind contributes to energy diversification through domestic electricity generation that is less exposed to international fuel-price volatility. Consequently, renewable-energy expansion is increasingly viewed as both an environmental and energy-security objective within European policy.

However, offshore wind faces inherent limitations. Its intermittent nature, driven by weather conditions, necessitates the development of storage solutions, grid enhancements, and backup generation capacities. As a result, renewable energy sources cannot entirely supplant conventional fuels across all economic sectors at present. Most transition scenarios project that natural gas and other traditional fuels will continue to play a stabilizing role during the transition period.

Ultimately, hydrocarbons and offshore renewables contribute to energy security in different ways. Hydrocarbons provide short- to medium-term supply flexibility and geopolitical leverage, whereas renewable energy supports long-term energy independence, sustainability and reduced exposure to international fuel markets. Both are therefore likely to remain relevant within future energy-transition strategies.

2.5.4 Long-Term Strategic Evaluation

From a long-term strategic perspective, the comparison between offshore renewable energy and hydrocarbons exemplifies the broader global transition from conventional fossil fuel systems toward low-carbon energy models. Nonetheless, the literature generally refrains from portraying this shift as an immediate replacement of one system by another. Instead, most analyses acknowledge the coexistence of both sectors during an extended transitional period.

Offshore wind energy aligns closely with European climate policies, carbon-neutrality objectives and sustainable-development strategies. Technological advances and continued policy support are expected to strengthen its strategic importance, while floating offshore wind technologies may further expand deployment opportunities in deep-water regions such as the Eastern Mediterranean and Greece.

At the same time, hydrocarbons continue to retain economic and geopolitical significance. Natural gas is frequently viewed as a transitional fuel capable of supporting electricity-system stability while renewable infrastructure continues to expand. Consequently, countries seeking to balance economic growth, energy security and decarbonisation objectives face increasingly complex strategic choices.

This challenge is particularly evident in Greece and the Eastern Mediterranean, where significant offshore renewable-energy potential coexists with ongoing hydrocarbon exploration activities. Policymakers must therefore balance environmental sustainability, regional geopolitics, industrial development, tourism protection and long-term energy security.

Consequently, the literature increasingly emphasizes the importance of flexible and adaptive energy-planning strategies rather than policies focused exclusively on a single energy pathway. The future energy landscape of the Eastern Mediterranean will depend not only on technological and economic developments but also on geopolitical stability, regulatory evolution and the pace of the global energy transition.

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3. Methodology

This chapter presents the methodology adopted to address the research objectives of the dissertation. The study employed a qualitative, comparative approach in order to evaluate the two alternative energy development pathways south of Crete: offshore wind farm development and hydrocarbon extraction.

Given the strategic and policy-oriented nature of the research, the methodology focuses on high-level evaluation rather than technical or engineering modelling. Secondary data from international organizations, European institutions, and national sources are used to support the analysis.

The chapter outlines the research design, data sources, and analytical framework applied in the study. In particular, SWOT and PESTEL analyses are employed to structure the comparison between the two scenarios, complemented by a set of basic quantitative indicators. The final section discusses the limitations of the methodological approach.

3.1 Research Approach

This study adopts a qualitative comparative research approach aimed at evaluating two alternative energy-development pathways rather than optimizing a technical solution. The purpose of the research is to assess offshore wind development and hydrocarbon exploration from strategic, economic, environmental and policy-oriented perspectives. A qualitative comparative approach is considered appropriate because the research focuses on complex decision-making processes that involve multiple interrelated factors extending beyond purely technical or financial considerations.

The qualitative nature of the research reflects the characteristics of the research problem. Decisions related to national energy strategies and long-term infrastructure development are influenced not only by quantitative factors, such as costs or energy output, but also by regulatory conditions, environmental considerations, geopolitical context and alignment with broader sustainability objectives (IEA, 2023; Porter, 1996). As a result, a qualitative approach is considered appropriate to capture the multidimensional nature of the energy transition debate.

Furthermore, the comparative design of the study enables a structured evaluation of the two development alternatives within the same geographic and institutional context. By focusing on the area south of Crete, the research ensures that both alternatives are assessed under the same political, regulatory and market conditions, enhancing the consistency of the comparison (Voss et al., 2002).

Moreover, the research avoids advanced technical or engineering modelling, as such approaches would require project-specific data that are not publicly available. That approach would also exceed the scope of an MBA-level strategic study. Instead, the analysis focuses on using established strategic assessment frameworks and secondary data sources, which are widely used in applied business and policy research (M. Saunders et al., 2023).

Overall, the selected research approach supports the objectives of the dissertation by providing a coherent and transparent framework for comparing hydrocarbon and offshore wind farm development as alternatives for Greece's long-term sustainable energy strategy.

3.2 Research Design

The research is structured as a comparative single-case design focusing on two alternative energy development scenarios within the same geographical and policy context. The area south of Crete constitutes the single-case design, while offshore wind farm and hydrocarbon extraction represent the two units of comparison within the case.

Defining a single geographical case ensures that both development options are examined under the same conditions, frameworks, constraints and considerations. This design allows the differences observed between the two scenarios to be attributed to their inherent characteristics rather than to external variations.

The unit of analysis in this research is the energy development pathway, assessed at a strategic level rather than at the level of individual projects or technical design specifications. Consequently, the analysis adopts a longer-term perspective, reflecting the planning horizons typically associated with large-scale energy investments and national energy strategies.

The research design is non-experimental and follows an evaluative logic commonly used in strategic and policy-oriented studies, where alternative actions are compared using consistent criteria and structured analytical frameworks. Both development pathways are assessed using the same data sources, analytical tools and evaluation indicators, ensuring methodological consistency.

This sub-chapter provides a clear and transparent structure for the comparative analysis presented in Chapter 4 and the conclusions developed in Chapter 5.

3.3 Data Sources

The analysis presented in the dissertation is based exclusively on secondary data, obtained from reliable resources publicly available. The use of secondary data is appropriate given the strategic scope of the study and the limited availability of primary data for offshore energy projects.

Data were collected from multiple categories of sources in order to ensure balance and credibility. Firstly, reports and datasets were used to obtain information on offshore wind development, energy transition trends and investment costs, published by international energy organizations, such as the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA). These sources provide comparable data and are widely used in academic and policy-oriented research.

Secondly, European Union policy documents and strategic frameworks were consulted, including the European Green Deal. These sources are used to highlight the strategic importance of renewable energy development within the European Union. Moreover, several national-level sources are examined, particularly some Greek energy planning documents from the Ministry of the Environment and Energy, such as the National Energy and Climate Plan (NECP) (Ministry of Environment and Energy, 2024).

Finally, peer-reviewed academic literature was used to support assumptions related to offshore wind energy, hydrocarbon extraction, and comparative energy strategy analysis. However, all data sources were selected based on their relevance, reliability and consistency with the strategic objectives of the study. Where multiple estimates were available, conservative and representative outcomes were preferred in order to support the comparative analysis.

3.4 Comparative Evaluation Framework

To ensure a structured and transparent comparison between offshore wind development and offshore hydrocarbon exploration, the study employs a comparative evaluation framework based on six key assessment criteria identified in the literature. These criteria were selected because they capture the principal economic, environmental, strategic and technical dimensions relevant to long-term energy planning and investment decisions.

The selected criteria are:

- Economic Feasibility
- Environmental Impact
- Policy Compatibility
- Energy Security Contribution
- Technological Readiness
- Investment Uncertainty

Economic feasibility was selected to assess the overall financial attractiveness and viability of each development pathway. Environmental impact was included to evaluate potential ecological consequences and sustainability considerations. Policy compatibility reflects the degree of alignment with European and Greek energy and climate strategies. Energy security contribution examines the extent to which each pathway can support diversification and domestic energy supply. Technological readiness assesses the maturity and practical deployment potential of the respective technologies. Finally, investment uncertainty captures geological, regulatory, market and technological risks associated with long-term project development.

The criteria were considered of equal importance for the purposes of this study. The objective was not to perform a formal multi-criteria decision analysis, but rather to provide a balanced comparative assessment based on consistent evaluation dimensions. SWOT and PESTEL analyses were subsequently used to support the assessment of each criterion, while basic quantitative indicators were incorporated where relevant in order to strengthen the comparison.

The comparative evaluation framework developed for this study is presented in Table 1. The selected criteria reflect the key economic, environmental, strategic and technical dimensions identified in the literature as relevant for the assessment of alternative energy-development pathways.

Table 1. Comparative Evaluation Criteria.

Criterion	Description	Reason for Selection
Economic Feasibility	Costs, revenues and overall financial viability	Determines economic attractiveness
Environmental Impact	Environmental and ecological effects	Evaluates sustainability implications
Policy Compatibility	Alignment with EU and Greek energy policies	Assesses regulatory support
Energy Security Contribution	Contribution to diversification and domestic supply	Evaluates strategic energy value
Technological Readiness	Maturity and implementation feasibility	Assesses deployment potential
Investment Uncertainty	Geological, regulatory and market risks	Evaluates long-term project risk

4. Presentation of Secondary Results

This chapter presents the secondary results of the comparative analysis between offshore wind farm development and hydrocarbon extraction south of Crete. The findings are derived from the secondary data sources and analytical framework described in Chapter 3 and are presented in a structured and descriptive manner.

The chapter is organized into three main sections. Firstly, Section 4.1 examines the offshore wind farm development scenario, focusing on its technical, economic, environmental and strategic characteristics. Secondly, Section 0 presents the hydrocarbon extraction scenario using the same analytical approach and evaluation criteria. Finally, Section 4.3 provides a comparative assessment of the two development alternatives, highlighting their respective advantages, limitations and broader strategic implications.

The purpose of this chapter is to present the main findings of the analysis and provide the foundation for the discussion and strategic conclusions developed in Chapter 5.

4.1 Offshore Wind Farm Development South of Crete

This section explores the offshore wind farm development scenario south of Crete, utilizing secondary data sources and the analytical framework outlined in Chapter 3. The discussion encompasses key technical, economic, environmental, and strategic aspects related to offshore wind projects in the region.

Initially, the focus is on the primary technical and economic characteristics of offshore wind deployment. This includes an examination of floating wind technology, infrastructure requirements, investment considerations, and the potential for long-term energy generation. Subsequently, the environmental and social impacts are assessed, with particular attention to effects on marine ecosystems, tourism, and sustainability objectives.

The analysis culminates with a strategic assessment employing SWOT and PESTEL frameworks. This provides a structured overview of the opportunities, challenges, and broader strategic implications associated with developing offshore wind energy south of Crete.

4.1.1 Technical and Economic Characteristics

The offshore wind farm development scenario south of Crete is examined based on indicative technical and economic parameters derived from secondary sources, including European policy documents, international energy organizations and industry literature. Since offshore wind development in Greece remains at an early planning stage, this analysis relies on representative assumptions, regional assessments and comparative Mediterranean studies rather than project-specific engineering or financial data (European Commission, 2020a; IEA, 2022). According to WindEurope (2023a), wind energy currently contributes approximately 19% of Greece's total energy demand, highlighting both the growing role of renewable energy within the national energy mix and the significant expansion potential of the sector.

The technical feasibility of offshore wind development south of Crete is strongly influenced by the geomorphological and bathymetric characteristics of the region. Water depths increase rapidly close to the coastline, frequently exceeding the limits considered suitable for conventional fixed-bottom offshore wind foundations. Existing studies indicate that several offshore areas south of Crete reach depths between 600 and 1000 m, making floating offshore wind technology the most technically suitable option for the region (Christoforaki & Tsoutsos, 2017). While fixed-bottom wind turbines are generally limited to water depths of approximately 50–60 m, floating foundations enable deployment in substantially deeper waters while maintaining high energy production potential (IRENA, 2016). Consequently, the deep-water conditions of southern Crete significantly strengthen the strategic relevance of floating offshore wind technologies within the Eastern Mediterranean context.

Floating offshore wind has attracted increasing interest across the Mediterranean due to the region's extensive deep-water conditions. Staschus et al. (2020) argue that the floating offshore wind potential of the Mediterranean is considerably greater than the potential associated with bottom-fixed technologies. In addition, floating foundations may reduce direct intervention on the seabed during installation procedures, potentially limiting certain construction-related marine impacts compared to conventional bottom-fixed infrastructure (IRENA, 2019). However, floating offshore wind systems remain technologically less mature than conventional monopile technologies and continue to face important engineering, logistical and economic challenges associated with deep-water deployment (WindEurope, 2023a).

Existing spatial-planning studies identify several offshore areas around Crete as potentially suitable for offshore wind deployment, particularly in southern and southeastern maritime regions near Gavdos, Chrissi, Ierapetra and Sitia (Gkeka-Serpetsidaki & Tsoutsos, 2022). These areas demonstrate favourable wind conditions and strategic positioning within the broader Eastern Mediterranean energy system. According to data from the National Observatory of Athens, offshore wind potential in parts of Crete ranges between 300 and 600 W/m², indicating substantial renewable energy potential for future offshore deployment (Kotroni et al., 2014). Mediterranean-scale assessments further reinforce the strategic importance of Greece within future offshore renewable energy development. Faraggiana et al. (2024) estimate that Greece possesses one of the highest floating offshore wind technical potentials in the Mediterranean region, with estimated installed capacity exceeding 100 GW and technical potential surpassing 300 TWh. These findings suggest that offshore wind could become an increasingly important component of Greece's long-term energy transition strategy.

From an economic perspective, offshore wind development is characterised by substantial upfront capital expenditure (CAPEX), reflecting the complexity of offshore installations, floating foundations, turbine manufacturing, mooring systems, subsea infrastructure and grid connection requirements. Installation costs increase considerably with water depth, offshore distance and transmission complexity (MEECC, 2008). Nevertheless, recent studies suggest that floating offshore wind may become progressively more economically competitive as the technology matures and economies of scale improve. Faraggiana et al. (2024) estimate that approximately 67.5% of the Mediterranean floating offshore wind technical potential is associated with LCOE values below 90 €/MWh, while several European studies suggest that floating offshore wind LCOE values may decline below 70 €/MWh by 2050 in certain offshore regions (Caglayan et al., 2019). Greece itself demonstrates relatively competitive indicative LCOE values of approximately 86.9 €/MWh, reinforcing the long-term economic potential of offshore renewable energy development in the country.

A more detailed socio-economic assessment conducted for Greece by ELIAMEP (2021) estimated that floating offshore wind projects commissioned in the early 2030s could achieve indicative capital expenditure (CAPEX) values of approximately €1.6 million/MW, with annual operational expenditure (OPEX) around €0.05 million/MW and decommissioning costs (DECEX) equivalent to approximately 2% of total investment costs. The study further suggests that floating offshore wind technologies may become increasingly cost-competitive as technological maturity improves and economies of scale are achieved. Although these estimates are project-specific and subject to uncertainty, they provide useful indicative benchmarks for assessing the economic viability of future offshore wind development in Greece.

Table 2. Indicative assessment of selected offshore wind development areas south of Crete based on technical, spatial and strategic characteristics.

Area	Suitability	Indicative Capacity Potential	Technical Characteristics	Main Supporting Characteristics
Gavdos	Medium-High	~8–10 MW	Deep waters suitable for floating platforms; strong offshore wind conditions	Strategic southern location; supports island energy autonomy
Chrissi	Medium	~7–10 MW	Moderate offshore suitability; favourable wind conditions	Potential integration with southern Crete energy infrastructure
Ierapetra	Medium-High	limited/moderate	Deep-water offshore zone; floating wind applicability	Spatial proximity to hydrocarbon exploration interest areas
Sitia	Medium	~10–14 MW	Strong wind exposure; southeastern offshore positioning	Potential role in Eastern Mediterranean energy diversification

As shown in Table 2, offshore regions near Gavdos, Chrissi, Ierapetra and Sitia demonstrate moderate-to-high suitability for offshore wind deployment under floating wind scenarios. Although the estimated development potential of these southern regions is lower than some northern Cretan offshore zones, their strategic importance remains significant due to their proximity to deep-water areas and their spatial association with broader Eastern Mediterranean energy activities, including hydrocarbon exploration interest zones.

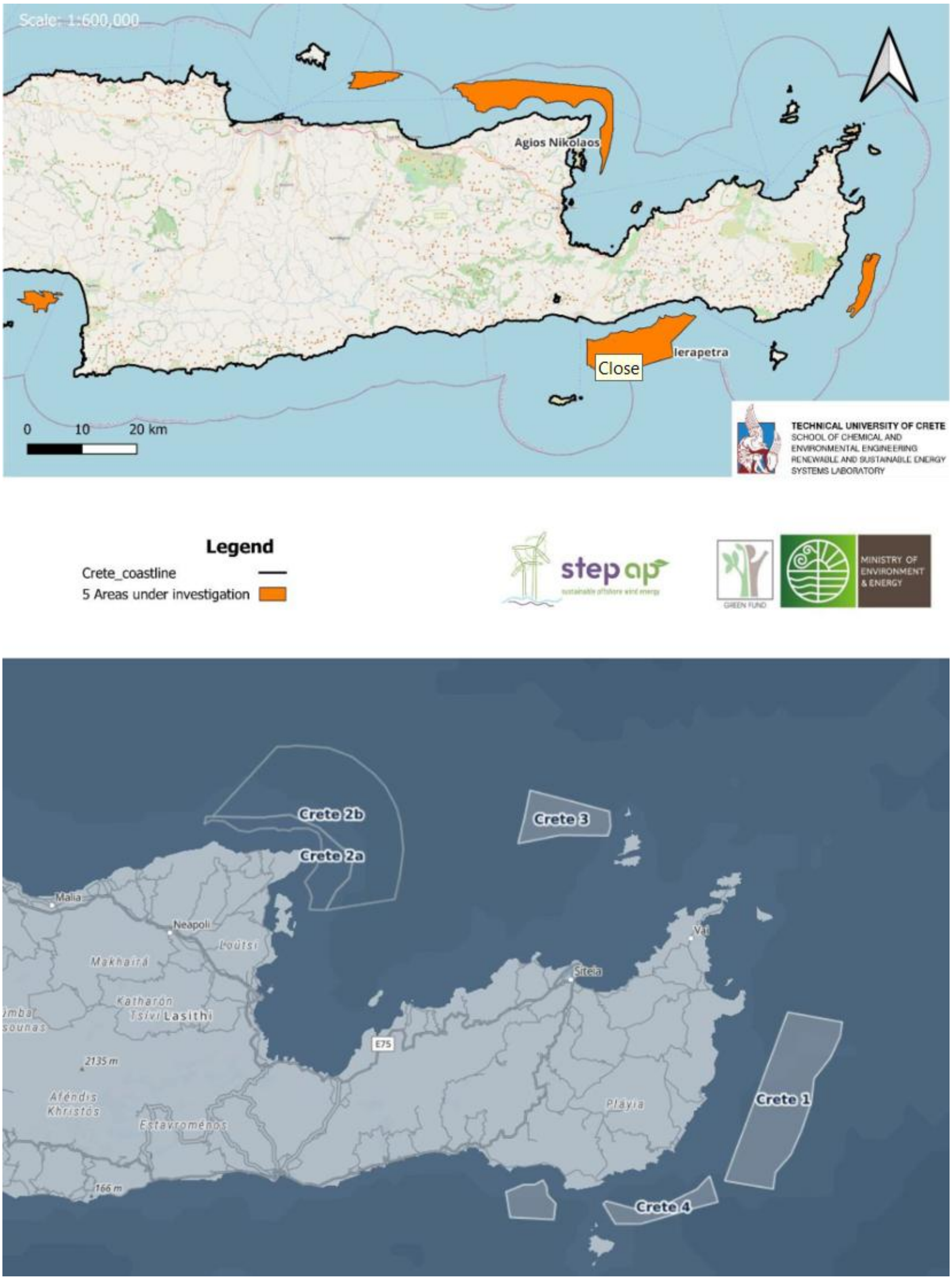

Figure 2. Indicative offshore wind development areas around Crete and selected offshore wind planning zones (Gkeka-Serpetsidaki et al., 2026).

Despite these positive long-term prospects, offshore wind development south of Crete remains associated with substantial infrastructure and implementation challenges. Offshore wind projects generally require long development timelines, often ranging between six and ten years from initial planning to commercial operation (Williams et al., 2025). This reflects the complexity of licensing procedures, environmental impact assessments, financing arrangements and offshore supply-chain requirements. Grid connection infrastructure represents one of the most important technical and economic considerations, requiring offshore substations, inter-array cables and export cables linking offshore facilities to the mainland network. Transmission distance, export-cable requirements and grid-integration needs may significantly affect project costs, particularly in island systems and deep-water regions such as Crete (Faraggiana et al., 2024).

The strategic importance of offshore renewable energy development is further reinforced by the existing energy profile of Crete. The island experiences substantial seasonal fluctuations in electricity demand, mainly associated with tourism activity, while simultaneously remaining significantly dependent on conventional fossil-fuel-based electricity generation. Existing studies further indicate that the interconnection of Crete with mainland Greece has historically faced delays due to deep-water conditions, seismic activity and adverse weather conditions in the marine region between Crete and the Peloponnese (Christoforaki & Tsoutsos, 2017). In this context, offshore renewable energy development could contribute to improved long-term energy security, greater diversification of the national energy mix and reduced dependence on imported fossil fuels. Offshore wind development has therefore increasingly been examined as a strategic option for Mediterranean island systems seeking greater energy autonomy and long-term decarbonisation.

Despite favourable long-term projections, offshore wind deployment south of Crete remains associated with technical, financial and logistical constraints. Floating offshore wind development requires specialised offshore engineering capabilities, including mooring systems, anchor deployment, offshore assembly operations and subsea infrastructure connections. Installation and maintenance activities depend on specialised vessels, suitable weather conditions and supporting port infrastructure, increasing both operational complexity and investment requirements. Maintenance costs are further influenced by offshore distance, environmental conditions and platform characteristics (Faraggiana et al., 2024).

Finally, offshore wind development in Greece is also shaped by important regulatory and spatial-planning considerations. The Greek legislative framework for offshore renewable energy development requires consideration of biodiversity protection, cultural heritage, marine ecosystems, coastal landscape impacts and human maritime activities (Tsoutsos et al., 2015). Existing legislation further establishes exclusion zones, setback distances and environmental assessment requirements for offshore wind projects (MEECC, 2008). Existing studies emphasize that renewable energy infrastructure, despite its environmental advantages, still requires careful spatial planning and sustainability-oriented policy design.

4.1.2 Environmental and Social Impacts

The marine environment surrounding Crete includes ecologically sensitive habitats and protected biodiversity zones that introduce important environmental constraints for offshore wind development. Existing studies identify Posidonia meadows, coral reefs and Special Protection Areas (SPA) for avifauna as environmentally significant ecosystems requiring careful spatial planning and environmental assessment (Christoforaki & Tsoutsos, 2017; Gkeka-Serpetsidaki & Tsoutsos, 2022). Posidonia meadows are considered particularly important for the Mediterranean marine ecosystem due to their role in biodiversity protection, carbon sequestration and coastal erosion reduction. However, these ecosystems are highly sensitive to human intervention and therefore constitute important exclusion zones for offshore infrastructure development (Duarte et al., 2010; Gkeka-Serpetsidaki & Tsoutsos, 2022).

Environmental restrictions related to Natura 2000 areas, migratory bird routes and protected marine habitats significantly influence offshore wind siting decisions in Crete. The literature emphasizes that offshore wind development may generate underwater and aerial disturbances affecting marine flora, fauna and coastal biodiversity (European Commission, 2000; Greek Legislation, 2017). In addition, construction activities associated with offshore wind projects, including pile-driving operations, increased vessel traffic and seabed intervention, may generate underwater acoustic disturbance affecting marine mammals, fish populations and other sensitive marine species (Kaldellis et al., 2016).

Although most offshore wind environmental studies originate from the North Sea, their findings remain useful for understanding potential impacts in other marine environments. Existing international studies indicate that offshore wind infrastructure may influence marine ecosystems through underwater noise, turbine movement, habitat alteration and modifications to migration behaviour of marine and avian species (Gill et al., 2020; Kaldellis et al., 2016). Additional environmental concerns are associated with submarine transmission cables, as electromagnetic fields generated during electricity transmission may influence the orientation and behaviour of certain marine organisms.

At the same time, several studies suggest that offshore wind infrastructure may also generate positive ecological effects under specific conditions. Offshore turbine foundations and scour protection systems may function as artificial reefs, creating new habitats for benthic organisms and increasing local biodiversity around the structures (Kaldellis et al., 2016). Nevertheless, the overall ecological outcome remains highly site-specific and dependent on the characteristics of the marine environment, construction practices and long-term operational management.

Social and spatial-planning considerations also constitute important factors in offshore wind development south of Crete. Coastal tourism, fisheries, maritime transport and visual impacts may generate local opposition and create competition for marine space in tourism-dependent regions (García-Doce & Bermúdez Pérez, 2024). Offshore infrastructure may therefore require adjustments to fisheries activities and navigation routes, highlighting the importance of marine spatial planning.

Visual disturbance associated with offshore wind farms constitutes an important consideration in tourism-oriented coastal regions of Crete, where landscape quality and coastal aesthetics represent important economic assets. Existing studies indicate that public acceptance generally improves as offshore wind farms are located further from the shoreline, reducing direct visual exposure from coastal settlements and tourist areas (Kaldellis et al., 2016). Similarly, offshore projects generally demonstrate higher levels of social acceptance compared to onshore wind developments due to their greater distance from populated areas and reduced direct acoustic disturbance. Nevertheless, public attitudes toward offshore wind development remain strongly dependent on project location, tourism intensity and local perceptions regarding environmental and landscape impacts.

International literature highlights the importance of integrated environmental planning, continuous scientific monitoring and cross-jurisdictional cooperation to address remaining knowledge gaps regarding long-term ecosystem impacts and biodiversity protection (Gill et al., 2020). Despite these environmental and spatial-planning challenges, offshore wind development remains associated with substantially lower operational greenhouse gas emissions compared to conventional fossil-fuel-based electricity generation.

Despite its contribution to renewable electricity generation, offshore wind development should not be regarded as an impact-free activity. Potential effects on marine ecosystems, fisheries, navigation routes, tourism and landscape perception require careful assessment and mitigation throughout the project lifecycle. Nevertheless, compared to offshore hydrocarbon extraction, these impacts are generally considered more manageable through environmental planning, monitoring and regulatory oversight, while remaining more compatible with long-term decarbonisation and climate-policy objectives.

Consequently, comprehensive Environmental Impact Assessment (EIA) procedures and marine spatial planning are considered essential for minimizing conflicts between offshore wind development, biodiversity protection, fisheries, tourism and other maritime activities.

4.1.3 Strategic Assessment (SWOT and PESTEL Summary)

Existing offshore spatial-planning studies identify marine areas south of Crete that overlap with hydrocarbon exploration and exploitation zones, highlighting the emerging strategic competition between offshore renewable energy development and conventional energy activities in the Eastern Mediterranean. At the same time, offshore wind development around Crete must consider additional spatial and operational constraints, including military exercise zones, shipping routes, airport safety corridors and underwater cable infrastructure. Despite these challenges, Crete is widely regarded as one of the most strategically important regions for offshore wind development in Greece due to its strong wind potential, proximity to high-voltage infrastructure and significance within future regional interconnection and energy-transition projects. Based on the technical, economic, environmental and social findings presented in the previous sections, the offshore wind development scenario south of Crete can be further evaluated through SWOT and PESTEL frameworks in order to assess its broader strategic implications.

Table 3. Strategic strengths and weaknesses of offshore wind development south of Crete.

Strengths	Weaknesses
Strong offshore wind potential and favourable wind conditions in southern and southeastern Crete	High upfront capital expenditure (CAPEX) and infrastructure costs
Deep-water conditions suitable for floating offshore wind technology	Floating offshore wind technology remains less mature than fixed-bottom systems
Alignment with EU climate policy, decarbonisation targets and the Greek energy transition strategy	Long permitting, licensing and development timelines
Potential contribution to long-term energy security and reduced fossil-fuel dependence	Grid connection complexity and dependence on transmission infrastructure
Strategic location within the Eastern Mediterranean energy system	Significant operation and maintenance (O&M) requirements in deep-water environments
Potential integration with future interconnection and offshore energy infrastructure projects	Limited existing domestic offshore wind supply chain and operational experience in Greece
Lower operational greenhouse gas emissions compared to fossil-fuel-based electricity generation	High financial uncertainty during early-stage market development

Beyond the internal strengths and weaknesses associated with offshore wind development south of Crete, additional external opportunities and threats may significantly influence the long-term viability and strategic implementation of offshore renewable energy projects in the region.

Table 4. Strategic opportunities and threats associated with offshore wind development south of Crete.

Opportunities	Threats
Increasing EU financial support for renewable energy and offshore infrastructure	Environmental restrictions associated with Natura 2000 areas and marine biodiversity protection
Technological improvement and future cost reduction of floating offshore wind systems	Potential local opposition related to tourism, fisheries and visual impacts
Development of new offshore engineering, port and maritime industries in Greece	Spatial competition with hydrocarbon exploration and exploitation activities
Potential strengthening of Greece's strategic role in the Eastern Mediterranean energy transition	Delays related to permitting procedures, environmental assessments and marine spatial planning
Contribution to island energy autonomy and diversification of electricity generation	Macroeconomic instability and investment uncertainty
Expansion of regional interconnection infrastructure and offshore energy corridors	Operational challenges associated with deep-water installation and maintenance
Potential future integration with hydrogen and offshore renewable energy systems	Climate-related risks and extreme weather conditions affecting offshore infrastructure

In addition to the internal characteristics identified through the SWOT analysis, offshore wind development south of Crete is also influenced by broader political, economic, social, technological, environmental and legal factors, as summarized in the following PESTEL analysis.

Table 5. PESTEL analysis of offshore wind development south of Crete.

Factor	Strategic Implications
Political	Strong alignment with EU Green Deal objectives, Greek National Energy and Climate Plan (NECP) targets and broader European decarbonisation policies. Offshore wind development is increasingly supported through renewable-energy transition strategies and regional energy-security initiatives.
Economic	Offshore wind development involves high investment requirements, substantial infrastructure costs and long development timelines. However, future reductions in floating wind costs and increasing competitiveness of renewable electricity may improve long-term economic viability. Potential economic benefits include investment attraction, employment generation and development of offshore engineering industries.
Social	Public acceptance remains influenced by tourism activity, visual impacts, fisheries concerns and coastal landscape protection. Offshore projects

Factor	Strategic Implications
	generally demonstrate higher social acceptance than onshore wind farms, although local opposition may still emerge in tourism-dependent regions of Crete.
Technological	Floating offshore wind technology enables deployment in deep-water regions unsuitable for conventional fixed-bottom systems. Nevertheless, the technology remains relatively immature compared to established offshore wind solutions and requires specialised engineering capabilities, offshore vessels and advanced grid infrastructure.
Environmental	Offshore wind development may contribute significantly to greenhouse gas emission reduction and long-term decarbonisation objectives. However, environmental concerns remain associated with marine biodiversity, Natura 2000 areas, underwater noise, migratory species, fisheries and seabed disturbance during construction and operation phases.
Legal	Offshore wind development in Greece is regulated through spatial-planning legislation, environmental permitting procedures and marine protection frameworks. Existing legislation imposes exclusion zones, environmental assessment requirements and restrictions related to military areas, shipping routes, cultural heritage sites and protected ecosystems.

Overall, the SWOT and PESTEL analyses indicate that offshore wind development south of Crete presents substantial long-term strategic potential, particularly in relation to energy diversification, decarbonisation and regional energy security. However, the analysis also demonstrates that successful deployment depends on overcoming important technological, environmental, financial and spatial-planning challenges. Consequently, offshore wind development in the region requires balanced policy implementation, effective marine spatial planning and long-term infrastructure investment in order to support sustainable offshore renewable energy deployment.

4.2 Hydrocarbon Extraction South of Crete

This section presents the hydrocarbon extraction scenario south of Crete based on the secondary data sources and analytical framework outlined in Chapter 3. The analysis examines the resource potential and economic prospects associated with offshore hydrocarbon exploration in the region, followed by an assessment of the main environmental risks and geopolitical considerations linked to offshore oil and gas activities in the Eastern Mediterranean. The section concludes with a strategic evaluation through SWOT and PESTEL frameworks, providing a structured overview of the opportunities, limitations and broader strategic implications of hydrocarbon development south of Crete.

In recent years, offshore areas south and southwest of Crete have attracted increasing exploration interest due to their geological characteristics, strategic location and potential contribution to regional energy diversification. International energy companies and Greek energy stakeholders have intensified exploration initiatives in the broader Eastern Mediterranean region, particularly following major natural gas discoveries in neighbouring offshore provinces. Nevertheless, hydrocarbon exploration south of Crete remains at a preliminary stage, while significant geological uncertainty, ultra-deepwater operational complexity and environmental concerns continue to influence the long-term viability of large-scale offshore hydrocarbon development.

4.2.1 Resource Potential and Economic Prospects

Hydrocarbon exploration south of Crete has attracted increasing scientific, economic, and geopolitical interest, largely due to the island's strategic position within the Eastern Mediterranean energy corridor. Situated between the hydrocarbon-producing regions of North Africa, Cyprus and the Levant Basin, Crete occupies a strategically important position within the Eastern Mediterranean energy system. (Bruneton et al., 2012). The discovery of substantial offshore natural gas reserves in the Eastern Mediterranean during the 2000s and early 2010s significantly heightened the region's geopolitical and economic significance within both European and global energy markets. In this context, the Eastern Mediterranean has emerged as a potential alternative hydrocarbon supplier for the European Union, amid growing European efforts to diversify natural gas imports and reduce reliance on Russian energy supplies. Offshore discoveries within the Exclusive Economic Zones (EEZs) of Cyprus, Israel, and Egypt have reinforced expectations that similar reserves might be found in neighbouring offshore areas, including south of Crete. Consequently, offshore hydrocarbon exploration around Crete has become increasingly linked to European energy-security and diversification strategies (Ellinas, 2022; Grigoriadis & Levoyannis, 2021).

Existing geological studies suggest that offshore southern Crete holds considerable hydrocarbon potential, particularly related to the Herodotus Basin and the Mediterranean Ridge systems (Bruneton et al., 2012; Maravelis et al., 2022; Zelilidis et al., 2016). The geological evolution of the Eastern Mediterranean is heavily shaped by the convergence of the African and Eurasian lithospheric plates, along with the tectonic interactions between the Anatolian and Aegean plates (McKenzie, 1972). Convergent tectonic environments are frequently associated with favourable conditions for hydrocarbon accumulation due to the presence of source rocks, reservoirs and structural traps (Kanasewich & Havskov, 1978; Mann et al., 2003). Consequently, offshore southern Crete is situated within a complex forearc basin system, structurally linked to the Mediterranean Ridge and the Hellenides thrust-and-fold belt (Hellenides TFB). These geological conditions are considered conducive to hydrocarbon generation and accumulation, despite the region's relatively low heat flow.

Particular interest has been directed toward the Mediterranean Ridge, which extends from the Ionian Sea around Crete toward the Eastern Mediterranean, following the subduction of the African Plate beneath the Aegean Plate (Kopf, 2003). The offshore region is notable for its thick Messinian salt deposits overlaying older carbonate and clastic formations, potentially creating structural and stratigraphic traps conducive to hydrocarbon accumulation. Geological investigations further indicate that some carbonate highs may have experienced subaerial exposure or developed Mesozoic pre-salt buildups. Additionally, post-Messinian sediments might serve as prospective reservoir formations. Offshore southern Crete, potential source rocks include Palaeozoic mudstones, shallow-marine carbonates, Cretaceous shales, as well as Neogene sapropels and mudstones, thereby enhancing the geological prospectivity of the region (HEREMA). Moreover, regional heat-flow values ranging from 40 to 60 mW/m^2, combined with burial depths exceeding 5 km within basin depocenters, suggest that hydrocarbon generation remains possible despite the region's relatively low thermal regime.

Beyond the broader tectonic framework, additional geophysical and seismic evidence also supports the hydrocarbon prospectivity of the area. Multichannel seismic surveys conducted in 2012 revealed seismic “bright spots” within carbonate build-ups, which may indicate the presence of gas-bearing sediments at depth. Geochemical analyses of methane emissions and mud-volcano activity in the Eastern Mediterranean further suggest the possible existence of thermogenic hydrocarbon systems offshore Crete (Cronin et al., 1997). Additional investigations have identified gas chimneys, pockmarks and other deep sedimentary features potentially associated with active petroleum systems offshore Crete (Loncke & Mascle, 2004). Regional geophysical studies have further identified several potential hydrocarbon plays south of Crete, including anticline structures and basin-related trapping systems (Kokinou et al., 2006; Leite & Mascle, 1982; Truffert et al., 1993). Despite these promising geological indicators and seismic anomalies, exploratory drilling has yet to confirm the existence of commercially recoverable hydrocarbon reserves. As a result, assessments of hydrocarbon potential south of Crete remain primarily geological and prospective, rather than definitively proven.

The strategic and economic significance of offshore hydrocarbon exploration south of Crete has grown considerably in recent years, following the official designation of offshore concession areas by the Greek government. The concession framework encompasses extensive offshore blocks south and southwest of Crete within the Libyan Sea. The “Southwest of Crete” concession alone covers approximately 19,868 km² and forms part of a broader offshore licensing system across Greece’s Eastern Mediterranean frontier. According to the Government Gazette of the Hellenic Republic (2017), offshore exploration rights are allocated through competitive international tender processes, enabling multinational energy companies to engage in long-term exploration and development initiatives. The legal framework divides hydrocarbon development into three primary operational phases: prospecting and seismic investigation, exploratory drilling, and eventual commercial exploitation if economically recoverable reserves are confirmed. Exploration licenses can last up to eight years and are structured into phased work-program periods, allowing operators to progressively assess geological prospects and decide whether to advance toward development or terminate exploration based on commercial viability.

Multiple multinational energy companies, including ExxonMobil and Chevron, have participated in offshore concession agreements south and southwest of Crete, focusing primarily on seismic exploration, geological evaluation and prospect assessment activities within frontier ultra-deepwater environments (Figure 3). According to Reuters (2024), the ExxonMobil-led consortium continues seismic research activities west and southwest of Crete, while more recent concession agreements between Chevron, HELLENiQ ENERGY and the Hellenic Republic expanded exploration interest toward the South Crete 1 and South Crete 2 offshore blocks. The awarded consortium, in which Chevron holds a 70% operating interest and HELLENiQ ENERGY 30%, secured exploration rights through an international tender process initiated by the Greek government in 2025. Chevron (2026) states that the agreements form part of the company's broader strategy to strengthen its exploration portfolio within the Eastern Mediterranean region, where it already maintains hydrocarbon assets and ongoing exploration activities offshore Israel, Cyprus and Egypt. Under the terms of the agreements, the consortium will conduct 2D and 3D seismic surveys during the initial exploration phase in order to evaluate the hydrocarbon potential of the concession areas south of Crete. Existing exploration activities already include approximately 1,334 km of offshore 2D seismic data acquired during a 2012 multi-client seismic campaign and subsequently reprocessed in 2018 using PSTM and PSDM methodologies. The concession areas are located within ultra-deepwater environments exceeding 1,500 m water depth, highlighting both the technological complexity and the substantial investment requirements associated with offshore hydrocarbon development in the region. Chevron's participation additionally expanded the total offshore concession area under exploration to approximately 47,000 km², increasing expectations regarding the possible identification of commercially exploitable hydrocarbon reserves in Greek offshore waters (HELLENiQ ENERGY, 2026).

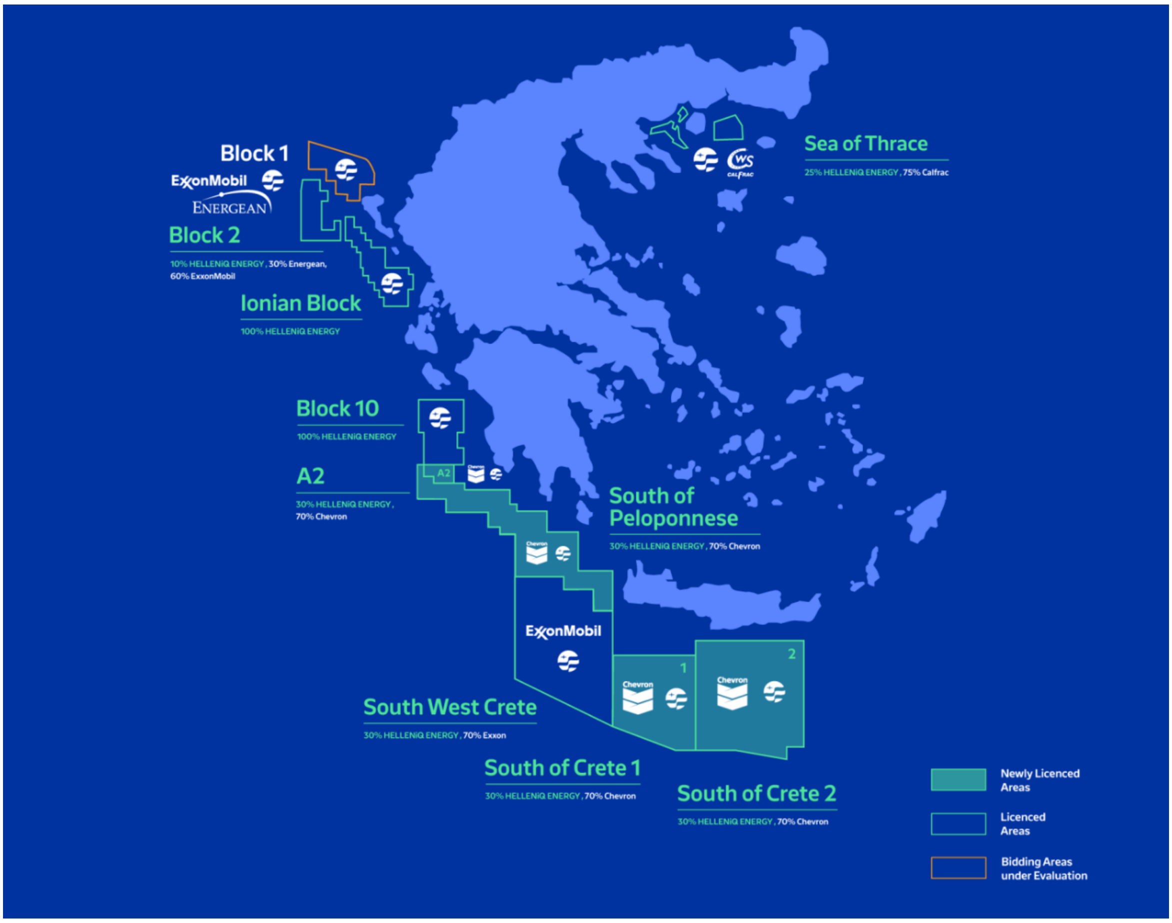

Figure 3. Offshore hydrocarbon concession areas and participating energy companies in Greece, including the offshore blocks south and southwest of Crete. Source: HELLENiQ ENERGY.

The economic prospects associated with hydrocarbon exploration south of Crete are closely linked to regional energy-security objectives and infrastructure development within the Eastern Mediterranean. Government authorities and energy stakeholders have highlighted the potential contribution of offshore hydrocarbons to energy diversification, reduced import dependence and enhanced energy security. Regional cooperation initiatives involving Greece, Cyprus, Israel and Egypt have also sought to facilitate the commercialization and transportation of Eastern Mediterranean gas resources to European markets. Proposed infrastructure projects include the EastMed pipeline, liquefied natural gas (LNG) facilities and regional interconnections designed to improve the commercial viability of regional gas resources. According to estimates presented during recent concession agreements, hydrocarbon production south of Crete could potentially begin between 2032 and 2035 if commercially viable reserves are confirmed. Offshore hydrocarbon development could also support employment, maritime activity and regional economic growth through the utilization of existing port infrastructure and offshore support services in Crete (HCMR et al., 2016).

Despite encouraging geological indications and increasing strategic interest, substantial economic and technical uncertainties continue to affect the long-term viability of hydrocarbon extraction south of Crete. The absence of confirmed commercially recoverable reserves, combined with ultra-deepwater operational challenges, high capital requirements and complex geological conditions, creates significant uncertainty regarding future project feasibility. Offshore development would require advanced deepwater technologies, extensive geophysical investigations and major infrastructure investments. Consequently, the realization of these resources remains dependent on exploration outcomes, technological progress, market conditions and the broader geopolitical and regulatory environment of the Eastern Mediterranean.

An additional source of uncertainty relates to the evolving European climate-policy framework and its potential implications for long-term hydrocarbon investments. Offshore hydrocarbon projects typically require lengthy exploration, appraisal and development phases before commercial production can begin. According to current estimates, production south of Crete could potentially commence between 2032 and 2035 if commercially viable reserves are confirmed. Under these conditions, future European decarbonisation policies, carbon-emission constraints and climate-neutrality objectives may influence the long-term economic value of new gas discoveries. This creates the possibility of stranded-asset risk, whereby investments made during the exploration and development phases may generate lower-than-expected returns if fossil-fuel demand declines more rapidly than anticipated. Furthermore, natural-gas production is associated with methane emissions, which are increasingly targeted by European climate policies due to their high global warming potential. Consequently, offshore hydrocarbon projects face growing exposure to regulatory, market and climate-policy risks, adding further uncertainty to their long-term economic competitiveness within the European energy-transition framework.

4.2.2 Environmental Risks and Geopolitical Considerations

Offshore hydrocarbon discoveries in the Eastern Mediterranean have intensified geopolitical tensions and transformed energy resources from a potential catalyst for regional cooperation into a source of strategic competition and political instability. Unresolved maritime-boundary disputes, particularly involving Cyprus and Turkey, have significantly increased the political risk associated with offshore energy investments. Although regional cooperation initiatives between Greece, Cyprus, Egypt and Israel strengthened during the last decade, regional instability has also affected the long-term viability of hydrocarbon monetization projects. Under these conditions, the extraction and transportation costs associated with offshore infrastructure projects such as the proposed EastMed pipeline remained relatively high for the European energy market (Doussis et al., 2022). Market volatility has further influenced investment decisions by multinational energy companies operating in the region. The geopolitical sensitivity of offshore hydrocarbon exploration south of Crete increased further after the signing of the Turkey–Libya maritime delimitation memorandum in 2019, which intensified tensions south of Crete and west of Cyprus and further deteriorated Greek–Turkish relations. EEZ-related confrontations gradually expanded toward Crete and the Dodecanese, highlighting the strategic complexity of offshore hydrocarbon activities in the broader Eastern Mediterranean region (Doussis et al., 2022; Grigoriadis & Levoyannis, 2021). At the same time, the hydrocarbon strategy south of Crete reflects the broader geopolitical importance of Greece within European energy diversification policies and the gradual reduction of European dependence on Russian natural gas imports. Nevertheless, the long-term feasibility of offshore hydrocarbon development continues to be influenced by geopolitical instability, environmental concerns and uncertainty regarding commercially recoverable reserves (Ellinas et al., 2022).

Beyond geopolitical considerations, offshore hydrocarbon exploration south of Crete is associated with substantial environmental and operational risks due to the geological and ecological characteristics of the region. The offshore areas south of Crete are located near the Hellenic Arc, one of the most seismically active zones in Europe, creating elevated risks for offshore drilling infrastructure and subsea installations. According to the Strategic Environmental Impact Assessment (SEIA), additional geohazards include submarine landslides, sediment instability, mud volcanoes and other seafloor hazards capable of affecting offshore infrastructure (HCMR et al., 2016). As the Mediterranean is classified as a MARPOL "Special Area", offshore operations are subject to strict environmental monitoring and waste-management requirements. The assessment also highlights significant uncertainty regarding deep-sea benthic ecosystems south of Crete, requiring site-specific Environmental Impact Assessments (EIAs) prior to drilling activities. Furthermore, accidental pollution events may have transboundary consequences extending beyond Greek waters and therefore require compliance with international environmental and offshore-safety regulations. According to WWF (2019), the cumulative ecological and economic impacts associated with regular operational pollution and small-scale offshore pollution incidents in Greek offshore hydrocarbon projects could reach approximately €1.2 billion over a 25-year period.

The operational complexity of ultra-deepwater drilling is further illustrated by the 2010 Deepwater Horizon accident in the Gulf of Mexico, where extraction operations at depths of approximately 1,522 m required several months to contain, while the long-term ecological consequences remain difficult to fully assess (Pallardy, 2010).

According to the SEIA evaluation framework (Adens Advanced Environmental Studies, 2018), offshore hydrocarbon exploration and production south of Crete may generate a wide range of environmental impacts, including marine ecosystem disturbance, underwater noise, seabed degradation, hydrocarbon contamination, atmospheric emissions and accidental spill risks. While most impacts are considered manageable under normal operating conditions, the assessment emphasizes that large-scale pollution incidents could have severe and long-lasting consequences, particularly within sensitive benthic ecosystems where environmental recovery may require many years. Additional concerns include impacts on coastal landscapes, maritime activities and water quality, as well as greenhouse-gas emissions associated with offshore operations. Despite these environmental and operational risks, the assessment also identifies potentially significant socioeconomic benefits, including improved energy security, reduced import dependence, employment creation and broader economic growth. Consequently, offshore hydrocarbon development south of Crete represents a complex balance between potential economic gains and environmental, operational and geopolitical risks within the Eastern Mediterranean.

4.2.3 Strategic Assessment (SWOT and PESTEL Summary)

The offshore hydrocarbon scenario south of Crete presents a complex combination of economic opportunities, geopolitical implications, environmental risks and technological challenges. Based on the analysis presented in Sections 4.2.1 and 4.2.2, offshore hydrocarbon development in the region can be strategically evaluated through SWOT and

PESTEL frameworks in order to assess its broader significance within the Greek and Eastern Mediterranean energy context.

Table 6. Strengths and Weaknesses of Offshore Hydrocarbon Development South of Crete.

Strengths	Weaknesses
Strategic location within Eastern Mediterranean energy corridor	No confirmed commercially recoverable reserves
Participation of ExxonMobil, Chevron and HELLENiQ ENERGY	Ultra-deepwater operational complexity (>1500 m)
Potential hydrocarbon prospectivity (Herodotus Basin, Mediterranean Ridge)	High exploration and infrastructure costs
Potential contribution to energy security	Geological uncertainty and tectonic complexity
Existing concession and seismic programs	Long development timelines

Table 7. Opportunities and Threats of Offshore Hydrocarbon Development South of Crete.

Opportunities	Threats
European energy diversification policies	EEZ disputes and geopolitical instability
Potential regional cooperation (Greece–Cyprus–Egypt–Israel)	Environmental risks and accidental spills
Future offshore infrastructure development	Decarbonization policies reducing fossil-fuel demand
Economic growth and employment creation	Volatile oil and gas prices
Advances in deepwater exploration technology	Potential social and environmental opposition

The SWOT analysis demonstrates that offshore hydrocarbon development south of Crete combines potentially significant strategic and economic opportunities with considerable geological, environmental and geopolitical uncertainty. While the participation of major multinational energy companies and the region's strategic position strengthen the investment outlook, unresolved maritime disputes, operational complexity and the global energy transition continue to challenge the long-term viability of large-scale offshore hydrocarbon exploitation. While the SWOT framework summarizes the main strategic advantages and limitations of offshore hydrocarbon development south of Crete, the PESTEL framework allows for a broader evaluation of the external political, economic, social, technological, environmental and legal factors influencing project feasibility.

Table 8. PESTEL Analysis of Offshore Hydrocarbon Development South of Crete.

Factor	Main Considerations
Political	EEZ disputes, Eastern Mediterranean geopolitics, EU energy-security policies
Economic	High capital investment requirements, potential GDP growth and energy diversification
Social	Employment opportunities, tourism concerns, local environmental sensitivity
Technological	Dependence on advanced seismic imaging and ultra-deepwater drilling technologies
Environmental	Marine ecosystem risks, greenhouse-gas emissions, spill hazards, waste-management requirements
Legal	UNCLOS framework, concession agreements, EU offshore-safety directives, EIA procedures

Overall, the PESTEL analysis indicates that offshore hydrocarbon development south of Crete is influenced by multiple interconnected factors extending beyond geology and energy economics. Political tensions, environmental constraints and legal obligations significantly affect project feasibility, while technological advances and European energy-security priorities continue to support exploration interest in the region.

4.3 Comparative Analysis of the Two Development Scenarios

The scenarios for offshore wind farm development and offshore hydrocarbon exploration south of Crete exemplify two distinct yet potentially complementary energy pathways within the broader context of Greek and Eastern Mediterranean energy strategies. Both options offer potential economic and strategic advantages for Greece; however, they also entail significant environmental, technological, and geopolitical considerations. While offshore hydrocarbon exploration could present future opportunities related to energy security, regional geopolitical influence, and potential economic benefits from commercially viable discoveries, its success remains contingent upon exploration outcomes, future market conditions, and long-term policy developments. Conversely, offshore wind energy development aligns more closely with current European decarbonization initiatives, rising electricity demand, and long-term renewable energy goals, benefiting from a more established technological and institutional framework.

This section offers a comparative assessment of these development pathways from economic, environmental, and strategic perspectives. The analysis extends beyond immediate profitability and energy production capacity to encompass broader considerations such as investment certainty, environmental sustainability, policy coherence, and the long-term strategic feasibility of each scenario within the evolving European energy-transition framework.

4.3.1 Economic and Financial Comparison

The offshore wind farm and offshore hydrocarbon development scenarios south of Crete present fundamentally different economic and financial characteristics, reflecting differences in technological maturity, investment certainty, operational complexity and long-term market conditions. Although both pathways involve high capital requirements and major offshore infrastructure development, their long-term feasibility and investment outlook are influenced by different economic and strategic factors.

Table 9. Comparative economic and financial characteristics of offshore wind and hydrocarbon development south of Crete.

Indicator	Offshore Wind	Offshore Hydrocarbon
CAPEX	~€1.6 million/MW	Multi-billion € project investments depending on reserve size and field development requirements
OPEX	~€0.05 million/MW/year	High operational expenditure
Decommissioning costs	~2% of CAPEX	High and project-specific
Development timeline	6–10 years	10–15+ years
Carbon-policy exposure	Low, Strong compatibility with EU funding and renewable-energy policies	High, Increasing financing uncertainty under decarbonization policies
Environmental-risk costs	Generally manageable through environmental planning and monitoring	Potentially >€1.2 billion over 25 years (WWF, 2019)
Geological uncertainty	Low–Moderate	High
Investment certainty	High policy and market visibility	Dependent on reserve confirmation and future market conditions

As shown in Table 9, offshore wind development south of Crete is associated with high initial investment requirements, particularly due to the deep-water conditions of the region and the corresponding dependence on floating offshore wind technologies. Major investment costs are linked to turbine manufacturing, floating foundations, mooring systems, subsea cables, offshore substations and grid-connection infrastructure. Nevertheless, offshore wind development benefits from increasing technological maturity, declining Levelized Cost of Energy (LCOE) trends and strong institutional support through European renewable-energy policies. Existing studies indicate that future floating offshore wind costs are expected to decrease progressively as economies of scale improve and technological innovation advances (Faraggiana et al., 2024). Furthermore, offshore wind development aligns closely with European decarbonization strategies, including the European Green Deal and REPowerEU, improving access to financial support mechanisms, investment incentives and long-term policy stability.

The growing electrification of modern economies further strengthens the strategic relevance of offshore renewable energy. According to the International Energy Agency (IEA, 2026), global electricity demand is expected to increase significantly in the coming decades due to electrification, electric vehicles, industrial demand and digital infrastructure expansion. Consequently, offshore wind development south of Crete is supported not only by climate-transition objectives, but also by broader long-term electricity-demand growth trends.

In contrast, offshore hydrocarbon development south of Crete is associated with potentially very high economic returns, while simultaneously involving considerably greater geological, commercial and geopolitical uncertainty. The hydrocarbon scenario remains largely dependent on the successful confirmation of commercially recoverable reserves through future exploratory drilling activities. Although seismic surveys, geological studies and regional analogues suggest promising hydrocarbon prospectivity within the Herodotus Basin and Mediterranean Ridge systems, no commercially viable offshore reserves have yet been confirmed south of Crete. As a result, the economic viability of the hydrocarbon pathway remains uncertain and highly speculative. Offshore drilling operations in ultra-deepwater environments exceeding 1,500 m would additionally require major investment in advanced drilling technologies, offshore infrastructure, seismic investigations and long-term production facilities under highly challenging marine conditions. Exploration activities are therefore characterized by elevated financial risk, long payback periods and uncertain return on investment.

At the same time, offshore hydrocarbon development may potentially generate important macroeconomic benefits if commercially exploitable reserves are eventually identified. Possible benefits include increased state revenues, employment creation, development of offshore support services and reduced dependence on imported hydrocarbons. Major multinational energy companies, including ExxonMobil, Chevron and HELLENiQ ENERGY, have already invested in seismic exploration programs and concession agreements south of Crete, demonstrating continued strategic interest in the hydrocarbon potential of the region.

Despite these potential benefits, offshore hydrocarbons face increasing long-term uncertainty associated with global decarbonization policies, carbon-emission reduction targets and the gradual transition toward low-carbon energy systems. Large-scale offshore hydrocarbon projects generally require extended development timelines, while future fossil-fuel demand within Europe may progressively decline under climate-neutrality objectives. Consequently, offshore hydrocarbon investments may face increasing exposure to market volatility, stranded-asset risk and future regulatory restrictions associated with climate policy.

Overall, the comparison demonstrates that the two energy pathways differ considerably in terms of economic certainty and long-term strategic positioning. Offshore hydrocarbon development south of Crete may potentially generate major economic returns in the event of commercially viable discoveries; however, the pathway remains highly dependent on uncertain geological outcomes, geopolitical stability and future market conditions. Offshore wind development, while associated with high initial investment requirements and technological challenges, currently represents a more predictable and institutionally supported energy pathway within the broader European energy-transition framework.

4.3.2 Environmental Impact Comparison

The offshore wind farm and offshore hydrocarbon development scenarios south of Crete are both associated with environmental impacts and spatial-planning challenges due to the ecological sensitivity of the Eastern Mediterranean marine environment. However, the nature, duration, scale and reversibility of these impacts differ considerably between the two energy pathways. While offshore wind development is mainly associated with localized marine disturbance and construction-related impacts, offshore hydrocarbon activities involve broader operational, pollution and accident-related risks with potentially long-term environmental consequences.

Table 10. Comparative environmental impacts of offshore wind and offshore hydrocarbon development south of Crete.

Offshore Wind Development	Offshore Hydrocarbon Development
Marine ecosystem disturbance during construction and operation	Spill, pollution and offshore accident risks
Visual and underwater acoustic impacts	Atmospheric emissions and greenhouse-gas contribution
Seabed intervention and cable-installation disturbance	Hydrocarbon contamination and drilling-related pollution
Mostly localized and partially reversible impacts	Potentially long-term or irreversible environmental consequences
Lower lifecycle greenhouse-gas emissions	High carbon footprint associated with fossil-fuel extraction and use
Stronger compatibility with EU climate-transition policies	Increasing pressure under decarbonization and climate-neutrality objectives
Impacts on fisheries, navigation and tourism activities	Potential impacts on fisheries, tourism and coastal ecosystems following accidental pollution

As shown in Table 10, offshore wind development south of Crete is primarily associated with environmental impacts related to marine ecosystems, underwater noise and spatial interactions with existing maritime activities. Construction activities such as pile-driving operations, seabed intervention, increased vessel traffic and submarine cable installation may disturb marine mammals, fish populations and benthic ecosystems, particularly within environmentally sensitive areas containing Posidonia meadows, coral habitats and protected Natura 2000 zones. Additional environmental concerns include underwater acoustic disturbance, electromagnetic-field effects from submarine transmission cables and potential impacts on avian migration routes and marine biodiversity (Gill et al., 2020; Kaldellis et al., 2016). Offshore wind farms may also generate visual impacts affecting tourism-oriented coastal regions, while fisheries and maritime transport routes may experience operational limitations due to offshore infrastructure deployment.

Nevertheless, the environmental impacts associated with offshore wind projects are generally considered more localized and manageable through marine spatial planning, Environmental Impact Assessment (EIA) procedures and continuous environmental monitoring. Existing studies additionally indicate that offshore wind infrastructure may under certain conditions generate positive ecological effects through the creation of artificial reef environments around turbine foundations and scour-protection systems, potentially supporting localized marine biodiversity and fish populations (Kaldellis et al., 2016). Most importantly, offshore wind energy remains associated with substantially lower operational greenhouse-gas emissions compared to fossil-fuel-based electricity generation, strengthening its compatibility with European climate and decarbonization policies.

In contrast, offshore hydrocarbon development south of Crete involves considerably broader environmental and operational risks due to the ultra-deepwater conditions and geological complexity of the region. Offshore drilling activities near the Hellenic Arc are exposed to elevated geohazard risks including submarine landslides, sediment instability, seafloor ruptures, mud volcanoes, gas hydrates and potential tsunami-related impacts affecting offshore infrastructure and maritime operations (HCMR et al., 2016). Additional environmental pressures are associated with drilling mud and cuttings disposal, produced-water discharge, hydrocarbon contamination, offshore waste management and increased maritime traffic related to support vessels and offshore installations. Atmospheric emissions generated during offshore operations, including CO_2, NOx and SOx emissions from vessels and gas-flaring activities, further contribute to greenhouse-gas emissions and climate-related impacts.

One of the most important differences between the two development pathways concerns the scale and reversibility of accidental environmental impacts. According to the Strategic Environmental Impact Assessment (SEIA) and related environmental evaluations, major offshore hydrocarbon spills or accidental releases south of Crete could generate severe long-term consequences for marine ecosystems, bathing-water quality, coastal landscapes and environmentally sensitive benthic habitats (Adens Advanced Environmental Studies, 2018). The transboundary nature of offshore pollution additionally increases environmental complexity, as accidental spills may affect broader Eastern Mediterranean marine systems beyond Greek maritime jurisdiction. WWF (2019) estimated that the cumulative ecological and economic impacts associated with operational pollution and small-scale pollution incidents in Greek offshore hydrocarbon projects could reach approximately €1.2 billion over a 25-year period. The operational risks of ultra-deepwater drilling are further illustrated by the 2010 Deepwater Horizon accident in the Gulf of Mexico, where drilling operations at depths of approximately 1,522 m required several months to contain while the long-term ecological consequences remain difficult to fully assess (Pallardy, 2010).

Overall, the comparison demonstrates that both offshore wind and offshore hydrocarbon development may generate important environmental impacts requiring careful environmental planning, monitoring and regulatory oversight. However, offshore hydrocarbon activities are generally associated with higher environmental risk intensity, broader pollution potential and more severe long-term consequences in the event of major accidents. Offshore wind development, despite its ecological and spatial-planning challenges, remains more compatible with long-term climate-transition objectives and lower-emission energy systems within the broader European decarbonization framework.

4.3.3 Strategic and Policy Implications

The comparative evaluation of offshore wind development and offshore hydrocarbon exploration south of Crete highlights two fundamentally different strategic energy pathways within the broader framework of Greek, European and Eastern Mediterranean energy policy. Although the two scenarios are not necessarily mutually exclusive, they differ significantly in terms of long-term sustainability, policy alignment, geopolitical implications and strategic certainty. Consequently, the comparison extends beyond economic and technical considerations to broader questions of energy security, sustainability and the future role of fossil fuels during the energy transition.

Offshore hydrocarbon exploration south of Crete has gained strategic importance primarily through its potential contribution to European energy diversification and regional geopolitical positioning. Following the deterioration of European–Russian energy relations, the Eastern Mediterranean emerged as a potentially important alternative energy corridor for Europe. Within this context, offshore hydrocarbon exploration activities involving multinational energy companies such as ExxonMobil, Chevron and HELLENiQ ENERGY strengthened the geopolitical importance of Greece within regional energy-security strategies. Potential hydrocarbon discoveries south of Crete could contribute to domestic energy supply, reduce import dependence and strengthen Greece's strategic role within the Eastern Mediterranean energy market.

At the same time, offshore hydrocarbon development is closely connected to broader geopolitical tensions and maritime disputes in the region. EEZ disputes involving Greece, Turkey, Cyprus and Libya, together with broader instability in the Eastern Mediterranean, continue to affect the political and economic feasibility of large-scale offshore hydrocarbon investments. The proposed EastMed pipeline project further highlighted both the strategic ambitions and geopolitical complexity associated with Eastern Mediterranean hydrocarbon monetization. Although hydrocarbons may provide important short- to medium-term energy-security benefits, the long-term strategic viability of large-scale fossil-fuel investments remains increasingly uncertain under evolving European decarbonization policies and climate-neutrality objectives.

In contrast, offshore wind development south of Crete aligns more directly with the long-term strategic direction of European energy policy. European initiatives such as the European Green Deal, Fit for 55 and REPowerEU emphasize decarbonization, renewable-energy expansion, electrification and reduction of greenhouse-gas emissions as central pillars of future European energy systems. Within this framework, offshore wind represents a strategically important renewable-energy technology capable of supporting long-term electricity generation, energy security and climate-transition objectives. The growing electrification of transport, industry and digital infrastructure further increases the strategic importance of renewable electricity production within future energy systems. According to the International Energy Agency (IEA, 2026), global electricity demand is expected to continue increasing significantly in the coming decades, reinforcing the long-term relevance of renewable electricity-generation technologies such as offshore wind energy.

Another important distinction between the two pathways concerns strategic certainty and implementation maturity. Offshore wind development already benefits from established European regulatory frameworks, financing mechanisms, technological experience and rapidly expanding international deployment. Although offshore wind projects south of Crete remain technically demanding, the underlying wind resource is measurable, continuously renewable and considerably more certain from an investment perspective. In contrast, offshore hydrocarbon development south of Crete remains largely dependent on the future confirmation of commercially recoverable reserves through exploratory drilling activities. While seismic surveys and geological studies indicate promising hydrocarbon prospectivity, the absence of confirmed commercially viable reserves introduces considerable uncertainty regarding the long-term feasibility and profitability of the hydrocarbon pathway.

Nevertheless, offshore hydrocarbons may continue to play an important transitional role within European and Greek energy systems during the coming decades. Natural gas is still considered a transitional fuel capable of supporting grid stability and energy security during the transition toward low-carbon energy systems. Consequently, offshore hydrocarbon exploration south of Crete cannot be dismissed entirely from a strategic perspective, particularly under conditions of growing global energy demand and continued geopolitical uncertainty within international energy markets.

Overall, the comparison demonstrates that offshore wind development and offshore hydrocarbon exploration represent different strategic approaches rather than strictly opposing energy pathways. Offshore hydrocarbons may potentially provide important geopolitical and economic benefits if commercially viable reserves are eventually confirmed, particularly in relation to energy security and regional strategic positioning. However, offshore wind development currently appears more compatible with long-term European decarbonization policies, increasing electricity demand and the broader transition toward sustainable energy systems. As a result, offshore wind energy presently represents the more institutionally supported and strategically predictable pathway within the evolving European energy-transition framework, while offshore hydrocarbons remain a potentially important but significantly more uncertain strategic opportunity for Greece and the Eastern Mediterranean region.

5. Conclusions

This study examined two alternative energy-development pathways south of Crete: offshore wind energy and offshore hydrocarbon exploration. The analysis evaluated their technical, economic, environmental, geopolitical and strategic dimensions within the broader context of European energy policy, energy security and the ongoing energy transition. Through the comparative assessment presented in Chapter 4, the study explored the opportunities, limitations and long-term implications associated with each development scenario.

The findings indicate that both pathways offer potential benefits for Greece but differ substantially in terms of strategic certainty, environmental sustainability and alignment with future European energy objectives. Offshore wind development is more closely associated with long-term decarbonisation policies, increasing electricity demand and the expansion of renewable energy systems, whereas offshore hydrocarbon exploration is primarily linked to energy-security considerations, regional geopolitics and the possibility of future economic gains from resource exploitation.

Although the two pathways are not necessarily mutually exclusive, they represent different approaches to addressing Greece's future energy needs. Offshore wind currently benefits from greater policy support, technological maturity and investment certainty, while offshore hydrocarbons remain dependent on the future confirmation of commercially recoverable reserves and are subject to significant geological, environmental and geopolitical uncertainties. The following sections summarise the principal findings of the study, discuss their implications for Greece's energy policy and identify areas for future research.

5.1 Summary of Key Findings

This study examined and compared two alternative energy-development pathways south of Crete: offshore wind farm development and offshore hydrocarbon exploration. The analysis demonstrated that both scenarios present important economic, strategic and geopolitical implications for Greece and the wider Eastern Mediterranean region, while also involving significant environmental, technological and regulatory challenges.

The findings indicate that offshore wind development south of Crete possesses significant long-term strategic potential due to the region's favourable wind resources and the suitability of floating offshore wind technology under deep-water conditions. Although offshore wind development remains associated with high capital expenditure, infrastructure requirements and environmental-planning challenges, the sector benefits from increasing technological maturity, declining Levelized Cost of Energy (LCOE) trends and strong alignment with European decarbonisation initiatives such as the European Green Deal and REPowerEU. In addition, increasing electricity demand driven by electrification and digitalisation further strengthens the strategic relevance of offshore renewable energy development.

At the same time, offshore hydrocarbon exploration south of Crete may provide economic and geopolitical opportunities, particularly in relation to energy security, regional energy diversification and Greece's strategic role within the Eastern Mediterranean energy system. Geological and geophysical studies indicate promising hydrocarbon prospectivity associated with the Herodotus Basin, Mediterranean Ridge and surrounding forearc basin systems. However, no commercially recoverable offshore hydrocarbon reserves have yet been confirmed south of Crete. Consequently, the hydrocarbon scenario remains associated with considerable geological uncertainty, high exploration costs, ultra-deepwater operational complexity and long-term investment risk.

The comparative analysis further demonstrated important differences between the two pathways regarding environmental impacts and long-term sustainability. Offshore wind development is primarily associated with localized marine disturbance, underwater acoustic impacts and spatial-planning challenges affecting fisheries, biodiversity and tourism activities. Nevertheless, these impacts are generally considered more manageable and partially reversible through environmental monitoring and marine spatial planning. In contrast, offshore hydrocarbon activities involve broader environmental risks associated with drilling operations, accidental spills, greenhouse-gas emissions and long-term marine pollution, particularly under the ultra-deepwater conditions characterizing the offshore areas south of Crete.

Overall, the findings suggest that offshore wind development is currently more compatible with European climate and energy-transition objectives and represents the more predictable and institutionally supported long-term pathway for Greece. Offshore hydrocarbons may still play a transitional role in future energy systems and provide potential geopolitical and economic benefits. However, the hydrocarbon pathway remains considerably more uncertain due to unresolved geological, environmental, geopolitical and market-related factors.

5.2 Strategic Implications and Recommendations for Greece's Energy Policy

The findings of this study suggest that Greece's long-term energy strategy should seek to balance energy security, economic development and decarbonization objectives within the evolving European and Eastern Mediterranean energy landscape. The comparative analysis demonstrated that offshore wind development and offshore hydrocarbon exploration represent distinct strategic pathways with different levels of certainty, technological maturity and policy alignment. Consequently, future Greek energy policy should avoid treating the two scenarios as strictly opposing alternatives and instead pursue a diversified and flexible energy strategy capable of adapting to future geopolitical, environmental and market developments.

The analysis indicates that offshore wind development currently represents the more strategically predictable and institutionally supported pathway within the broader European energy-transition framework. European initiatives such as the European Green Deal, Fit for 55 and REPowerEU increasingly prioritize renewable electricity generation, electrification and greenhouse-gas emission reduction as central components of future energy systems. At the same time, the continuously increasing demand for electricity associated with electrification, transport transformation and digital infrastructure expansion further strengthens the strategic importance of offshore renewable energy. Under these conditions, Greece possesses a significant opportunity to strengthen long-term energy security and strategic autonomy through offshore wind development, particularly by utilizing the floating offshore wind potential of the southern Cretan maritime region.

At the same time, offshore hydrocarbon exploration south of Crete may continue to retain strategic importance within future Greek and European energy policy, especially in relation to transitional energy security and regional geopolitical positioning. Although the hydrocarbon pathway remains highly uncertain due to the absence of confirmed commercially recoverable reserves, continued exploration activities may contribute to improving geological knowledge, strengthening Greece's strategic role within the Eastern Mediterranean and potentially supporting future energy diversification. Natural gas may additionally continue to play a transitional role within European energy systems during the coming decades, particularly in relation to grid stability and supply security during the gradual transition toward lower-carbon electricity systems.

Nevertheless, the analysis demonstrated that offshore hydrocarbon development south of Crete is associated with significantly higher environmental, geopolitical and financial uncertainty compared to offshore wind development. Consequently, future Greek energy policy should approach offshore hydrocarbon exploration with cautious long-term planning, strict environmental oversight and realistic expectations regarding future commercial viability. Particular emphasis should be placed on Environmental Impact Assessments (EIAs), offshore safety standards and integrated marine spatial planning in order to reduce ecological risks within the sensitive marine ecosystems of the Eastern Mediterranean.

Overall, the findings suggest that Greece should prioritise offshore renewable-energy development while maintaining strategic flexibility regarding future hydrocarbon exploration. Such an approach would support long-term decarbonisation objectives while preserving potential opportunities associated with future hydrocarbon discoveries.

5.3 Limitations of the Study and Directions for Future Research

This study was primarily based on secondary data sources, including academic literature, policy documents, environmental assessments and industry reports related to offshore wind development and hydrocarbon exploration south of Crete. Consequently, the analysis remains dependent on the availability, quality and reliability of existing published information rather than project-specific engineering, financial or operational datasets. In addition, offshore energy development in Greece remains at a relatively early stage, particularly regarding floating offshore wind technologies and ultra-deepwater hydrocarbon exploration. As a result, several assumptions within the study were based on indicative regional assessments and comparative international studies rather than confirmed commercial project data.

Another important limitation concerns the uncertainty surrounding offshore hydrocarbon potential south of Crete. Although existing geological and geophysical studies indicate promising hydrocarbon prospectivity, no commercially recoverable reserves have yet been confirmed through exploratory drilling activities. Consequently, the long-term economic viability of the hydrocarbon scenario remains highly uncertain and subject to future exploration outcomes, technological developments and global energy-market conditions.

The study is also influenced by the rapidly evolving nature of European energy policy, geopolitical developments and climate-transition objectives. Future changes in energy prices, carbon regulations, technological innovation, regional geopolitical stability and European decarbonization policies may significantly affect the comparative feasibility of both development pathways.

Future research could therefore focus on more detailed techno-economic modelling of floating offshore wind deployment south of Crete, including grid integration, infrastructure costs and long-term electricity-market scenarios. Additional research may also examine detailed reservoir assessment, exploratory drilling results and offshore geological modelling associated with hydrocarbon prospectivity in the Eastern Mediterranean. Finally, future studies could further investigate integrated energy-transition scenarios combining renewable energy, natural gas and regional energy-security strategies within the broader Eastern Mediterranean region.

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