The State of the Art of the Energy Transition on Islands: The Case Study of Corsica

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Abstract

The energy sector is a significant contributor to climate change, prompting the need for a sustainable energy transition. The European Union has set ambitious climate objectives, and while France has implemented national energy transition plans, Corsica, a French island, faces unique energy challenges. Islands offer valuable opportunities for studying renewable energy transitions, but also serves as testbeds for innovative technologies and contributes to national decarbonization efforts. Understanding Corsica’s energy transition is thus crucial not only for addressing its specific challenges but also for informing scalable, resilient solutions that support broader European Union sustainability goals. This study aims to investigate the current state of Corsica’s energy transition, using a systematic literature review complemented by the Multi-Level Perspective (MLP) framework. Findings reveal that technical and economic approaches are dominant at the expense of social and ecological ones. Solar, wind, and hydrogen are key components in Corsica’s renewable energy strategy, whereas bioenergy and geothermal sources remain underexplored. Significant research was done about hybrid systems, small-scale technologies, large-scale projects, the MYRTE platform, and renewable integration. Applying the MLP framework shows that Corsica is making gradual progress in its transition, supported by notable research efforts. Nonetheless, certain challenges persist and setbacks can arise, indicating the need for continued improvements and initiatives. Hydrogen, energy storage, wind, solar, bioenergy, and hybrid systems could therefore be crucial for advancing Corsica’s energy transition. Overall, a holistic approach would allow for a more sustainable and just energy transition, both for humans and biodiversity.

Introduction

Climate change is one of the most significant challenges of this century and the energy sector has been identified as a major contributor (IEA, n.d.; United Nations, n.d.-a). In fact, as global energy systems are the foundations of our societies and economies, 75% of greenhouse gas emissions are caused by the production and consumption of energy, contributing to climate change. Moreover, the intensification of this phenomenon presents a risk to energy security and leads to an increase in energy usage. This highlights the necessity for decarbonizing the energy sector but most importantly the need for a sustainable energy transition (IEA, n.d.).

In response to the climate crisis and associated energy challenges, the European Union (EU) has dedicated itself to a clean energy transition, which aims to support the achievement of the Paris Agreement's climate objectives set in 2015 and ensure universal clean energy to all. To fulfill this commitment, the EU has established mandatory climate and energy targets for 2030 and compelled every member state to produce its National Energy and Climate Plan for the next 10 years (European Commission, n.d.).

France's Energy Transition

For the EU to accomplish its climate objectives, every member state thus has to take action. France, one of the largest and most influential EU members, has committed to its national energy transition plans such as the Multiannual Energy Plan (Ministry of Ecology, Sustainable Development and Energy, n.d.). This plan outlines the French government's energy priorities, which aim to achieve the goals dedicated to the energy transition under the green growth law. It sets quantitative targets for renewable energy (RE) development, with important national government support (Ministry of Ecology, Sustainable Development and Energy, n.d.).

While France is a very geographically diverse country, it has about 1300 islands, following diverse paths in the energy transition. Corsica is one of the main islands and accounts for approximately 90% of the island territory in metropolitan France. Its energy situation, beyond the fact that it is an island, is particular since it is in part connected with Italy (Notton et al., 2019a). Regarding its energy mix, in January 2025, about 40% of Corsica's electricity consumption was from hydropower, 8.5% from solar power, and 1.8% from wind power, but more than 30% was from oil, representing about 97% of Corsica's total emissions. Furthermore, the island emitted in January 2025 approximately 387gCO_2eq/kWh while France emitted 45gCO_2eq/kWh, which is about 8.5 times less than Corsica. These data highlight the gap between the advancement of the energy transition in France and Corsica (Electricity Maps, n.d.).

Renewable Energy and the Energy Transition

The energy transition primarily relies on renewable energy sources, as they are key for more economical, ecologically responsible, and sustainable electricity production (Ang et al., 2022). Renewable energy sources are also known to be the least expensive way to replace fossil fuels, which have negative impacts on the environment. Since renewable energy is often highly intermittent, energy storage has been identified as key for smoothing its power generation scheme (Olabi & Abdelkareem, 2022).

The transition to renewable energy is thus a way to replace conventional power sources, and has the potential to shape our economy, our relationship with the environment, and larger societal values. For instance, the United Nations recognizes the importance of the energy transition and energy as a fundamental component of societal advancement and well-being. This is evidenced by the seventh Sustainable Development Goal aiming to "ensure access to affordable, reliable, sustainable, and modern energy for all" by 2030 (Hassan et al., 2024).

The sources of renewable energy are numerous and have a crucial influence on the global energy transition path (Hassan et al., 2024). The main renewable energy sources include solar, wind, hydropower, geothermal, bioenergy and ocean energy, while hydrogen is considered an energy carrier. Because they have different operating conditions and energy conversion efficiency, renewable energy technologies are highly dependent on the locations and conditions (Ang et al., 2022).

Available Renewable Energy Sources

Hydropower can be considered one of the cleanest renewable energy sources and has also been proven to be cost-effective (Ang et al., 2022; Olabi & Abdelkareem, 2022). In this case, the energy captured from the movement of water from higher elevations to lower elevations is converted into electrical energy. Moreover, hydropower has a conversion efficiency of 90%, which is higher than most other renewable energy sources. Lastly, hydropower comes in a variety of forms, including cascaded reservoir systems, small hydropower plants, and pumped storage (Ang et al., 2022).

Regarding solar energy, it is already used commercially in a number of sectors and is widely available (Olabi & Abdelkareem, 2022). It is one of the main used energies in the world and is produced from the radiant ionization of the energy emitted by the sun (Ang et al., 2022). The widespread use of solar energy is dependent on photovoltaic (PV) systems coupled with effective energy storage technologies like batteries (Olabi & Abdelkareem, 2022).

Bioenergy is a very attractive renewable energy source that finds its origin in biological raw materials such as biomass. It can be produced from various materials but in traditional methods, bioenergy usually comes from agricultural ones like fuelwood, charcoal, crop residues, and animal secretion, which are then processed for use in urban areas. Contemporary bioenergy uses a variety of thermal conversion technologies for biomass, including carbonization, torrefaction, gasification, combustion, and pyrolysis, to produce biogas, biodiesel, and biochar (Ang et al., 2022).

Then, wind energy benefits from comparatively simple infrastructure, affordability, and technological maturity. Electricity is produced from the conversion of wind energy by power plants using wind turbines. It is mainly produced by offshore and onshore wind farms. Their location is chosen based on the average wind speed per year, which should be adequate to produce the estimated amount of power (Ang et al., 2022).

Geothermal energy refers to thermal energy derived from the Earth's primitive structure and the radioactive decay of mineral resources. In comparison to solar energy, hydropower, and wind energy, which are intermittent, geothermal energy is abundant and inexhaustible. It is also naturally stable, and if it is associated with hydrothermal energy, geothermal energy has significant economic potential, particularly in nations with active volcanoes (Ang et al., 2022).

The last renewable energy is ocean energy, encompassing many different forms. For instance, wave energy is created when the wind blows the surface of the ocean and transfers its energy to the water, while ocean current energy is the kinetic energy harvested from ocean surface currents. Moreover, ocean thermal energy conversion refers to a technology that uses the temperature difference between warm waters and deep, cold ocean water to generate electricity. Tidal energy is the energy harnessed from the rise and fall of sea levels and the movement of water (Neill, 2021).

While hydrogen cannot be considered a renewable energy source, it has great potential to help the energy transition and is thus worth mentioning in this section. In fact, it is a clean energy carrier that can be stored for electricity generation. Hydrogen is defined as "green" if it is produced without emitting any CO_2. In this case, it is produced through electrolysis, the process using renewable electricity to split water by electrochemical means.

In the future energy market, it is said that green hydrogen will become one of the best options for energy storage media, energy vectors, and fuel for industry, transportation, and other uses (Squadrito et al., 2023).

The Particularity of Energy Transition in Islands

As islands are confronted with specific challenges regarding the implementation of a sustainable energy transition, the EU designated them as "small isolated networks". This special category allows member states to implement tailored measures distinct from those applied on the European mainland. Indeed, islands, including Corsica, have limited or partial interconnection with mainland electricity grids and have highly variable energy demand which makes the use of large power plants impossible. The energy managers have to balance supply and demand without external backup, making island grids fragile. Islands are therefore restricted in their choices with smaller and more adaptable units often chosen to maintain grid stability. Also, islands often rely on polluting and costly diesel generators due to their flexibility (Notton et al., 2019a).

Islands are unique locations for studying energy transitions, particularly in the context of renewable energy systems. There are about 85,000 islands globally, home for around 740 million people. Islands suffer from the economic impacts of fossil fuel-driven energy sources and the effects of climate change, but also face specific challenges, highlighting the significance of transitioning to renewable energy (Meschede et al., 2022). Furthermore, islands have a significant role in national decarbonization strategies, with many serving as test sites for new technologies aimed at decarbonizing energy systems while also fostering blue and green economy investments (Kallis et al., 2021). Islands have the potential to promote sustainable and resilient energy futures on larger scales. Understanding the energy transition in Corsica is thus key for addressing its specific challenges but also uncovering opportunities. It can also provide valuable insights applicable to other islands facing similar constraints. Overall, the energy transition in Corsica could help with developing resilient and scalable solutions for sustainable energy, which would ultimately contribute to the achievement of the EU's goals.

Aim of the study

In light of the situation described, the research question guiding this study is: What is the current state of Corsica's energy transition, what challenges does it face, and what factors or strategies could accelerate its progress? With this research question, the purpose is to provide an extensive analysis of the state of the art of energy transitions on islands, focusing on the case of Corsica. Moreover, the aim is to explore the policies and strategies that have been put in place for the energy transition, investigate the technologies and innovations that are being researched to facilitate the energy transition, and inspect the multiple factors shaping this transition. The following sections present the methodology, the systematic literature review's findings, the Multi-Level Perspective analysis, and a concluding discussion.

Methodology

Study Site

Corsica is a French island located in the Mediterranean Sea. It is the fourth largest island of the Mediterranean, after Sicily, Sardinia, and Cyprus. The island has an area of 8,722 km^2 and there were approximately 350,000 inhabitants in 2021 (Chin Choi et al., 2024; INSEE, n.d.). The two largest towns are Bastia and Ajaccio, situated on the coast and where roughly 50% of the island's population resides. Moreover, about four-fifths of Corsica's population lives in cities, and while the region of Balagne is heavily populated, partially populated rural villages primarily located at elevations between 200 and 800 meters, have seen a significant influx of people moving to the coast and continental France (The Editors of Encyclopaedia Britannica, 2025).

Regarding its geographical features, Corsica is dominated by mountains, with an ancient crystalline massif dividing the island on a northwest-to-southeast axis for about two-thirds of its land area. The island has six major rivers: the Golo, Liamone, Tavignano, Taravo, Gravone, and Profiano. Corsica also has luxuriant vegetation, as most of it is covered by maquis, pine, and chestnut, and approximately one-fifth of the island is covered by forests. Regarding the climate, Corsica benefits from a Mediterranean one, prevailing especially on the coasts. The average temperature is 15.5 °C, while in winter it is 10.5 °C. With an average of 880 mm per year, there is high precipitation on the island (The Editors of Encyclopaedia Britannica, 2025).

Compared to mainland France, Corsica has lower standards of living. Tourism, sheep rearing for ewe's milk, and the production of citrus fruits, grapes, and olives are the main drivers of its economy. While along the eastern coastal plains, agriculture has been modernized, there has been little industrial development (The Editors of Encyclopaedia Britannica, 2025).

Corsica’s energy consumption amounted to 1,928 GWh in 2016 (CEIC, 2018). It was not possible to find more recent data. It was either not available for later years, combined with the energy consumption data of France’s mainland, or data for Corsica was simply excluded (RTE, n.d.). However, the energy production in 2030 is expected to attain 2677 GWh or 3012 GWh depending on the scenario (Chin Choi et al., 2024).

Systematic Literature Review

In order to rigorously understand the energy transition in Corsica and its potential pathways, a mixed-method approach combining both qualitative and quantitative analysis was conducted through a systematic literature review. This is an appropriate method for this study as it is very effective for examining the existing body of knowledge of specific domains like renewable energy and environmental sciences, organizing information thematically, and identifying differences and similarities within a topic. Furthermore, it holds the potential to highlight research gaps and thus guide future ones (Bhattarai et al., 2022).

The systematic literature review was done by analyzing papers gathered from the Scopus database. The platform provides a large range of peer-reviewed literature and access to citation tracking, advanced search tools, and high-quality sources that are relevant to this research (Elsevier, n.d.). The keywords “Corsica”, “Renewable” and “Energy”, were used alongside the connector “AND” to get relevant papers for this research. The query resulted in 32 peer-reviewed articles, in French and English. The selection criteria were: the paper has a strong focus on Corsica (case study or extensively applied methodology) and it was accessible. While it was not possible to access three papers, a first round of filtering was done after the analysis of the paper’s abstract, leading to four papers being excluded, resulting in 25 papers remaining. A second round of filtering was done after reading the papers, leading to the exclusion of four more papers, resulting in the final 21 papers selected for this research (Figure 1).

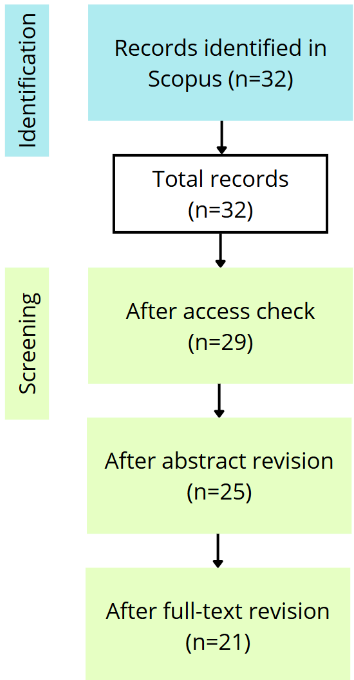

Figure 1. Literature Review Criteria Workflow

The papers selected for this research were published between 1996 and 2024 and were reviews, conference papers, and articles. The papers were analyzed using a Google form and classified into an Excel table, allowing for better visualization, organization, and comparison. Examples of categories were the methods used, the renewable energy sources discussed, the drivers and barriers.

Multi-Level Perspective

In addition to the systematic review, this study applied the MLP framework used in socio-technical transitions, providing a deeper analysis to the research. The MLP is useful for examining socio-technical shifts towards sustainability, making it relevant for this study. In fact, it allowed for the assessment and identification of the best options or paths for the energy transition in Corsica, but also the analysis of how systemic changes and transition occur across the different levels: niches referring to the innovation spaces, regimes referring to the established practices and rules, and the landscapes referring to the broader societal context. Applying the MLP was key to understanding the complex interactions and dynamics that influence the energy transition in Corsica (Geels, 2011). In this regard, another Google form was used, focusing on the aspect of the three different levels of the MLP.

Systematic Literature Review Results

Bibliometric Analysis

This first section is dedicated to examining the metadata of the publications gathered from Scopus to gain preliminary insights of the papers' content. The first aspect discussed is the timeline of publications, then the institutional and geographic distribution.

Publication Timeline

The papers selected for this research ranged from 1996 to 2024. While not all years have publications, the highest numbers were both in 2008 and 2019 with three papers. Some years contain more papers than others, with a few having multiple entries while most have only one. While no significant and clear trend appears, the period with the most publications is from 2008 until 2012, followed by a slight drop from 2013 to 2018 (Figure 2). Lastly, in 2019, the number of publications matches the 2008 peak year, and in 2024 there is a slight resurgence with 2 papers.

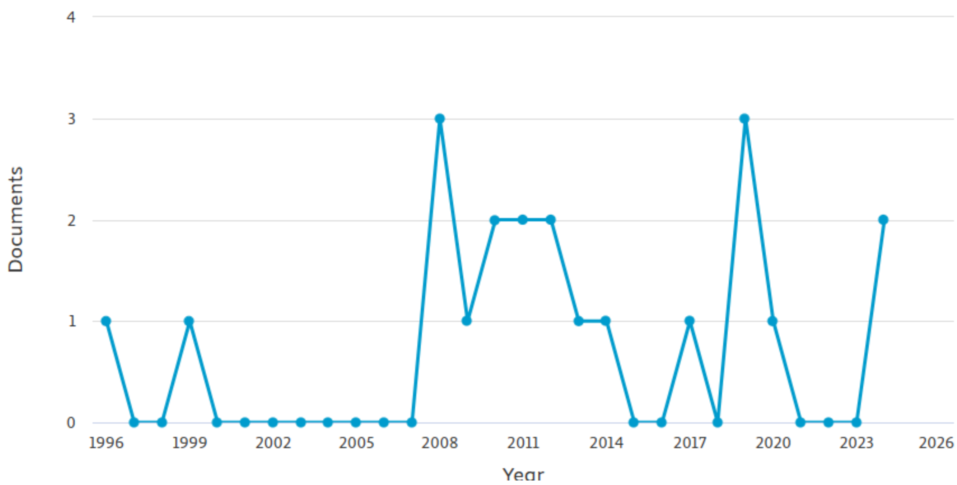

Figure 2. Number of Papers Published Every Year Between 1996-2024

Institutional and Geographic Distribution

While institutions involved are not only located in Corsica, the dominant and most recurrent one is a local university: the Università di Corsica Pascal Paoli, with 20 papers (Figure 3). Due to many translations of the university name, it is important to note that Università di Corsica Pascal Paoli, University of Corsica Pascal Paoli, and University of Corsica Pasquale Paoli all refer to the same institution. The second most important one is another Corsican institution: the Castelluccio Hospital (3 papers). This reveals a strong local involvement in research on the Corsican energy transition. Moreover, France's mainland affiliations all account for 2 papers with for example the National Center for Scientific Research (CNRS) and the University of the Reunion. Nonetheless, some foreign affiliations appear, like the Technical University of Sofia (Bulgaria) and the University of East Anglia (United Kingdom). Most interestingly the Renewable Energy Development Center (Centre de Développement des Énergies Renouvelables), is Algerian and the third most common affiliation after both Corsican institutions. This could be related to historical energy ties and a francophone connection.

France leads the authorship landscape, yet other countries such as Tunisia, Italy, and Albania are involved in the research on Corsica's energy transition (Figure 4). This bibliometric analysis reveals the institutional and geographic diversity of author affiliations but also highlights the border academic relevance of Corsica.

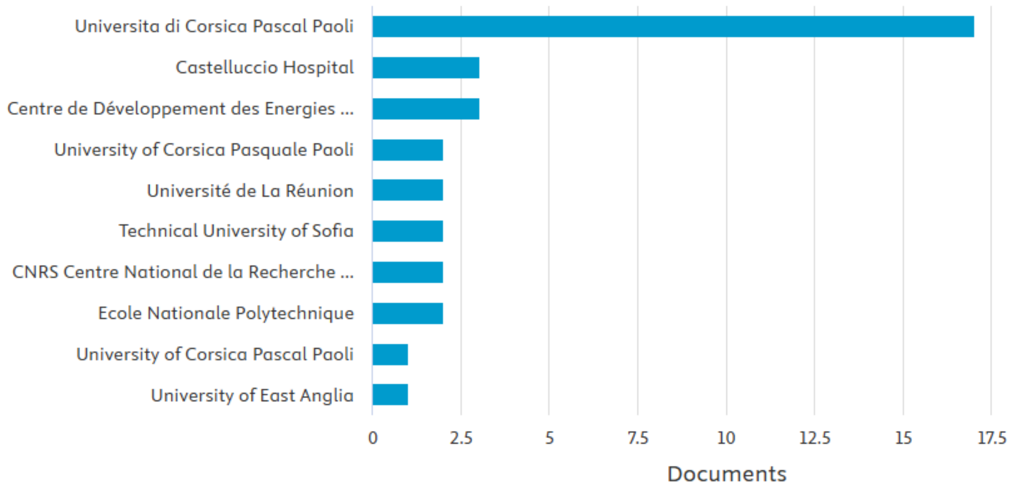

Figure 3. Institutional Distribution of Publications by Affiliation

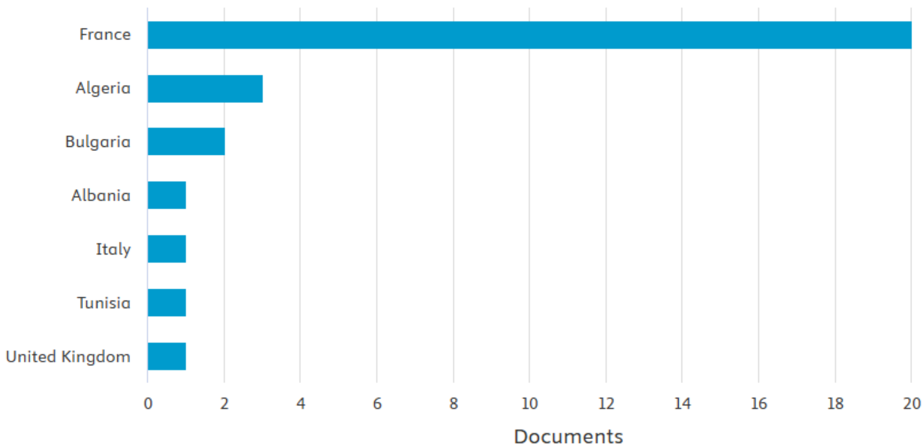

Figure 4. Geographic Distribution of Publications by Country

Approach and Methodologies Used

After having classified papers, authors seem to privilege technical and technical-economic approaches for their research in the field of renewable energy in Corsica. In fact, almost half of the papers (10) were classified with a technical-economic approach (Figure 5)(for example Notton et al., 2019a; Muselli et al., 1999). In addition, 9 papers used a technical approach (for example Battaglia et al., 2019; Darras et al., 2008; Notton et al., 2011). The remaining approaches account for only one paper each, with for example Haurant et al. (2011) opting for a multi-criteria decision analysis approach and Cristofari et al. (2014) adopting a socio-economic one. This data suggests that the focus is on the technical and economic dimensions of the energy transition, while other important approaches such as the environmental and social ones are under-represented, highlighting a gap in the existing research.

The technical-economic approach dominating, a substantial share of the papers used modeling and simulations for their research (for example Diaf et al., 2008b; Notton et al., 1996; Ouédraogo et al., 2020). Diaf et al. (2008a) used various models such as Loss of Power Supply Probability, Levelized Cost of Energy, System Sizing Model, and Economical Model to optimize the size of a PV/wind system combined with storage for three Corsican sites. Other papers used different methods such as literature survey (Dubois et al., 2013), comparative analysis (Notton et al., 2019a), and Geographic Information Systems (GIS)(Muselli et al., 1999; Mai et al., 2024). Moreover, since these papers have a technical-economic approach they used a lot of financial metrics and indicators like Life-cycle cost, Net Present Value, and CAPEX and OPEX indicators. Specifically, Muselli et al. (1999) used life-cycle cost to inform economic optimization while Hajjaji & Cristofari (2024) used Net Present Value to prove their project's financial viability. They also used CAPEX and OPEX as the foundation for the cost model of their project.

A similar trend could be observed for technical classified papers, as a high number of them also used modeling and simulations (for example Darras et al., 2008; Notton et al., 2011; Poggi et al., 2009). For instance, Cristofari et al. (2010) used modeling, such as polynomial and physic models, as well as simulations to assess a photovoltaic/hydrogen hybrid system's performance. Moreover, Notton et al. (2017) developed a simulation tool using hourly weather and load data to evaluate a hydro-pumping storage system combined with photovoltaic and wind energy for peak shaving. This study also used various models such as third-order polynomial models and the Durish model proven to be the most efficient photovoltaic (PV) production model. These methods were used to determine whether the system could meet peak demand and accomplish this without turning on expensive and environmentally harmful combustion turbines (Notton et al., 2017). Besides models and simulations, technical papers also employed other methods, such as performance analysis (Toure et al., 2012) and scenario analysis (Battaglia et al., 2019, Notton et al., 2011).

Lastly, the other papers had different approaches using methods like literature review (Cristofari et al., 2014) and multicriteria analysis complemented by sensitivity analysis and stakeholder-based criteria (Haurant et al., 2011).

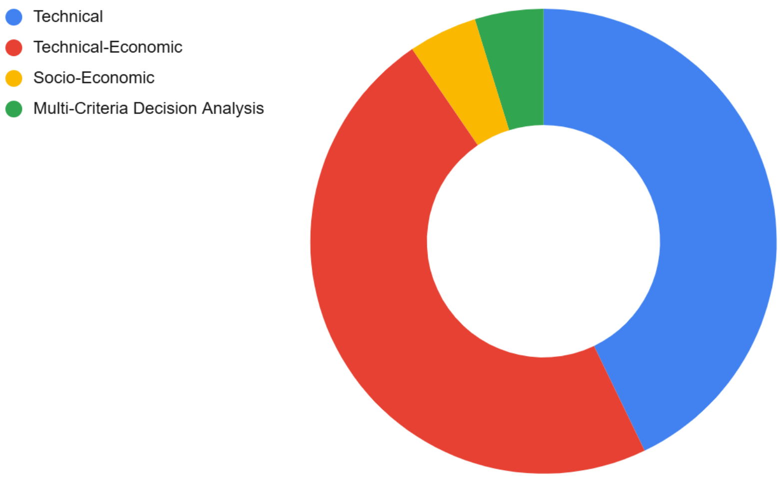

Figure 5. Distribution of Publications by Approach Used

Research Trends in Energy Transition

Diving deeper in the analysis and examining the research trends regarding the topics in line with the energy transition, a suite of important and recurrent themes are discussed in the next section.

Renewable Energy

Following this analysis, the renewable energy options considered for Corsica are examined. Solar energy emerges as a central focus in renewable energy research since it is the only renewable source addressed across all the selected studies (Figure 6). With the use of PV, solar energy is an important way to not only reduce reliance on the main grid for residential power but also support local renewable energy production, which promotes sustainability in Corsica (Ouédraogo et al., 2020). While solar energy was often discussed among other renewable energies, it was the focus of 6 papers (for example Haurant et al., 2012; Muselli et al., 1999; Toure et al., 2012). For instance, Paoli et al. (2010), calculated the daily horizon's global irradiation and used neural networks in order to forecast solar radiation accurately. This is essential for energy management, grid integration, and solar energy system design (Paoli et al., 2010). Lastly, multiple studies evoked the fact that Corsica has a high solar potential (for example Haurant et al., 2011; Toure et al., 2012).

Although solar energy appears to be a primary focus in Corsica's renewable energy research, wind energy also plays a significant role as testified by the 11 papers discussing it. This renewable energy was always examined together with other sources like solar, hydrogen, and hydropower. In the study by Diaf et al. (2008a), wind energy was discussed in the context of a standalone battery-operated hybrid PV/wind system. They pointed out that, in contrast to conventional systems, this configuration enables wind energy to be sent straight to the load. If there is excess energy, it is transformed into direct current and stored in batteries. It is also notable that Corsica has a substantial wind potential but it was not fully utilized until 2011, with only 18 MW of energy generated from wind (Haurant et al., 2011). Nonetheless, government plans have focused on developing renewable energy technologies for wind power generation (Cristofari et al., 2014).

In addition to wind energy, hydrogen also emerged as a key component in Corsica's renewable energy strategies, as the island has two ongoing projects HyCor and PurH2Corse, further exploring the hydrogen sector (Mai et al., 2024). Often considered in combination with solar and wind energy, these are necessary to produce hydrogen in a sustainable way. For example, in the research by Cristofari et al. (2010), a PV array, electrolyzer, and 50 kW fuel cells were used to meet seasonal load peaks. The PV array powered the load, with the fuel cell providing backup, while excess energy was stored as hydrogen. Moreover, while hydrogen seems to be an effective way to store intermittent RE, such as sun and wind, it also seems to have a recent high potential for decarbonizing the mobility sector, particularly the heavy transportation industry (Dubois et al., 2013; Hajjaji & Cristofari, 2024; Mai et al., 2024). Specifically, Hajjaji & Cristofari (2024) noted that green hydrogen-powered cars might be good alternatives to traditional vehicles as they do not generate any tailpipe emissions, resulting in better air quality and a decrease in greenhouse gas emissions.

Beyond solar, wind, and hydrogen, hydropower also contributes to the island's energy mix, though it has been less widely discussed, potentially due to the limited number of hydropower plants in Corsica (Battaglia et al., 2019). It is worth mentioning that Corsica has a hydraulic potential, but in summer it is reduced due to lower water availability and the use of dams for drinking water, leading to diesel power taking over (Notton et al., 2019a). While pumped hydro storage cannot be considered traditional hydropower it remains an important, related technology. Notton et al. (2011) revealed how energy storage with short-term energy power combined with hydro pumping, may be an effective way to enhance the integration of wind and solar energy systems into the grid. Hydraulic Pumped Storage (HPS) systems rely on water volume and elevation difference to define their storage capacity (Notton et al., 2017). They later noted that combining HPS with wind farms is an effective solution for small and island electrical grids (Notton et al., 2017).

Lastly, while hydropower has been explored in some studies, other renewable sources, such as bioenergy and geothermal energy, have received even less attention despite their potential. This underrepresentation contrasts with the recognition of bioenergy through biomass as a promising sector for future energy development (Battaglia et al., 2019). In addition, although they are the most competitive, waste combustion, small hydraulic plants, geothermal, and wind energy have not developed as much as they could (Notton et al., 2019a, 2019b). Similarly, ocean energy has not been explored in any of the reviewed studies, pointing to another potential gap in research.

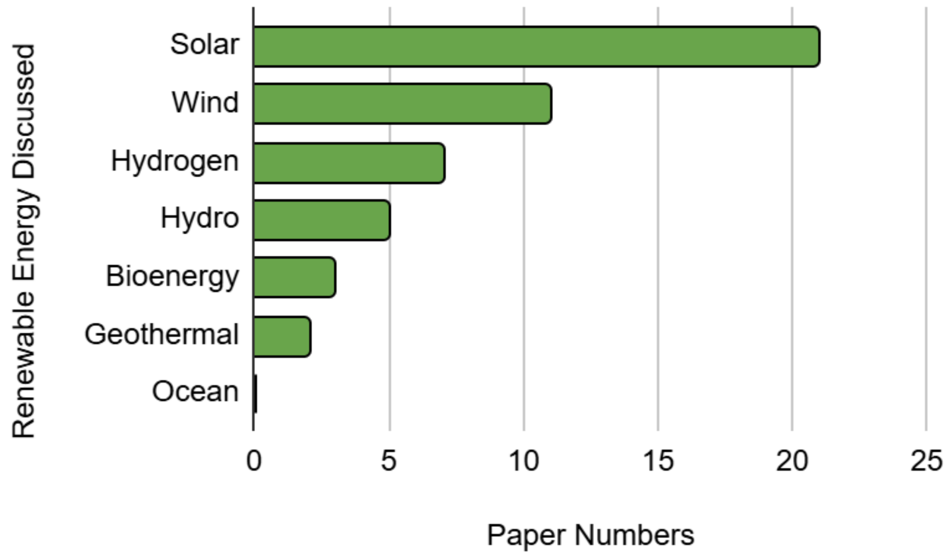

Figure 6. Distribution of Publication by Renewable Energy Discussed.

Hybrid Solar-Hydrogen Systems for Load Management

Firstly, photovoltaic and hydrogen hybrid systems were the subject of several papers (Cristofari et al., 2010; Darras et al., 2008; Poggi et al., 2009). It is interesting to note that while these papers were written by different lead authors and published in different years, these seem to be similar in terms of content. This suggests that there is a repetition in research, leading to a lack of renewal and raising questions about the diversification of research efforts in this area. In any case, these papers present photovoltaic and hydrogen hybrid systems reducing load peaks, which have been researched since the eighties. In the studies by Cristofari et al. (2010), Darras et al. (2008) and Poggi et al. (2009), the configuration consists of a photovoltaic array, an electrolyzer, a hydrogen storage tank, a fuel cell, and pumps. Solar panels are used to power the load and the fuel cells are used as backup when solar energy is not enough. When excess solar energy is produced, it is then used for hydrogen production. Through their research, the authors found that, in order to efficiently balance energy production and demand, the hybrid system using hydrogen to store excess solar energy and provide power during peak hours, can efficiently do so. Moreover, they discovered that it is technically possible for isolated grids to combine solar PV and hydrogen storage and recognized that the project helps reduce carbon emissions and promote energy independence (Cristofari et al., 2010; Darras et al., 2008; Poggi et al., 2009).

Optimized Hybrid PV/Wind Systems for Isolated Grids

Secondly, the Hybrid PV/Wind System (HPWS) was another well and diversely studied hybrid system (Diaf et al., 2008; Diaf et al., 2008b; Notton et al., 2017). In their papers, Diaf et al. (2008) and Diaf et al. (2008b) both focused on optimizing the size of a stand-alone HPWS to meet energy needs, with special attention to minimizing costs and ensuring energy independence through modeling. Nonetheless, they differed in terms of context since Diaf et al. (2008) focused on three sites in Corsica while Diaf et al. (2008b) focused on a system for remote consumers. Differences also emerged in system configurations. Diaf et al. (2008) studied a setup comprising a PV generator, wind generator, battery storage, multiple converters, an inverter, and an uninterruptible power supply. Conversely, Diaf et al. (2008b) analyzed two alternative configurations, prioritizing either wind or photovoltaic generation. Both studies concluded that optimal system size depends heavily on local renewable resources and that while these systems are cost-effective, surplus energy production often necessitates backup generators.

The other research on PV/wind systems was done by Notton et al. (2017). They had a sensibly different focus than the other papers since they wanted to know if coupling PV and wind energy systems with hydro-pumping storage (HPS) storage could produce a sufficient amount of energy for shaving the energy peak and thus avoid the startup of costly and polluting combustion turbines to do it. Differently to the research by Diaf et al. (2008a) and Diaf et al. (2008b), which used batteries as a means of storage, Notton et al. (2017) used HPS, considered efficient and the most cost-effective way to smooth electrical production. They were successfully able to demonstrate the viability and effectiveness of combining HPS with renewable energy sources, such as wind and solar, to control peak electricity demand on an island grid, like Corsica (Notton et al., 2017).

Overall, these studies illustrate that PV/wind hybrid systems are able to ensure a more reliable and cost-effective energy supply. This notably has the potential to improve energy management but also help to meet energy demand, especially during peak electricity.

Large-Scale Energy Transmission and Stability Technologies

Other important studies such as Battaglia et al. (2019) examined larger-scale technologies like the Sardinia-Corsica-Italy 3 (Sa.Co.I 3). This is a high-voltage direct current link and multi-terminal scheme, linking the Italian mainland, Sardinia, and Corsica, designed to help manage and optimize the transmission and stability of the power in the different grids. At the time of the study, it had been in operation for 30 years but with the integration of renewable energies it required more flexibility but also an improved voltage regulation, enhanced resilience to network disturbances, and fault-tolerant functionality among others (Battaglia et al., 2019). Diverse technologies were implemented as solutions such as Line Commutated Converter technology which was considered promising. More specifically, this technology was combined with synchronous condensers at each terminal, an emergency generator for power restoration capability, a specialized direct current disconnecting scheme at the converter substations, and a frequency regulator at different terminals. These elements are beneficial as, for example, synchronous condensers enabled voltage regulation and the disconnecting scheme at each converter station allowed the power to keep flowing at the terminals within the limit of one converter's capacity (Battaglia et al., 2019). This research was the only one focusing on the implementation of a multi-territory project.

While the two large-scale studies did not focus on a project or technology, they explored the electrical energy situation of several French islands with a focus on Corsica (Notton et al., 2019a, 2019b). Multiple aspects such as the energy means repartition, the use of renewable energy in production, with an emphasis on intermittent renewable sources, and the financial and legal aspects were discussed (Notton et al., 2019a, 2019b).

Small-Scale Renewable Energy Applications for Everyday Use

Regarding smaller-scale projects, these were also examined among the several selected papers such as the one by Toure et al. (2012). In their research, they discussed an air conditioning system using solar power to do the cooling process. This project has a high potential of being sustainable and might be a way to promote the use of renewable energy for everyday applications. In fact, the air conditioning system mostly runs on solar power (over 70%), which makes it a good real-world example of how solar energy can be used for cooling buildings (Toure et al., 2012). It is thus an innovative initiative competing with other solar technologies, such as photovoltaic and thermal.

Another small-scale project was studied by Ouédraogo et al. (2020), presenting a microgrid in Ajaccio, using photovoltaic generation and battery storage to power a building and an electric car. As the goal was to find out how the management strategy choice could affect the microgrid's cost and energy share, the authors applied various energy management strategies such as three different types of Rule-Based Control Strategies. Notable results were the fact that every improvement in strategy led to a decrease in the amount of lost PV production and that the more complex the strategy is, the better it performs. Overall, this study revealed how energy management strategies, particularly the ones using PV production forecasts, have the potential to significantly improve the economic performance of a system (Ouédraogo et al., 2020).

MYRTE Project

After having discussed large-scale and smaller-scale studied projects, the Renewable hYdrogen Mission for Electrical grid inTegration (MYRTE) appeared to be well-documented and particularly relevant to this study. Mentioned in 5 different papers (Cristofari et al., 2010; Cristofari et al., 2014; Dubois et al., 2013; Mai et al., 2024; Poggi et al., 2009), the MYRTE is a demonstration project set up in 2009 aiming to test hybrid solar-hydrogen technology on a large scale in order to create “an optimal strategy of operation between a photovoltaic field and a high power hydrogen chain” (Dubois et al., 2013; Mai et al., 2024). The MYRTE is a component of the University of Corsica's larger project of solar energy storage platform in the Vignola location. It uses a 3670 m^2 photovoltaic system generating 560 kWp and about 725 MWh/year. Part of the solar energy is converted into hydrogen and oxygen with the help of an electrolyzer (Dubois et al., 2013). The hydrogen produced is notably used to support the electrical grid and supply hydrogen for transportation purposes (Mai et al., 2024). The system also incorporates thermal energy storage and reuses heat and water to enhance performance. Moreover, besides being an important research and development platform, MYRTE is also involved in the competitiveness pole Corsica-PACA called "CAP ENERGIES" and the energy plan adopted by the Territorial Collectivity of Corsica, which aimed to attain 34% of renewable energies by 2020 (Dubois et al., 2013).

Cristofari et al. (2010) as well as Poggi et al. (2009), discussed the earlier phase of the MYRTE project: PEPITE. This was a research program launched in 2007 after the approval by the National Research Agency of France, part of the Pan-H program's framework. Dubois et al. (2013) studied the hydrogen safety aspect of the MYRTE demonstration project, providing valuable insights into the plant's construction authorization process and the associated delays. In order to determine the cost of storing hydrogen and oxygen safely, they conducted a literature survey but also used cost allocation and levelized methods. Notable results emphasized that the location and maintenance of the storage facilities for hydrogen and oxygen constituted the main costs of hydrogen safety. Based on the findings of the study, cost optimizations for H2 safety could then be planned (Dubois et al., 2013).

Thus, the MYRTE project emerges as a concrete example of how hydrogen can assist renewable integration, and regional decarbonization efforts, making it an important initiative in Corsica's energy transition.

Tools for Renewable Energy Integration

Aside from project-oriented studies, other research focused on the integration of renewable energy into the grid through technologies and innovations. For example, Muselli et al. (1999) used a geographical information system (GIS) to implement an integration plan for multiple renewable energy systems in remote areas in order to ascertain the best way to manage and use energy in these areas. For their research, they compared an engine generator, a hybrid PV/batteries/backup generator system, a stand-alone PV/batteries system, and an extension of the current electrical network. They found that the most cost-effective way to electrify 60–90% of remote locations is with a PV decentralized electricity system. They also noted that, when compared to grid extension, hybrid systems have a higher profitability boundary than photovoltaic systems because they are more competitive.

Notton et al (2011) focused on assessing the integration limits of renewable energy sources in small grids by identifying technical constraints, evaluating how energy storage can support it, and understanding the role of backup sources. With the help of models and scenario analysis, they discovered that hybrid renewable energy systems can significantly increase the share of renewables in total energy production, but optimizing the operating strategy is crucial to meaningfully reduce fossil fuel use.

Thus, these studies highlight how technological innovation, system modeling, and decentralized solutions are useful for the implementation of a resilient and cost-effective energy transition in Corsica.

Neglected Aspects of the Energy Transition

While most of the selected papers present technical and economic aspects of the energy transition, only one paper explicitly included social and ecological considerations. This paper is the one by Haurant et al. (2011), which used the multicriteria model ELECTRE IS in order to select the best photovoltaic plant projects. Among other dimensions, they considered the ecological one, with some attention also given to the social one. In fact, they highlight how, while PV plants are viewed as a sustainable option for producing electricity, they also might have an ecological cost that needs to be assessed to guarantee their ecological advantages (Haurant et al., 2011). For instance, they formulated an evaluation criterion to judge how rigorously the projects address ecological degradation and mitigation efforts. It is expected that projects follow a rigorous ecological methodology including doing field inventories of flora and fauna and providing objective, measurable ecological data (Haurant et al., 2011). Since the main goal was to avoid net biodiversity loss and improve the ecological quality of the project site, the evaluation scale used to examine the files' possible ecological degradation consisted of species and habitat descriptions, number of species affected, and species resilience just to name a few. Ultimately, ecological impact was a meaningful and differentiating criterion in the final project selection and had a veto power (Haurant et al., 2011).

Regarding the social dimension of the paper, they only considered social acceptability. Both the beneficial and adverse effects (e.g. visual and financial) of the projects on local communities were studied. Overall, due to technical limitations, local policymakers are only able to choose a small number of projects because of the need for electrical network stability, the need to avoid geographical electrical production excess, and the need to satisfy social acceptability and field use conflict avoidance standards (Haurant et al., 2011).

Thus this highlights a gap in literature since the ecological and social dimensions of the energy transition are poorly studied while significantly relevant. These are in fact crucial to balance and consider as they influence decision-making and project outcomes. They are also key to guarantee human well-being and biodiversity.

Multi-Level Perspective Analysis Results

In this section, the analysis will be taken further by discussing the niche, regime and landscape levels of the energy transition in Corsica, following the MLP framework.

Niche Actors

The majority of the niche actors are research teams, as they are responsible for innovating, experimenting, and developing technologies and ideas at the early stages (19 papers)(Figure 7). The University of Corsica emerges as the second most prominent niche actor as it is involved in five papers, followed by students and guest researchers (3 papers). This reinforces the earlier observation of this institution's dominance in the early part of the results section. CAPENERGIES is only a niche actor for one paper, together with the Sciences for Environment (SPE) laboratory, which is actually part of the University of Corsica. Overall, this highlights that niche innovations and alternatives for the Corsican energy transition are significantly driven by research teams, while other actors are less involved and thus show a lack of diversity.

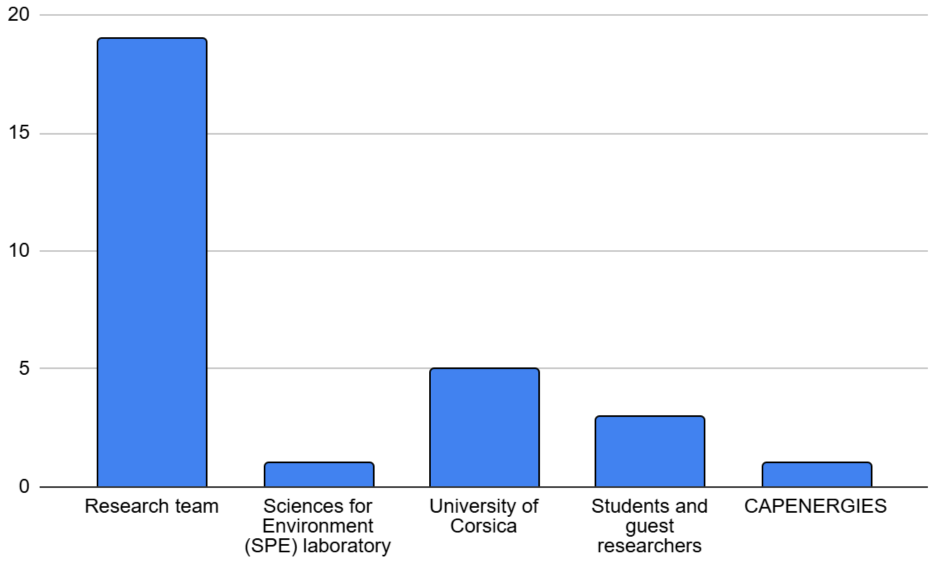

Figure 7. Actors Involved in the Niche Level of the MLP

Niche Innovations

Almost all analyzed papers discuss a niche innovation or alternative, except the ones by Notton et al. (2019a, 2019b), which described the electrical energy situation of various French islands, while focusing on Corsica. Various niche innovations or alternatives are discussed such as Hybrid PV/Wind plant coupled with a hydro pumping storage (Notton et al., 2017), hydrogen refueling stations tailored for bus transit, situated within the framework of a pertinent case study in Ajaccio (Hajjaji & Cristofari, 2024) or Artificial Neural Networks to predict time series of meteorological data (Paoli et al., 2010)(Table 1). Furthermore, it is interesting to note that most of these were in the experimental stage at the time of the studies (15 papers), with a few addressing niche innovations in between the experimental and scaling stages (3 papers) and only one being in the middle of the scaling and institutionalizing stage (Battaglia et al., 2019)(Figure 8).

Niche Innovations or Alternatives	Papers
Artificial Neural Networks (ANNs) to predict time series of meteorological data which is an attractive alternative by providing nonlinear parametric models	(Paoli et al., 2010)
Integration plan for various renewable energy systems in remote areas using a geographical-information system (GIS)	(Muselli et al., 1999)
The combination of photovoltaic (PV) energy generation with hydrogen storage to create a hybrid energy system specifically designed for isolated electrical grids.	(Cristofari et al., 2010)
Green hydrogen supply chain for sustainable mobility in island territories	(Mai et al., 2024)
The large-scale hydrogen system for photovoltaic energy regulation	(Dubois et al., 2013)
Implementation of management strategies applied to an existing R&D photovoltaic microgrid supplying in electricity an accommodation building for researchers and students.	(Ouédraogo et al., 2020)
Policy and economic mechanisms designed to support the renewable energy sector, especially SMEs and emerging actors (e.g Business Clusters)	(Cristofari et al., 2014)
Stand-alone HPWS that guarantee the energy autonomy of a	(Diaf et al., 2008b)

typical remote consumer with the lowest levelized cost of energy	
Sa.Co.I 3 technology for a flexible and new generation LCC (Line Commutated Converter) HVDC (High Voltage Direct Current) system	(Battaglia et al., 2019)
None	(Notton et al., 2019a)
None	(Notton et al., 2019b)
Air conditioning provided by solar energy and combined with an Absorption Chiller	(Toure et al., 2012)
Tailored multicriteria decision-making tool (ELECTRE IS) for PV project selection on agricultural land	(Haurant et al., 2011)
PV/H_2 Hybrid System for Peak Load Management	(Poggi et al., 2009)
Optimization of a stand-alone hybrid photovoltaic/wind system (HPWS) with battery storage	(Diaf et al., 2008a)
Hybrid PV/Wind plant coupled with a hydro pumping storage (HPS)	(Notton et al., 2017)
Development and implementation of a hybrid energy system that combines photovoltaic (PV) solar power with a diesel generator	(Notton et al., 1996)
High-Resolution Disaggregation of Satellite Irradiance Data	(Haurant et al., 2012)

PV–Electrolyzer–Fuel Cell Hybrid System for Peak Load Management	(Darras et al., 2008)
Hydro-Pumped Storage Integration in Small Island Grids using solar and wind energy	(Notton et al., 2011)
Hydrogen refueling stations tailored for bus transit, situated within the framework of a pertinent case study in Ajaccio	(Hajjaji & Cristofari, 2024)

Table 1. Niche innovations or alternatives discussed in each paper.

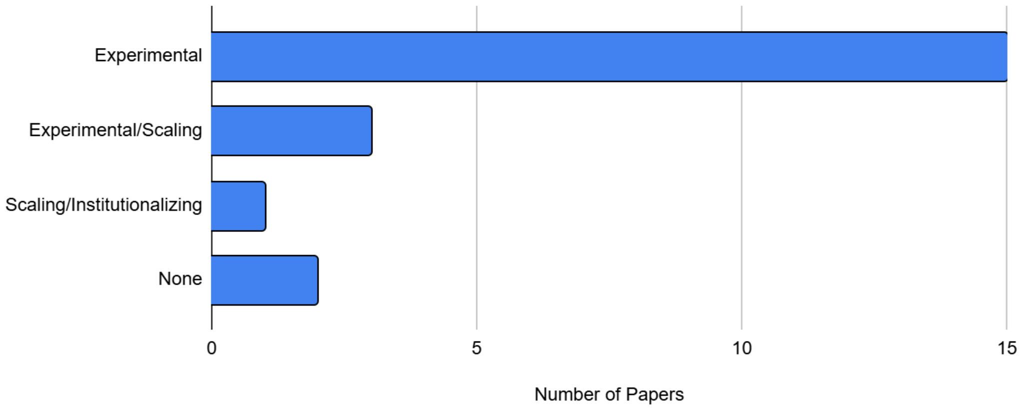

Figure 8. Stage of Development of the Niche Innovations or Alternative

Regime Level Actors

Various actors emerge in the regime level, notably EDF, a state-owned energy company present in 12 papers (for example Darras et al., 2008; Notton et al., 2011; Poggi et al., 2009). Other important actors are the EU (9 papers), the French government providing for example research funding (6 papers), the Energy Regulatory Commission (4 papers), and the National Research Agency (3 papers). Moreover, Corsican institutional actors such as the Corsican government, the Territorial Collectivity of Corsica, and the Corsican Assembly are only mentioned in 3 papers. Other notable regime actors are the Italian government and Italy's national electricity transmission system operator Terna. In fact, Corsica imports electricity from Sardinia and Italy through the SARCO and SACOI cable (Notton et al., 2019a). Thus, it becomes clear that Corsica's regime is centralized and reliant on external actors, with limited regional agency.

Socio-Technical Regime Characteristics

Firstly, it seems like Corsica's regime was and still is dominated by fossil fuels and centralized energy systems (Mai et al., 2024; Muselli et al., 1999). In fact, fossil fuel-fired power plants are the primary electricity production methods, and fossil fuel generators are still used mainly for technical reasons (Mai et al., 2024; Ouédraogo et al., 2020). Moreover, Muselli et al. (1999) highlighted a focus on off-grid diesel solutions and grid-based planning, but it is unclear whether this still reflects current practice.

Secondly, Corsica implemented various institutional and regulatory frameworks. In fact, the island put in place plans such as the Energy Plan of the Territorial Collectivity of Corsica aiming by 2020 to attain 34% renewable energy, the plan for the regional and sustainable development of Corsica (PADDUC plan) for sustainable development and land use in Corsica, and the long-term energy plan PPE (Pluriannual Planning for Energy) aiming to improve RE's installed power in the electrical generation as well as energy security (Cristofari et al., 2014; Dubois et al., 2013; Notton et al., 2019b). Moreover, many regulations related to the energy sector emerged throughout the papers such as safety measures in the context of Hydrogen and Oxygen production (Dubois et al., 2013) and the uniformization of electricity tariffs across France, meaning that the electricity tariffs for end-users in Corsica are the same as those in mainland France (Notton et al., 2019a). The mainland consumers subsidize the electricity costs in Corsica through their electricity bills (Notton et al., 2019a; Ouédraogo et al., 2020).

Corsica's socio-technical regime is also characterized by various energy initiatives and a will to achieve sustainable energy autonomy (Haurant et al., 2011). The territorial collectivity of Corsica notably adopted a renewable energy sources (RES) development and energy consumption control plan in 2007 aiming for 30% of electricity production coming from RES (Haurant et al., 2011). It also approved the Corsica photovoltaic development charter in 2009, as well as charters for wind farm development in 2003 and wind farm controlled development in 2005 (Haurant et al., 2011). Furthermore, while Notton et al. (2019b) discussed the law of February 2000, establishing a purchasing obligation for renewable power, more recently Mai et al. (2024) stated that, with goals of 62% for Corsica by 2028, policies are being put in place to raise the proportion of renewable energy in the energy mix. Also, Hajjaji & Cristofari (2024) introduced the Corsica 2030 vision, aiming to decarbonize the transportation sector and improve the conversion of renewable energy sources while lowering greenhouse gas emissions.

Corsica manifestly takes initiatives for the energy transition at the regime level but faces some grid and energy infrastructure constraints, potentially undermining transition efforts. In fact, Notton et al. (2011) already pointed out relatively high energy costs due to lower consumption, a lack of connections, and structural costs associated with issues with storage and shipment. Later, they also noted the structural fragility of islands, high fault probabilities, diesel engine-dependent electricity generation, high reliance on energy supply, and a demand for electricity significantly susceptible to climatic changes (Notton et al., 2019a). It is important to mention that approximately 87% of the island's primary energy in 2014 came from outside sources, despite the fact that renewable energy played a significant role in the energy mix (Notton et al., 2019b). Furthermore, a limit of 30% of the electrical network mix's intermittent renewable energy sources at any given time is necessary to guarantee the security of the electricity supply in an unconnected electrical network (Notton et al., 2019a). This clearly had a detrimental effect on the islands' development of wind and photovoltaic energy, but it is not straightforward if it is still the case today (Notton et al., 2019a).

Regarding the economic and market structure of Corsica, there is a total lack of any of the large corporations and holdings that drive the global economy and it is uncommon for medium-sized businesses to serve large corporations (Cristofari et al., 2014). Furthermore, capital investment in the public sector is hypertrophied and has an imbalanced economy, characterized by a dominance of downstream trade and non-market services close to end-user demand, coupled with structural weaknesses in upstream production sectors. Thus, the private sector appears to be the only practical choice that can provide a dynamic impetus for regional development (Cristofari et al., 2014).

Landscape Pressures

This section examines the broader landscape-level pressures that influence Corsica's energy transition. These developments originate outside the island's direct control yet shape the conditions under which local and regional changes occur.

Firstly, it is notable that technological advancements constitute a key landscape pressure impacting the Corsican energy situation. For instance, the increasing use of AI and machine learning for energy forecasting and the increase in computer performance constitute global digital trends (Muselli et al., 1999; Paoli et al., 2010). These developments have for example improved tools such as the GIS, becoming useful for politics or economics and thus applicable in multiple sectors (Muselli et al., 1999). While these technologies are not unique to Corsica, they provide new capabilities for managing and planning regional energy systems.

Secondly, policies and regulations represent another major landscape pressure influencing the energy transition in Corsica. In fact, global initiatives such as Chapter 17 of Agenda 21 from the 1992 Earth Summit in Rio de Janeiro and regional efforts, including the First European Conference on Sustainable Island Development reflect increasing global commitment to sustainability (Cristofari et al., 2014; Notton et al., 2011). These are also reinforced by international frameworks such as the Paris Agreement, EU directives, and legislations, as well as the 2009/28/EC directive which all aim to decarbonize the energy sector by reducing greenhouse gas emissions, improving energy efficiency, promoting renewable energy use, and securing energy supply (Hajjaji & Cristofari, 2024; Haurant et al., 2011; Notton et al., 2019a). Thus, even if Corsica is a small island, these global and regional policies influence its energy development trajectory. Also, while it was not explicitly mentioned in the papers, these initiatives clearly stem from broader concerns about climate change and environmental sustainability.

Lastly, market trends and economic dynamics play an important role as landscape forces. For instance, solar energy plays a major role in global electricity production and benefits from a growing photovoltaic market. Another growing market is electric vehicles, which are becoming widely adopted (Ouédraogo et al., 2020). Moreover, renewable sources are seen as an environmental solution but also as tools for enhancing economic competitiveness in Europe (Haurant et al., 2011). In addition, as energy demand is increasing, economic competition intensifies globally, with countries striving to meet consumption needs while sustaining economic performance (Hajjaji & Cristofari, 2024).

Discussion

In this study, I explored the state of the art of the Corsican energy transition. The main outcomes of this assessment are various. Firstly, various foreign institutions and countries beyond Corsica, are involved in research even if the Università di Corsica Pascal Paoli dominates. Secondly, it was notable that the analyzed papers focused on the economic and technical dimensions of the energy transition, while social and ecological ones were overlooked. Thirdly, solar energy dominated, followed by wind energy and hydrogen. In addition, while hydropower was explored in some studies, other renewable sources such as bioenergy and geothermal energy received even less attention. Lastly, besides small-scale innovations, the Sa.Co.I 3 improvements emerged as an important large-scale project, the

MYRTE and hybrid systems as promising, and multiple efforts towards RE integration were examined.

The Corsican Transition

With the help of the MLP framework, the Corsican energy transition can be examined, by looking at all three levels and their interactions (Figure 9).

At the niche level, innovations such as HPWS, solar air conditioning, hydrogen refueling stations, or PV/hydrogen hybrid systems, are supported by small networks of actors. In the case of Corsica, research teams, the University of Corsica, CAPENERGIES, and students are the ones supporting these novelties. This phase especially involves efforts to interconnect various technical, institutional, and social elements as well as multidimensional learning. Then, as niche innovations mature, some of them eventually align and settle into a dominant design, thereby gaining wider support (Geels, 2011). For example, multi-criteria decision-making tools and emerging business clusters, suggest partial stabilization and increasing momentum for these innovations.

Next, windows of opportunity arise in favorable conditions, leading to the scaling up and influence of new configurations on the existing socio-technical regime (Geels, 2011). This is the case of the Sa.Co.I 3 technology modernization. The regime, which is characterized by centralized energy systems, fossil fuels dominance, and structural imbalances, starts to adapt in response.

Furthermore, landscape developments, like market trends, technological development, climate change, and supranational regulations, apply pressure to the current regime. This also creates windows of opportunity for innovations, thus destabilizing dominant practices and fostering transformations (Geels, 2011). For instance, the interaction between these landscape developments and niche innovations fostered the implementation of multiple renewable energy plans and initiatives.

Ultimately, the interaction between niches, regimes, and landscape pressures shapes the transformation of socio-technical systems and dynamically influences the energy transition in Corsica.

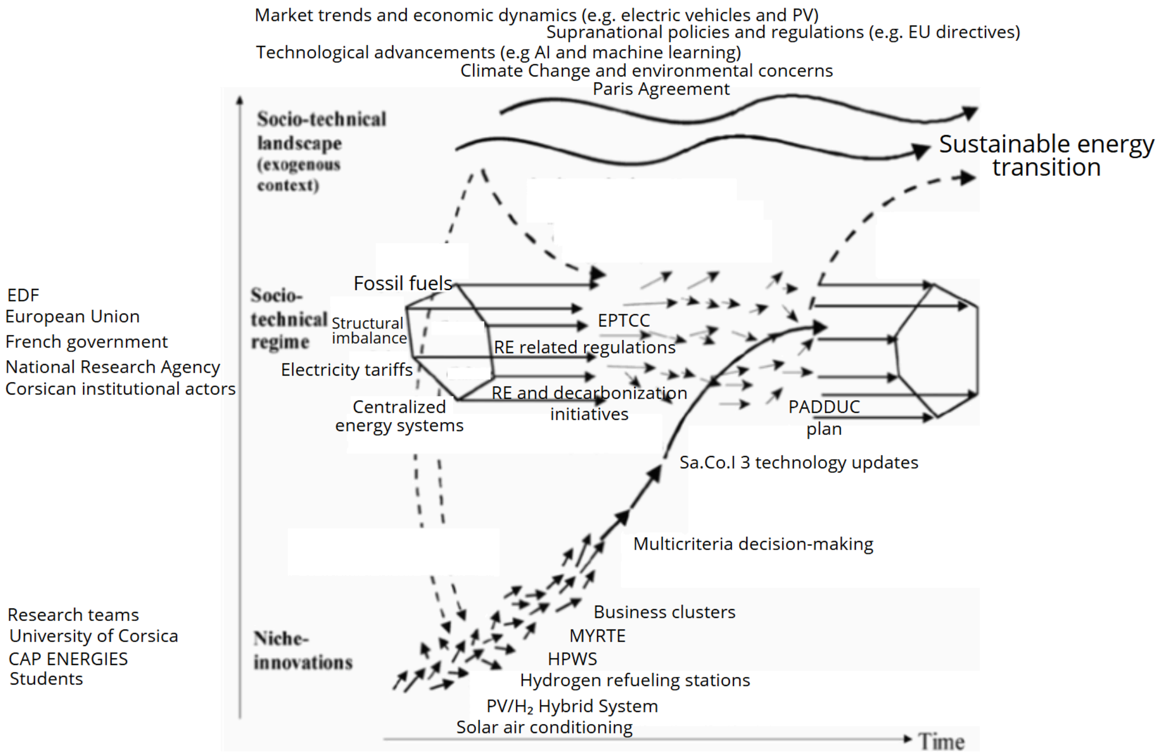

Figure 9. Multi-Level Perspective Diagram Applied to the Energy Transition in Corsica

What Counts as Renewable?

As discussed earlier in this study, renewable energy sources play a critical role in the energy transition especially due to their widespread integration into energy systems. However, despite their importance, the classification of energy as renewable remains somewhat contingent. While the results of this study suggest that the regime narrowly defines RE and favors solar and wind energy, niches like bioenergy and more specifically biomass, even if offering alternatives, are overlooked in the Corsican research environment. This is surprising because while research about bioenergy was relatively limited, biomass actually plays a significant role in Mediterranean islands (Peñalvo-López et al., 2024). In particular, a recent push for this RE can be observed through the Ricanto project, a 130 MW plant running on liquid biomass aiming to ensure Corsica's energy security from 2027 onwards (EDF PEI, 2024). This underrepresentation could arise from the choice of the keywords “renewable” and “energy” during literature selection, potentially excluding more complex, less widespread, and context-dependent renewable energy sources like bio, ocean, and geothermal energy. Furthermore, the United Nations defines RE as “energy derived from natural sources that are replenished at a higher rate than they are consumed” (United Nations, n.d.-b). This is pretty broad and ambiguous, potentially leading to confusion and inconsistencies when categorizing what counts as renewable or not, especially for authors. This discrepancy is particularly highlighted in this study, by the significant lack of research about other renewable energy sources besides solar, hydro, and wind energy. Moreover, the fact that hydrogen was likely categorized as such further emphasizes this lack of cohesion. Indeed, hydrogen is not a proper renewable energy source but a renewable energy carrier when produced using renewable energy (Yue et al., 2021).

Comparison with other Islands

It is difficult to assess whether Corsica has achieved its aims and if the implemented plans and regulations were successful. In the reviewed papers, these initiatives were mentioned but no follow-up data or performance tracking was provided. Additionally and as briefly discussed in the introduction, since the island suffers from a lack of accessible data regarding its energy mix, it is even more difficult to identify potential drawbacks or improvements. Therefore, comparing Corsica with other islands may offer useful context for evaluating its progress regarding the energy transition.

Firstly, according to Lamnatou et al. (2023), studies on the energy transition in the context of small-island economies are lacking, which could explain why I did not get a lot of queries and selected papers especially because I chose to analyze papers with a strong focus on Corsica. Moreover, when comparing Corsica with Guadeloupe, Martinique, Guyane, Reunion, and Mayotte, together with Guyane, Corsica has the lowest emissions (0.373 and

0.505 kg CO_2eq/kWh respectively) thanks to their use of renewable energy sources and network interconnection (Lamnatou et al., 2023).

Secondly, since Corsica has similar characteristics to other Mediterranean islands like Sardinia, Sicily, and Crete, Peñalvo-López et al. (2024) were able to make comparisons. For instance, Corsica, Sicily, Sardinia, and Tenerife saw their oil consumption increase in 2023 in comparison to the previous six years, even if the production of renewable energy has been steadily increasing in recent years. Moreover, Corsica and El Hierro are on their way to achieving 50% energy independence, while Sicily and Sardinia have levels around 30% despite their larger populations and higher energy production. Nonetheless, even if Corsica has taken significant steps towards a more sustainable energy sector, it is the only island where carbon intensity has increased, rising from 633 to 752 gCO_2eq/kWh in 2023. The drop in hydropower in 2023, due to rainfall deficit, is potentially responsible for the increase in non-renewable sources usage. Lastly, despite an increase in solar energy production during the previous six years, Corsica is one of the islands with the highest CO_2 emissions per capita (Peñalvo-López et al., 2024).

Finally, to briefly touch upon bioenergy, while the islands with the greatest annual potential for bioenergy generation are Sicily, Sardinia, and Cyprus, Corsica leads in bioenergy generation per capita, with 29.83 Tonne of Oil Equivalent per inhabitant. Nevertheless, managing digestate application on soils poses a big challenge for Corsica and Malta (Attard et al., 2023).

Thus, it is clear that Corsica is committed to the energy transition and is doing well compared to the other islands. Nonetheless, challenges remain and setbacks can emerge, meaning that improvements can still be made.

Barriers

In the first place, due to the geographical and infrastructural isolation of the island, affordable and feasible energy interconnection with the mainland is limited (Haurant et al., 2011). Moreover, the grid is vulnerable and risks emerge from key component failures (Battaglia et al., 2019; Darras et al., 2008). Also, some projects might be technologically complex, with losses of efficiency and facing technological maturity constraints (Cristofari et al., 2010; Darras et al., 2008, Mai et al., 2024; Notton et al., 1996). Another important barrier relevant to the study by Haurant et al. (2012) and Paoli et al. (2010) could be limited data quality and availability for technical analysis and decision-making. Most importantly, the intermittency of renewable sources is a challenge, leading to more difficulties in integrating them into the grid and load variability (Notton et al., 2011; Ouédraogo et al., 2020). Wind and solar energy distribution especially are inhomogeneous in nature and intermittent (Diaf et al., 2008b; Dubois et al., 2013). In addition, Corsica’s tourism-based economy drives oversized energy capacity needs and hinders investment and workforce diversification, challenging a sustainable energy transition (Notton et al., 2011; Notton et al., 2019a).

Secondly, the energy transition requires high costs and investments, whether for implementing technologies or projects (for example Battaglia et al., 2019; Cristofari et al., 2014; Darras et al., 2008; Mai et al., 2024). Moreover, while interconnection is almost impossible, the infrastructure would be very expensive to build (Haurant et al., 2011). In alignment with this, potential economic uncertainty and cost sensitivity as well as high safety-related costs, and difficult cost optimization could arise (Diaf et al., 2008b; Dubois et al., 2013; Ouédraogo et al., 2020).

Thirdly, the remoteness and topography of the island can make energy supply even more difficult (Haurant et al., 2011). Besides variability in geography, there is also meteorological and environmental variability that needs to be taken into account (Haurant et al., 2012; Notton et al., 2011; Paoli et al., 2010). Concerns especially arise regarding the availability of suitable land and water resources (Notton et al., 2017). In fact, geographic and climatic limitations must be carefully taken into account when deploying the hydrogen sector, with water availability presenting a significant challenge (Mai et al., 2024).

Lastly, safety might be a concern, with energy supply security being especially challenging (Cristofari et al., 2010; Ouédraogo et al., 2020). Moreover, while it was not widely discussed, problems regarding public acceptance and wide acceptance could occur (Hajjaji & Cristofari, 2024; Notton et al., 2017). Then, a lack of supportive regulations, infrastructure, and financial incentives can be a challenge for future development of the energy transition (Muselli et al., 1999; Notton et al., 2017; Poggi et al., 2009).

Drivers

Corsica implemented a lot of energy plans such as its energy plan for the period 2005–2025, its Plan for Renewable Energy Development and Energy Management, and the Pluriannual Planning for Energy and Corsica 2030 vision (Cristofari et al., 2014; Hajjaji & Cristofari, 2024; Haurant et al., 2011; Notton et al., 2019a). It also put in place goals such as reaching 62% of renewable electricity generation in Corsica by 2028 and achieving energy self-sufficiency by promoting sustainable utilization and managing consumption effectively by 2050 (Mai et al., 2024). Research efforts like the MYRTE project and the PEPITE program are also key drivers, alongside supportive government policies and incentives (Darras et al., 2008; Paoli et al., 2010; Toure et al., 2012). Notably, the special status attributed to Corisica by the EU could facilitate energy transition efforts (Notton et al., 2019b).

Other drivers are technological advancements and innovations, notably in renewable energy systems and technologies but also in machine learning and Artificial Intelligence (for example Darras et al., 2008, Notton et al., 2017, Mai et al., 2024; Paoli et al., 2010).

Moreover, growing attention toward long-term energy storage solutions with batteries, hydrogen, and management strategies for example, might also act as a catalyst for RE integration, electricity distribution, and quality (Darras et al., 2008; Notton et al., 2011; Notton et al., 2017; Ouédraogo et al., 2020).

In addition, specific and profitable purchasing conditions for RE, as well as strategic and supportive investments could propel the Corsican energy transition (Hajjaji & Cristofari, 2024; Haurant et al., 2011; Notton et al., 2019a). Furthermore, high operational and installation costs of conventional energy systems on islands, dependence on imported fuels, and thus susceptibility to high fuel price variation, might encourage the implementation of RE systems (Notton et al., 2011; Notton et al., 2019b; Toure et al., 2012). Other economic tools such as renewable energy feed-in tariffs and business clusters, might be beneficial for the energy transition while creating jobs and local economic benefits (Cristofari et al., 2014; Notton et al., 2017; Notton et al., 2019a).

Lastly, while islands have emerged as practical models for testing sustainable energy solutions, Corisca benefits from abundant renewable energy sources thanks to high solar and wind potential (Cristofari et al., 2010; Mai et al., 2024; Notton et al., 2019a; Toure et al., 2012). In fact, owing to its geographic location and natural resources, Corsica is well-positioned to take the lead in the energy field (Cristofari et al., 2014). Moreover, the fact that there are increasing concerns about environmental issues might prompt people to take action, which, coupled with community support and participation, but also positive public perception and knowledge exchange, could expedite the energy transition (Cristofari et al., 2010; Diaf et al., 2008a; Hajjaji & Cristofari, 2024; Notton et al., 2017; Toure et al., 2012).

Recommendations for the Energy Transition

Based on this study, hydrogen, storage technologies, wind, solar, and bioenergy as well as hybrid systems appear to be key for the energy transition in Corsica. Green hydrogen presents a clean fuel alternative, especially useful for the transportation sector which is difficult to electrify. Then, while Corsica has a high potential for solar and wind energy, these are intermittent. Therefore, energy storage systems could help capture excess energy when production is high and release it when demand is greater or production is low, ensuring a more stable power supply. Together, storage technologies and hydrogen fuel cells also have the potential to improve the reliability of the Corsican energy grid, notably by efficiently balancing fluctuations in demand and supply, which are inherent to most renewable energies. Furthermore, as Corsica relies a lot on imported fossil fuels, the development of local renewable sources combined with storage could reduce the dependence on imports and further increase self-sufficiency. Besides wind and solar energy being already widely deployed, Corsica has a high potential for biomass, which could play a key role. Indeed, biomass provides a steady, controllable energy source that could complement intermittent renewables such as solar and wind. Lastly, hybrid systems would also be important for the energy transition in Corsica as they combine storage technologies and numerous energy sources, allowing them to overcome the limitations of each and optimize overall performance.

Future Research

While I did not have access to three papers, it is important to mention that this could have altered the results. This highlights the necessity for more open access sources, which promotes broader dissemination and more knowledge sharing. Regarding further research, the use of different keywords could be beneficial for encompassing more energy sources and other important aspects of the transition. The use of different databases than Scopus could also add depth from different disciplines and increase completeness. Then, further research could assess if Corsica's energy goals and plans have been achieved, are on track, or behind. More generally, more research should be done about the ecological and social dimensions of the energy transition as it is not merely about reducing CO2 emissions, but also reducing air pollution, improving human well-being and environmental benefits (United Nations, n.d.-c). A more holistic approach would allow for a better understanding of transitions globally, ultimately supporting more effective, just, and sustainable energy transitions, without being at the expense of biodiversity and humans.

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Appendix

Systematic Literature Review Papers List

Authors	Paper Title	Year	Source Title	DOI/URL
Battaglia A.; Buono L.; De Zan R.; Di Bartolomeo E.; Marzinotto M.; Palone F.; Pazienza M.; Pede F.; Michi L.; Carlini E.M.; Scirocco T.B.; Bruno G.; Gnudi R.; Pecoraro G.; Pisani C.	Analysis of the plant and operational requirements for the design of a flexible and new generation LCC HVDC system: The Sa.Co.I 3 technology case	2019	2019 AEIT HVDC International Conference, AEIT HVDC 2019	10.1109/AEIT-HVDC.2019.8740651
Cristofari C.; Canaletti J.L.; Darras C.; Muselli M.; Poggi P.; Panighi J.	Investigation on Photovoltaic/Hydrogen Hybrid System for an Isolated Electrical Grid	2010	Proceedings of the International Conference on Energy and Sustainable Development: Issues and Strategies, ESD 2010	10.1109/esd.2010.5598871
Cristofari C.; Storai C.; Canaletti J.L.	Development policy to increase the competitiveness of renewable energy-sector companies in a territory like Corsica (France)	2014	Renewable and Sustainable Energy Reviews	10.1016/j.rser.2014.01.006
Darras C.; Muselli M.; Poggi P.; Cristofari C.; Le Pivert X.	Modeling and simulating of a PV/H2 hybrid system for reducing load peaks on an electrical grid	2008	ECS Transactions	10.1149/1.2921587
Diaf S.; Belhamel M.; Haddadi M.; Louche A.	Technical and economic assessment of hybrid photovoltaic/wind system with battery storage in Corsica island	2008a	Energy Policy	10.1016/j.enpol.2007.10.028
Diaf S.; Notton G.; Belhamel M.; Haddadi M.; Louche A.	Design and techno-economical optimization for hybrid PV/wind system under various meteorological conditions	2008b	Applied Energy	10.1016/j.apenergy.2008.02.012

Dubois J.; Hû G.; Poggi P.; Montignac F.; Serre-Combe P.; Muselli M.; Hoguet J.C.; Vesy B.; Verbecke F.	Safety cost of a large scale hydrogen system for photovoltaic energy regulation	2013	International Journal of Hydrogen Energy	10.1016/j.ijhydene.2012.10.027
Hajjaji M.; Cristofari C.	Economic and technical evaluation of on-site electrolysis solar hydrogen refueling station in Corsica: A case study of Ajaccio	2024	Renewable Energy	10.1016/j.renene.2024.120982
Haurant P.; Muselli M.; Pillot B.; Oberti P.	Disaggregation of satellite derived irradiance maps: Evaluation of the process and application to Corsica	2012	Solar Energy	10.1016/j.solener.2012.08.010
Haurant P.; Oberti P.; Muselli M.	Multicriteria selection aiding related to photovoltaic plants on farming fields on Corsica island: A real case study using the ELECTRE outranking framework	2011	Energy Policy	10.1016/j.enpol.2010.10.040
Moustapha Mai T.; Azzaro-Pantel C.; Cristofari C.; Chin Choi M.	A prospective approach to the optimal deployment of a hydrogen supply chain for sustainable mobility in island territories: Application to Corsica	2024	International Journal of Hydrogen Energy	10.1016/j.ijhydene.2024.10.374
Muselli M.; Notton G.; Poggi P.; Louche A.	Computer-aided analysis of the integration of renewable-energy systems in remote areas using a geographical-information system	1999	Applied Energy	10.1016/S0306-2619(99)00027-6
Notton G.; Duchaud J.L.; Nivet M.L.; Voyant C.; Chalvatzis K.; Fouilloy A.	The electrical energy situation of French islands and focus on the Corsican situation	2019a	Renewable Energy	10.1016/j.renene.2018.12.090
Notton, G., Voyant, C., Duchaud, J.L.,"6603908310	Difficulties of Solar PV Integration in Island Electrical Networks – Case Study in the French Islands	2019b	E3S Web of Conferences	10.1051/e3sconf/20191110602 8
Notton G.; Mistrushi D.; Stoyanov L.; Berberi P.	Operation of a photovoltaic-wind plant with a hydro pumping-storage for electricity peak-shaving in an island context	2017	Solar Energy	10.1016/j.solener.2017.08.016

Notton G.; Muselli M.; Louche A.	Autonomous hybrid photovoltaic power plant using a back-up generator: A case study in a mediterranean island	1996	Renewable Energy	10.1016/0960-1481(96)00016-X
Notton G.; Stoyanov L.; Ezzat M.; Lararov V.; Diaf S.; Cristofari C.	Integration limit of renewable energy systems in small electrical grid	2011	Energy Procedia	10.1016/j.egypro.2011.05.075
Ouédraogo S.; Faggianelli G.A.; Pigelet G.; Duchaud J.L.; Notton G.	Application of optimal energy management strategies for a building powered by PV/battery system in corsica Island	2020	Energies	10.3390/en13174510
Paoli C.; Voyant C.; Muselli M.; Nivet M.-L.	Forecasting of preprocessed daily solar radiation time series using neural networks	2010	Solar Energy	10.1016/j.solener.2010.08.011
Poggi P.; Cristofari C.; Canaletti J.L.; Darras C.; Muselli M.	Sizing of a PV/H 2 hybrid system to supply peak loads on an isolated electrical grid - A case study in Corsica Island (France)	2009	Proceedings of the IASTED International Conference on Solar Energy, SOE 2009	https://www.researchgate.net/publication/255704024_Sizing_of_a_PVH2_hybrid_system_to_supply_Peak_loads_on_an_isolated_electrical_grid_-_A_case_study_in_Corsica_Island_France
Touré S.; Faggianelli A.; Muselli M.; Cristofari C.	Air conditioning using thermal solar collectors coupled with an absorption chiller in Corsica	2012	Asia-Pacific Power and Energy Engineering Conference, APPEEC	10.1109/APPEEC.2012.6306949