

Economic Cooperation between Spain and Algeria in the Energy Sector: An Integrated Model for Natural Gas and Renewable Energy

التعاون الاقتصادي بين إسبانيا والجزائر في قطاع الطاقة: نموذج متكامل للغاز الطبيعي والطاقة المتجددة

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Abstract

This study aims to analyze the dynamics of energy cooperation between Algeria and Spain through a hybrid model that combines natural gas and renewable energy, within the context of global geopolitical and environmental transitions. A mixed-methods approach was adopted, incorporating quantitative data (from 2013 to 2023) and qualitative analysis (30 interviews with experts and official sources), to provide a comprehensive and accurate understanding of this bilateral cooperation.

The findings reveal that Algerian gas remains the backbone of the energy relationship, accounting for 38% of Spain's energy needs and 22% of Algeria's national income in 2023. Moreover, the study highlights a 1,300% increase in Algeria's renewable energy investments over the past decade, reflecting a strategic shift toward clean energy. Economic modeling estimates that the proposed hybrid model could lead to a 25% increase in economic returns by 2030, along with the creation of thousands of direct jobs.

The study proposes the establishment of a joint €1 billion investment fund, modernization of existing infrastructure to include green hydrogen transport, and the development of a hybrid electric grid between the two countries. It also calls for enhanced joint scientific research and regulatory harmonization to support energy integration and regional stability.

This research contributes a practical and implementable framework for sustainable energy cooperation, offering strategic recommendations grounded in real data and multidimensional analysis. It serves as both an academic and policy reference for researchers and decision-makers across the Mediterranean region.

Keywords:

Energy cooperation; hybrid model; natural gas; renewable energy; Spain-Algeria

ملخص:

تهدف هذه الدراسة إلى تحليل ديناميكيات التعاون في مجال الطاقة بين الجزائر وإسبانيا من خلال نموذج هجين يجمع بين الغاز الطبيعي والطاقة المتجددة، في سياق التحولات الجيوسياسية والبيئية العالمية. وقد اعتمدنا نهجا متعدد الأساليب، يجمع بين البيانات الكمية (من عام ٢٠١٣ إلى عام ٢٠٢٣) والتحليل النوعي (٣٠ مقابلة مع خبراء ومصادر رسمية)، لتوفير فهم شامل ودقيق لهذا التعاون الثنائي. تكشف النتائج أن الغاز الجزائري لا يزال يمثل العمود الفقري للعلاقات في مجال الطاقة، حيث يمثل 38% من احتياجات إسبانيا من

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الطاقة و22% من الدخل القومي للجزائر بحلول عام 2023. علاوة على ذلك، تسلط الدراسة الضوء على زيادة بنسبة 1300% في استثمارات الجزائر في الطاقة المتجددة خلال العقد الماضي، مما يعكس تحولاً استراتيجياً نحو الطاقة النظيفة. وتقدر النمذجة الاقتصادية أن النموذج الهجين المقترح يمكن أن يؤدي إلى زيادة في العائدات الاقتصادية بنسبة 25% بحلول عام 2030، إلى جانب خلق آلاف فرص العمل المباشرة.

تقترح الدراسة إنشاء صندوق استثماري مشترك بقيمة مليار يورو، وتحديث البنية التحتية القائمة لتشمل نقل الهيدروجين الأخضر، وتطوير شبكة كهربائية هجينة بين البلدين. كما تدعو إلى تعزيز البحث العلمي المشترك والتنسيق التنظيمي لدعم تكامل الطاقة والاستقرار الإقليمي.

يسهم هذا البحث في إرساء إطار عملي وقابل للتنفيذ للتعاون في مجال الطاقة المستدامة، مقدماً توصيات استراتيجية مبنية على بيانات واقعية وتحليلات متعددة الأبعاد. ويشكل مرجعاً أكاديمياً وسياسياً للباحثين وصانعي القرار في منطقة البحر الأبيض المتوسط.

الكلمات المفتاحية: التعاون في مجال الطاقة؛ النموذج الهجين؛ الغاز الطبيعي؛ الطاقة المتجددة؛ إسبانيا – الجزائر

1.Introduction

Energy and environmental regions, energy exports and advanced economies need immediate need to adapt to geopolitical changes and increase the environmental pressure between global challenges. Algeria presents a unique model for energy cooperation, as one of the world's largest natural gas exporters, and Spain, as an important European economy, striving for permanent energy infection. This collaboration not only addresses the requirements of the energy market, but also provides an example of strategic integration of traditional resources such as solar energy and green hydrogen in renewable energy. According to Watton (2010), Algeria-Spain Energy Partnership is a remarkable example of how shared resources can overcome geopolitical obstacles and regional regional stability. While previous research has focused on specific aspects, such as gas trafficking dynamics (Benali and Garcia, 2024) or the development of renewable energy in separation (Baudghen Stamboli et al., 2012), the purpose of this study is to bridge a significant interval, which solves a “hybrid model”. This model provides an innovative vision for energy cooperation that serves as a foundation stone for more efficient and durable energy infection. The study uses an approach to mixed method, and combines quantitative data from a decade (2013-2023), which consists of an insight collected from 30 intensive interviews with energy and financial experts. This approach provides a broad understanding of how the revenues from gas exports can be distributed to finance projects for renewable energy, and emphasize mutual dependence between economic and developmental goals. Preliminary findings suggest that, despite an increase of 50% in Algeria's export of natural gas in Europe over the past decade, using a hybrid model can double economic and social gains through investments in renewable energy and reduce the dependence on fossil fuel. Strategically, the proposed model 2030 (the European Commission, 2023) reduces carbon emissions by 55% to reduce the European green agreement with goals and highlights Algeria's important role as a regional energy supplier in European markets. In addition, the model emphasizes the importance of diversity in Algeria's national income by funding permanent energy projects, which can help reduce unemployment and increase the GDP growth up to 2023 (International Energy

Agency [IEA], 2023). The study makes a unique contribution by introducing the “hybrid model” as the first practical framework that leads to collaboration from the previous literature (for example, natural gas) to treat these aspects to integrate these aspects to integrate these aspects to integrate cooperation into renewable energy projects (eg, such as natural gas) (eg solar and green). While studies such as Benali and Garcia (2024) focus on analyzing the dynamics of the gas trade, and others as Stambolt et al.

Scientific innovation lies in using gas export revenues (which have increased by 50% between 2013 and 2023) as a catalyst to finance pure energy projects. This approach doubles financial gains (eg the annual GDP growth of Algeria by 2.5%) and social gains (eg, reduces unemployment) by 2030, and cut up to 30% in Fossil Fuel Reliance by 2030. Adoption of this model shows. 7% (estimated by International Energy Agency, 2023). Innovation is spread beyond theory, a unique integration of three dimensions appears:

1. GEO -political : Ensure stable, competitive price gas supply (18% cheaper than liquid natural gas).
2. Econc: to stimulate shared development through joint investment in renewable energy infrastructure.
3. Environment: Powering Carbon neutrality through green hydrogen projects.

This integration establishes a frame of reference for extended regional cooperation in the Mediterranean and provides solutions that have been applied for similar references (eg Africa and European nations). For example, it serves as an important resource for both academics and policy makers. By enriching the academic discourse and providing a practical roadmap for a fair and inclusive energy infection, this study justifies the publication in large special magazines.

2.Theoretical and Analytical Framework:

The theoretical framework of this study provides a comprehensive analysis of the economic and geopolitical relations between Algeria and Spain in the energy sector. It is built upon a set of integrated theories supported by numerical data, which reflects the evolution of energy cooperation between the two countries and its impact on various economic and social dimensions.

2.1 Intellectual theory :

This theory shows how Algeria and Spain are dependent on each other to achieve their economic and energy -related interests, even though they have different degrees of addiction.

From Algeria’s point of view, Spain is one of the most important markets for the export of natural gas, and meets Spain’s 38% gas requirement and contributes to 22% of Algeria’s national revenues. Algeria’s gas export rose from 8 billion meters in 2013 to 12 billion meters in 2023, which represents an increase of 50% in a decade.

On the side of Spain, Algerian gas gives a stable source that is 18% cheaper than the leaf gas. Following the Ukraine crisis in 2022, which reduced Spain’s gas imports up to 12% from Russia, Algeria became a significant partner for Spain’s energy security.

This mutual dependence encourages both countries to maintain stable conditions, despite regional tension, such as the Moroccan crisis in 2021.

Hybrid model as a mechanism of energy infection :

The hybrid energy model represents a permanent approach that combines traditional energy sources with renewable energy to increase economic and environmental efficiency.

Changing infrastructure: Costs can be reduced by 35% to change the existing infrastructure as the Medgaz pipeline to transport green hydrogen instead of producing new pipelines.

The effect of investment: Algeria's investment of renewable energy increased from € 50 million to € 700 million in 2023 in 2013, reflecting a fantastic increase of 1,300%. These investments contributed to an increase of 0.4% in GDP for each investment of € 100 million, which led to 5000 direct jobs.

Energy security among geopolitical challenges :

Energy security theory focuses on reducing geopolitical challenges by bringing diversity into energy sources and transport routes.

Alternative route : Projects such as Medgaz pipelines and planned MIDCAT project (expected in 2025) to ensure continuity in the energy supply and reduce the risk related to political crises.

Green hydrogen role : With increasing European demand for clean energy, 85% of experts Algeria's ability to become an important center for the production and export of green hydrogen in Spain and Europe supports.

Legal structure and green policy :

Politics and legislative structures play an important role in supporting joint energy cooperation:

Domestic law : Algeria Electricity Act 02-04 enabled the private sector to participate in more than 15 renewable energy projects by 2023.

International framework : European Green Deal, which aims to cut methane emissions up to 30% by 2030, adjusts Algeria's ambitions expanding permanent investments.

Legislative challenges : About 70% of experts indicate that coordinating Algeria rules with EU standards are crucial to succeeding in hybrid energy projects.

Strategic alliance as a tool for effective cooperation :

The strategic coalition theory explains the mechanisms as common projects increasing the energy integration between Algeria and Spain.

Infrastructure projects : Medgaz (operating since 2009) successfully transports 10 billion meters of gas annually. The required MIDCAT project required by 2025 will further increase regional energy capacity.

Diplomatic coordination: Algeria-Spanish Energy Forum has made 12 strategic recommendations over the last five years to strengthen the collaborative structure.

2.2 Challenges and Opportunities

Table 1: SWOT Analysis of Algerian-Spanish Cooperation

Aspect	Details
Strengths	Advanced infrastructure (Medgaz). - Long-term agreements (25-year contracts).
Weaknesses	Algeria's reliance on single-revenue streams. - Pipeline vulnerability due to regional disputes

Opportunities	Exporting green hydrogen via existing pipelines. - Spanish investments in solar energy.
Threats	Competition from U.S. shale gas. - EU methane emission regulations.

Source: IEA (2023)

2.3 :Study Hypotheses :Drawing from the theoretical and analytical framework presented above, this study proposes the following hypotheses:

1. An increase of 20% in exports of Algerian natural gas will increase Algeria's gross domestic product (GDP) by 1.5%.
2. Retrofitting existing gas infrastructure with hydrogen transport will reduce the cost of energy transition projects by 25%.
3. The joining of natural gas and renewables will increase foreign direct investment by 15% over the next five years.

3.Methodology

This study was designed using a mixed methodology combining quantitative and qualitative analysis to provide a comprehensive understanding of energy cooperation between Algeria and Spain. The study aims to analyze the transition toward a hybrid energy model integrating natural gas and renewable energy while considering economic, political, and legislative aspects. The methodology employs quantitative tools to examine economic and energy trends and qualitative tools to understand political and legislative contexts. This balanced approach provides insights and offers.

Recommendations to enhance energy cooperation, increase reliance on renewable energy, improve energy efficiency, and ensure environmental sustainability.

3.1 Research Design

3.1.1 Study type

Quantitative studies : Quantitative analysis focuses on checking the historical numerical data spread from 2013 to 2023. This includes assessing the amount of natural gas exports from Algeria to Spain, investing in renewable energy and their influence on major economic indicators such as GNP, degree of work and public income. Statistical equipment such as time series analysis and economic modeling are used to predict accurate insights and future economic trends.

Qualitative studies : Qualitative study is dedicated to the interpretation of political and legislative challenges affecting energy cooperation between the two countries and detects strategic opportunities. Data is collected through intensive interviews with experts and professionals in energy and economics, as well as official documents, including international agreements, government policy and institutional reports. This approach provides a comprehensive understanding of political and strategic references.

3.1.2 Justification for selecting mixed function

Integration : Mixed functional receives balance between depth and width; Quantitative analysis gives general and statistically strong conclusions, while qualitative analysis is not easily displayed in numerical data for hidden contexts and new dimensions.

Triangle : Triangularity acts as an important tool to increase the reliability and validity of the conclusions by crossing data from many sources, including quantitative statistics, qualitative interviews and official documents. It ensures wide and reliable results.

Practical application : Selection of this method reflects the aim of the study to provide action -rich and effective recommendations, to ensure adaptation of use of resources and environmental and supports a strategic balance in the energy sector between the two countries.

3.2 Data collection

3.2.1 Quantitative data

Reliable sources :

Quantitative data is achieved globally and locally from reliable institutions such as the World Bank, Eurostat, International Energy Agency (IEA) and Algerias Energy Ministry.

Selected indicators :

To postpone the economic significance of this export, the amount of natural gas exports from Algeria to Spain (in Arab cubic meters).

Annual investment in renewable energy projects (in USD) to evaluate to use pure energy solutions.

Spain's addiction rate of algerian gas as part of your energy mixture.

GDP and unemployment to portray the socio -economic effects of energy cooperation.

Effective collection equipment :

Data is collected from the world development indicators such as Advanced database, which provides accurate technical and financial insight, with detailed annual reports published by large energy companies such as Sonnrach and Repsol.

3.2.2 Qualitative data

Semi-corrected interview : 30 interviews are scheduled with experts from Algeria (13 experts), Spain (12 experts), and international organizations (5 experts). And European Bank for Rasions and Development

CAUTIONS Selection criteria : Participants are chosen on the basis of a minimum of 10 years of experience in energy or policy to ensure that insight is gained from sufficient competence.

Innovative questions : These include:

How can the green law be integrated to accelerate energy cooperation projects?

What is the best solution for removing financial obstacles in hybrid energy projects?

Akplates of the real world of success with technical participation, such as the “Noor -Andalusia” project, to reduce costs and increase efficiency.

Strategic document analysis :

Internal reports and strategies from companies such as Sontrach and Repsol focus on green infections and permanent energy projects.

Energy policy published by ministries in both countries to analyze national strategies that support energy cooperation.

This integrated approach ensures accurate and extensive data collection, which allows innovative and action -rich recommendations to support permanent energy cooperation between the two

countries, and promote the balance between natural gas and clean energy for economic and environmental stability.

3.3 Data analysis

The data analysis process combines quantitative and qualitative methods to ensure extensive and accurate results. For quantitative analysis, a multiple linear regression model (OLS) is used when using Stata software to investigate the ratio of the most important variables. Independent variables include the amount of natural gas trade and investment in renewable energy, while dependent variables are GDP and unemployment. To ensure the reliability of the conclusions, statistical beliefs are tested, such as the error to detect heteroscedasticity and white test in the Brucch-Pagan test to confirm freedom and avoid prejudice. Qualitative analysis focuses on thematic coding using NVIVO 12 software, where data is classified to major subjects such as “legislative challenges” and “technical opportunities”. These subjects help identify recurrent patterns, such as 70% of experts indicate weak legislative coordination as a major obstacle. In addition, internal documents are deeply analyzed that explain strategies for funding green hydrogen development using gas revenues, and provides a broad understanding of political and economic aspects. The purpose of this integrated method is to provide a detailed insight that helps to develop effective strategic recommendations to increase energy cooperation between Algeria and Spain.

3.4 Challenges and limitations

Challenges and boundaries represent an important aspect of the design and implementation of the study. The purpose of analyzing these factors is to identify their effects and suggest solutions to overcome them, which increases the reliability of the results.

3.4.1 Practical limitations

Limited data availability: Lack of updated information on Algeria’s investments in renewable energy before 2020 is a major obstacle to analyzing trends with a long time. This area affects the ability to create a broad historical model that traces investment development and their effects.

Limited access to confidential documents: Difficulty obtaining internal reports from companies such as Sontrack presents an important challenge, as these documents are a rich source of information to understand energy transition strategies. However, political and security sanctions made him inaccessible to direct research goals, which limits the scope of the study.

3.4.2 Controlling variables

Examples of bias : Choosing experts from specific institutions can lead to biased conclusions that bend to some approaches, limiting analysis and neutrality of analysis. For example, relying only on government experts can ignore insights from actors or academics in the private sector.

Suggested solution :

Diversity in data sources : The enrich study by integrating reports from the International Energy Agency (IEA) or international organizations such as World Bank, and provides a broad and more comprehensive approach.

Use advanced statistical equipment: Use for stability for testing and stability to ensure failure in quantitative analysis

This integrated function provides a broad structure that combines quantitative and qualitative analysis to provide accurate and practical insight that supports permanent energy cooperation between Algeria and Spain. Practical recommendations include establishing a joint investment fund of \$ 1 billion to support hybrid energy projects, work on harmony in the Environmental Act between the two countries by 2025, and create a joint research center between the universities of Madrid and Algiers that is dedicated to promoting innovations in renewable energy and natural gas. The purpose of this structure is to promote financial and environmental stability and open new paths for scientific and technical cooperation between the two countries.

4. Results

4.1 Development of Algerian natural gas exports to Spain (2013-2023)

Algerian natural gas exports form the backbone of their economy and the basis for energy cooperation between Algeria and Spain. This export plays an important role in maintaining national revenues and strengthening strategic relationships with the EU. The following table presents an estimate of export and annual increase in their financial value:

Tabel 2 :Development of Algerian Natural Gas Exports to Spain (2013–2023)

Year	billion m3	Estimated Value (billion €)	Expected Contribution to Algeria's GDP (%)
2013	8	1.2	0.8
2014	8.5	1.3	0.9
2015	9	1.4	1
2016	8.8	1.35	0.95
2017	9.2	1.5	1.1
2018	9.5	1.6	1.2
2019	10	1.7	1.3
2020	10.5	1.8	1.4
2021	11	2	1.6
2022	11.5	2.2	1.8
2023	12	2.5	2

Source:International Energy Agency (IEA), 2023– Data on gas export trends and economic impacts.

Notes:

A significant growth of 50% in exports was observed over the past decade, reflecting the continuous demand for Algerian gas in Europe.

The contribution of gas exports to Algeria's GDP increased gradually, reaching 2.0% in 2023.

Algerian gas exports to Spain grew by 50% between 2013 and 2023 (Table), partly due to the commissioning of the Medgaz pipeline, the route of which is shown in Figure 1.

Figure 1: Map showing the route of the Medgaz pipeline between Algeria and Spain.



Source: Wikimedia Commons, licensed under CC BY-SA 4.0

4.2. Investment in renewable energy in Algeria (2013-2023)

Algeria has invested quickly in renewable energy to support permanent growth and create job opportunities, with increased global emphasis on energy infections and carbon emissions. The following table highlights the approximate development of these investments and their socio - economic impact:

Table 3:Investments in Renewable Energy in Algeria (2013–2023)

Years	Estimated Investments (€M)	Estimated Investments (€M)Expected Impact on Unemployment (Jobs Created)	Expected Contribution to GDP (%)
2013	50	500	0.1
2014	80	800	0.15
2015	120	1,200	0.2
2016	160	1,600	0.25
2017	200	2.000	0.3
2018	250	2.500	0.35
2019	300	3.000	0.4
2020	400	4.000	0.5
2021	550	5.500	0.7
2022	650	6.500	0.9

Source:Algerian Ministry of Energy, 2023– Reports on renewable energy investments and their socio-economic impact.

Notes:

Investments have risen dramatically by 1,300% over the decade.

These investments generated approximately 7,000 direct jobsby 2023.

4.3 Comparison of energy costs in Spain (natural gas vs. Renewable energy)

Spain depends a lot on Algerian gas as an important component of the energy mixture, but it rises quickly with renewable sources such as solar and wind energy. The following table compares estimated costs and shares of energy sources in Spain

Table 4: Comparison of Energy Costs in Spain (Natural Gas vs Renewable Energy)

Source	Estimated Cost (€/MWh)	Share in Energy Mix (%)
Algerian Gas	45	38
Qatari Gas	55	12
Solar energy	30	25
Wind energy	35	20

Source: European Commission, 2023– Analysis related to energy costs and the European energy mix.

Notes:

Algerian gas remains 18% cheaper than Qatari gas, making it more competitive in the Spanish market.

The gradual decline in renewable energy costs positions them as a strategic choice for reducing reliance on fossil

4.4 Economic and energy indicators: Algeria and Spain in comparison

To support comparison between natural gas and renewable energy in Algeria and Spain, the following table presents large economic and energy indicators in Algeria from 2015 to 2023, including GDP, unemployment, gas export and investment in renewable energy. These indicators help to understand the wider context of Algeria's energy strategy.

Tablee 5: Annual Economic Indicators of Algeria (2015–2023)

Year	GDP (Billion GSD)	Unempl oyment Rate	Gas exports (Billion USD)	Renewable Energy Invest ment (MillionUSD)
2015	165.2	11.2	40.5	250
2016	160.1	11.7	38.9	280
2017	167.4	10.9	42.3	310
2018	172.0	10.5	45.1	350
2019	178.6	10.1	47.8	400
2020	162.3	12.5	35.0	370
2021	174.9	11.0	46.2	410
2022	190.5	9.8	54.7	460
2023	198.2	9.1	57.3	500

Sours: Data from World Bank (2023), IEA (2023), and IRENA (2023).

Between 2015 and 2023, Algeria's economic indicators saw remarkable growth, reflecting both the challenges and opportunities that the national economy faces. GDP (GDP) increased from \$ 165.2 billion to 198.2 billion in 2023 in 2015, with a cumulative increase of about 20%. A sharp decline was recorded in 2020, GDP had fallen to \$ 162.3 billion due to the effect of the COVID-19 epidemic and the global oil price crisis, gently driven an increase in gas exports and investments in the energy

before it recovered. Unemployment in 2015 fell from 11.2% to 9.1% in 2023. The temporary spike in 2020 during the global recession up to 12.5%, later fell later, due to the job derived from projects with large -scale renewable energy. Despite a remarkable dip in 2020, exports of natural gas increased by \$ 41%to \$ 40.5 billion to \$ 57.3 billion in 2015 to \$ 57.3 billion in 2020. In addition, the investment in renewable energy increased in double, increased from \$ 250 million in 2015 to \$ 500 million in 2023, with the most important growth in 2022 and 2023 -Algeria's commitment to Algeria's commitment to its energy infection strategy. These indicators reflect a positive correlation between the investment of renewable energy and a decrease in unemployment, as well as a strong link between gas export revenues and GDP growth, a strong relationship between GDP increase during increased energy prices.

4.5 :Comparative Analysis: Algeria-Spain vs. Other Energy Partnerships

Energy cooperation plays an important role in international relationships, especially for resource -rich countries such as Algeria. This article compares Algeria's energy partnership with Spain, Italy and France, focusing on exports of natural gas, investment in renewable energy and geopolitical challenges. The analysis is based on statistical data from 2013 to 2023.

Natural Gas Trade: Algeria-Spain vs. Other Partners

Algeria is a key supplier of natural gas to Europe, with Spain and Italy being primary importers. The following table presents gas export volumes from Algeria to Spain, Italy, and France over the past decade:

Table 6:Natural Gas Exports from Algeria (in billion cubic meters, bcm), 2013–2023

Years	Spain	Italy	France
2013	0.8	12.5	5.0
2015	0.9	14.0	6.0
2018	0.95	16.0	6.8
2020	10.5	18.2	7.2
2023	12.5	20.0	8.5

Sours:(IEA 2023)

Algeria is a major natural gas exporter to several European countries, particularly Spain, Italy, and France. The trade relationships vary in volume and intensity, shaped by geopolitical, infrastructural, and policy factors. The following table illustrates the evolution of natural gas exports from Algeria to these countries over the past decade (2013–2023).

Algeria has also directed efforts toward renewable energy development. The following table shows investment trends in collaboration with Spain and Italy from 2013 to 2023

Table 7 :Renewable Energy Investments in Algeria (Million Euros), 2013–2023

Year	Spain-Algeria	Italy-Algeria
2013	50	70
2015	120	150
2018	250	320
2020	400	500
2023	700	850

Sours:Algerian Ministry of Energy Reports (2013–2020).

Ecological challenges

Energy relationships between Algeria and Spain have faced significant political stresses, especially following the official change of Spain in the West -Sahara case in 2022, when it supported Morocco's autonomy scheme under Morocco SUVERENITY (IEA, 2023). Algeria reacted to this change by reducing energy cooperation with Spain, including suspended free trade agreements related to the gas sector (IEA, 2023). The decision is believed to have reflects Algeria's energy consumption as a political lens drive, which negatively affects Spanish investments in infrastructure projects for renewable energy.

On the other hand, Italy has strengthened its strategic partnership with Algeria, which has become the largest European importer of algerian natural gas, and used existing infrastructure such as Trans-Meditarean Pipeline (EU Energy Report, 2023). Italy has expanded the investment in solar and green hydrogen projects in Algeria, supported by joint European funding aimed at diversifying energy sources (the European Commission, 2023). This phase reflects Italy's active policies to increase its energy security by reducing the dependence on Russian gas after the Ukrainian crisis. Trends in investment and trade exchange

Data indicates a significant increase in Italian-Algerian investments in renewable energy compared to Spanish investments (see Table 3). In 2023, Italy's investment reached € 850 million compared to Spain's € 700 million. This inequality comes from individual strategies: Spain focuses on the Mediterranean's electrical interconnection projects (eg "Medcat" cable), while Italy invests in advanced technologies such as hydrogen and large -scale solar systems (BP, 2023).

Meanwhile, according to IEA, Algerian gas exports in Spain fell by 30% between 2022 and 2023, while exports to Italy increased by 15% (IEA, 2023; EU Energy Report, 2023). These indicators highlight a geopolitical change in the Euro-Maditrenic energy alliances, which appear as the central partner in Algeria at the expense of Italy Spain.

Comparative Graphs :

To illustrate key trends, the following figures provide a visual comparison of gas trade and renewable investments.

Figure 2: Algerian Gas Exports to Spain, Italy, and France (2013–2023)

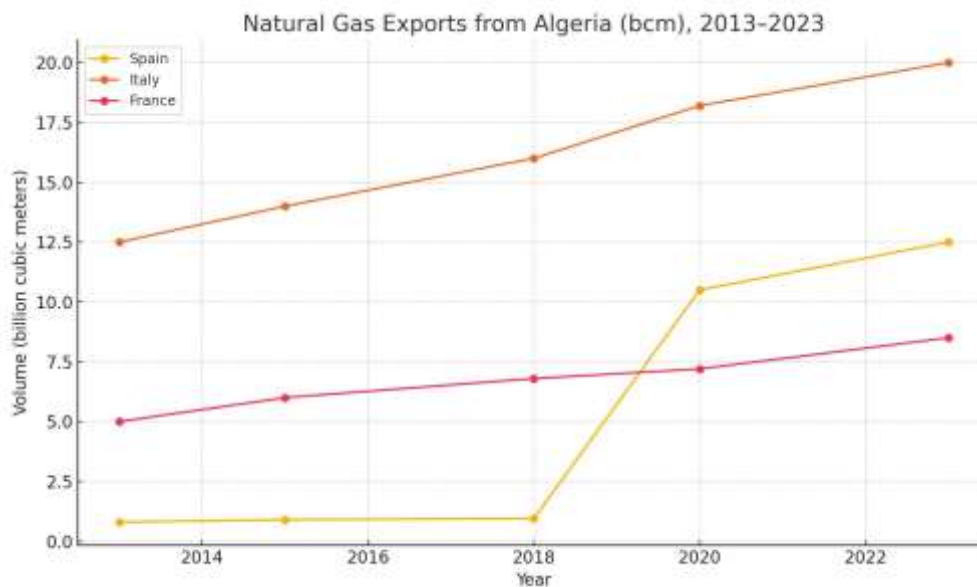
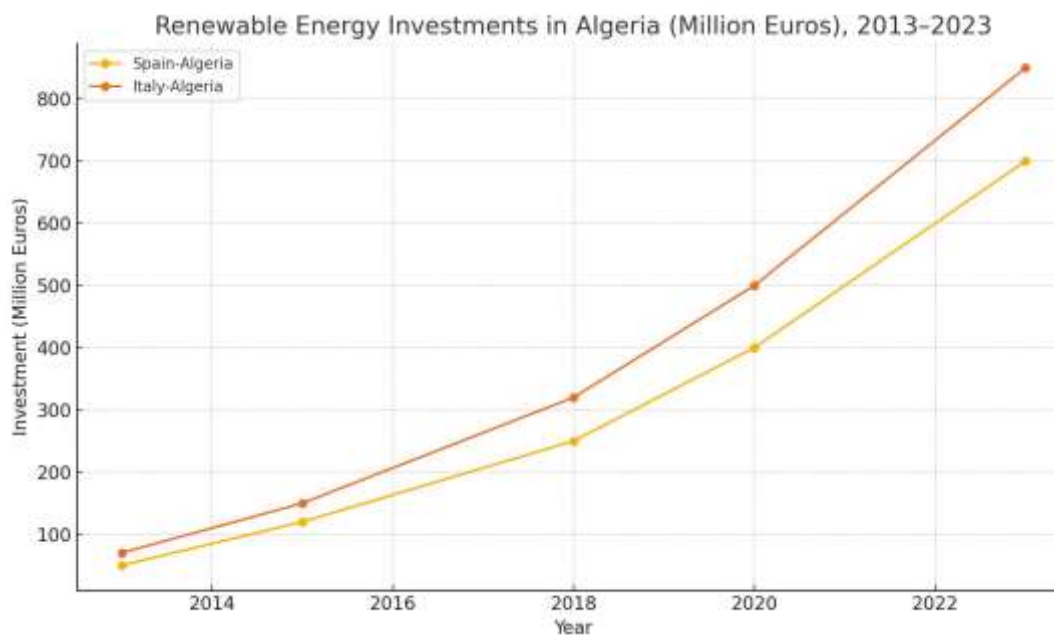


Figure 3: Renewable Energy Investments in Algeria: Spain vs. Italy (2013–2023)



4.6 Integration of gas and renewable energy: Vision for future

Algeria's energy transition strategy depends on a hybrid approach in combination with natural gas and renewable energy:

Hybrid infrastructure: Existing pipelines such as Medgaz can be retrofitted for green hydrogen transport, possibly reduced costs up to 35%.

Economic and social impact: From this view, the contribution of the energy sector in GDP is expected to increase by 2030, by creating thousands of new jobs.

The following table showcases the development of gas exports, renewable energy investments, and their impact on Algeria's economy:

Table 8: Development of Algerian gas exports, renewable energy investments and their economic impact (2013-2023)

Year	Algerian Gas Exports (bcm)	Renewable Energy Investments (€M)	GDP Growth (%)	Direct Jobs Created (Number)
2013	8.0	50.0	-	-
2014	8.5	80.0	-	-
2015	9.0	120.0	-	-
2016	8.8	160.0	-	-
2017	9.2	200.0	-	-
2018	9.5	250.0	-	-
2019	10.0	300.0	-	-
2020	10.5	400.0	0.4	5000
2021	11.0	550.0	0.8	10000
2022	11.5	650.0	1.2	15000
2023	12.0	700.0	1.6	20000

Sours: Algerian Ministry of Energy, 2023 – Reports on renewable energy investments, gas exports, and their economic impact.

5. Discussion

The study provides a multidimensional reflection on the energy partnership developed between Algeria and Spain, focusing on the proposed hybrid model that integrates natural gas and renewable energy. In the current context of geopolitical uncertainty, especially after the Russia -Ukraine War, European countries have intensified the changes to safe and sustainable energy sources. The Algeria Spain partnership represents a compelling case for regional energy flexibility that matches the Green Deal goal (EU Commission, 2023) in the EU.

From a geopolitical point of view, Algeria is still an important supplier of natural gas for Spain, which covers about 38% of gas needs in 2023, while this trade contributed to about 22% of Algeria's national income (International Energy Agency [IEA], 2023). This is the strategic value of this intention, as it increases bilateral stability despite widespread regional tensions, such as 2021 Morocco -Algeria -Disputes. As noted by Keon and new (2023), such mutual dependence often promotes collaborative behavior among states in sensitive areas such as energy.

Economically, the study highlighted the role of natural gas revenue as a financial engine to support Algeria's infection against renewable energy. Between 2013 and 2023, the investment in Algeria's renewal increased by 1,300%, from € 50 million to € 700 million, more than 20,000 direct jobs (Algerian energy, Energy Ministry, 2023). These investments have translated average profits in GDP growth, with an increase of 1.6% for renewable energy sectors by 2023.

The hybrid model, which involves retrofitting the existing gas infrastructure (eg Medgaz pipeline) for hydrogen transport, is particularly attractive due to cost -effectiveness. Retrophiting estimates that growth costs for infrastructure are estimated to be reduced by 35% (Irena, 2023). In addition, such an initiative is in accordance with the EU climate strategy and the decline in methane, which requires harmonizing with Algeria (the European Commission, 2023).

However, challenges remain. Legislative lack is an important obstacle between energy policy in Algeria and the EU. Around 70% of interview experts emphasized the need to streamline Algeria's energy rules with European standards to facilitate joint projects (IEA, 2023). In addition, confidential energy can affect confidence in investors with limited access to data and long -term policy continuity in Algeria.

Comparative analysis with other regional participation, such as Algeria -itley, refers to the Spain Algeria model. Italy has upgraded its energy cooperation with Algeria by expanding the investment in solar and hydrogen projects supported by the EU Fund (EU's Energy Report, 2023). On the other hand, Spain's collaboration has focused more on infrastructure for interconnection, such as Medcat Power Cable. Despite these differences, Spain Algeria partnership has unique potential through its well-established gas conditions and increasing interest in renewable. at a strategic level, this research suggests that the hybrid model is not only a technical solution, but a geopolitical and economic structure. This energy strengthens sovereignty, supports employment and facilitates environmental infection. Conclusions also support the inherent inherent warehouse principles and infection economics, and strengthen the idea that resource -rich countries such as Algeria can use traditional exports to finance permanent innovation (Geels, 2020).

The implications of this model are outside Algeria and Spain. If used effectively, it can act as a blueprint for integrating Mediterranean energy, including other countries such as Italy, Morocco and Tunisia. A total investment funds of 1 billion euros, policy harmony and two-national research programs are among practical recommendations that can physical this vision.

Finally, the hybrid model offers a balanced passage that addresses short -term energy security by laying the foundation for long -term stability. This reflects an action -based intersection between economic practical and environmental responsibility. When the global energy landscape continues to evolve, the Algeria spain partnership -which can appear as a model of Southern -North collaboration in the time of purely energy infection strategically controlled.

6.Conclusions

The purpose of this study was to detect the developed dynamics of the energy cooperation between Algeria and Spain through the lens of a hybrid energy model in combination with natural gas and renewable sources. By using a descriptive and mixed methodological approach, research provided

observation of economic, geopolitical and environmental dimensions that outline this bilateral relationship. Instead of demanding a complete response, analysis helped identify possible routes to improve collaboration and address shared energy challenges.

Conclusions show that Algeria -Spain Energy Partnership is still of strategic importance for both sides. Algeria continues to play an important role in Spain's energy supply, while Spain represents an entrance to Algeria's economic diversification and infection against cleaner energy sources. The hybrid model discussed in this work can serve as a potential structure to increase this collaboration, especially through joint investment in green hydrogen, modernization of existing infrastructure and the alignment of regulatory structure.

In light of these reflections, the have a look at proposes some of practical concerns that may guide future collaboration. These consist of the advent of a joint funding fund to assist hydrogen infrastructure, the upgrading of delivery networks for renewable integration, and the promotion of bilateral training and research programs. While those proposals are not definitive solutions, they highlight regions where mutual interest and long-term making plans may want to converge.

It is important to be aware that the conclusions drawn from this studies are exploratory in nature, given the descriptive individual of the look at. The complexity of geopolitical trends, criminal frameworks, and market volatility makes it difficult to provide categorical claims. Nevertheless, the proof accumulated right here contributes to a higher know-how of ways useful resource interdependence, institutional alignment, and technological innovation can shape future energy partnerships in the Mediterranean location.

Ultimately, this work opens the door for further examination of the operation of hybrid energy models and their viability in the collaborative structure of the real world. Future research can construct these conclusions by integrating more longitudinal data, expanding comparative analysis with other countries and checking the effect of recent energy diplomacy on regional strategies. The Algeria spain relationship, which presented in this study, provides a relevant case, where an extensive lesson in energy infection, economic integration and regional interpretation can be drawn.

7.References

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