LUISS

Degree Program in Global Management and Politics

Course of Political Risk Analysis

Rebalancing power: Italy’s strategic energy policy between geopolitics and technological choices

Prof. Manfredi Valeriani

SUPERVISOR

Prof. Francesco Galietti

CO-SUPERVISOR

Leonardo Raspanti
786521

CANDIDATE

Academic Year 2024/2025

Table of contents

List of figures

Introduction

In 2025, Italy will continue to import about 74 per cent of the primary energy required for its needs. This dependence exposes the country to economic, industrial, and geopolitical vulnerabilities in an increasingly unstable and competitive global context. The Russian-Ukrainian conflict, the emergence of China as a technological superpower, the climate crisis and the acceleration of European policies for decarbonisation have made it clear how energy supply chains and access to critical raw materials are now a national security issue, as well as an industrial one. The ecological transition is not only about technologies but, perhaps most importantly, about the political ability to ensure access, continuity and sovereignty along the entire value chain.

This thesis seeks to answer the question of how Italy can rebalance its energy strategy to reduce geopolitical vulnerabilities and ensure long-term security by integrating technological choices and political decision-making within a coherent national framework.

The problem is as urgent as it is neglected in the public debate: technological choices are never neutral, and every material dependence translates into political dependence. If not supported by a solid industrial strategy and stable programmable sources, adopting renewable energy risks replacing dependence on fossil fuels with a new form of vulnerability linked to external, uncontrolled supply chains. Against this picture, nuclear power comes up again as a possible complementary, pragmatic, and politically divisive answer.

This thesis aims to analyse the political risk of managing critical raw materials in Italy and assess the role a more balanced energy strategy, based on a mix of renewables and nuclear, could play in reducing that risk. The starting hypothesis is that Italy, to maintain industrial competitiveness, energy security and climate consistency, must integrate the political dimension into the planning of its technology choices. To support this hypothesis, the thesis employs a mixed methodology: on the one hand, a documentary and geopolitical analysis of Italian and European policies; on the other hand, the application of the Cross Impact Analysis methodology to model three alternative scenarios and assess the interactions among key variables (technological, geopolitical and industrial).

The thesis is divided into four main chapters: the first describes the Italian energy structure, with a focus on production, foreign dependencies, plants, energy mix and geographic distribution; the second focuses on the geopolitics of critical raw materials, analysing the main strategies of China, the United States and Europe and assessing Italy's role in the context of standard policies and international tensions; the third introduces and applies the Cross Impact Analysis methodology to construct three possible scenarios for Italy: accelerated decarbonisation, lock-in on gas, and strategic nuclear power; the fourth develops in detail the scenario deemed most effective and coherent: the return of nuclear power to the Italian energy mix, with a technical, political, and communicative analysis of its potential role.

The analysis shows that one of the best solutions for Italy is integrating renewables with nuclear power. This solution would reduce emissions, increase the electricity grid's stability, contain energy costs, and structurally address geopolitical dependence on external supply chains.

However, its achievability depends on the political ability to transparently manage consensus, build reliable international partnerships, and ensure secure and sustained access to needed raw materials. Political risk is not just an obstacle but the first strategic factor to be governed.

Chapter 1

1 Italian Energy Structure

This chapter provides a detailed picture of Italy's energy production, consumption and infrastructure, with an analysis of the energy sources used, their efficiency and critical issues in the national system.

1.1. The Italian energy mix: production and consumption

Italy is one of the European countries with the highest foreign energy dependence, with about 74 per cent of primary energy imported in 2023. The leading source nations for gas supply were Algeria with 38 per cent, Russia with 21 per cent, Azerbaijan with 17 per cent, and Qatar with 9 per cent. As for imported electricity, on the other hand, which covers about 23 per cent of national consumption, the countries from which we import are mainly France, Switzerland and Slovenia.

The rest comes from domestic energy sources, mainly renewables. In 2024, net domestic electricity production was 264 billion kWh, 264 TWh, registering a 2.7 per cent increase over 2023[1]. In 2023, we had a drop in thermoelectric production of about 20 per cent, balanced by the increase in renewables. Domestic production is divided into

[1] Terna: nel 2024 consumi elettrici in aumento del 2,2% - Terna spa. (2024). Terna.it. https://www.terna.it/it/media/comunicati-stampa/dettaglio/consumi-elettrici-2024

different sources, in Terna's annual report[2] we find production through thermoelectric, that is, natural gas and coal, amounting to 168TWh roughly 65% of the total produced by the country, with a significant prevalence of gas; hydro, with as much as 42TWh in 2023, up from 2022 due to favorable weather conditions; wind power with about 23TWh produced, the wind power sector is growing strongly due to significant investment packages in the industry; photovoltaics amounting to about 30TWh, booming due to large government and non-government incentives; geothermal with about 5TWh, a stable source of energy as production; and finally bioenergy with a production of about 16TWh. Renewable energies contributed about 45 per cent of Italy's total production, an excellent percentage. If it wasn't just that our primary energy import is still very high and is an issue that needs to be addressed structurally.

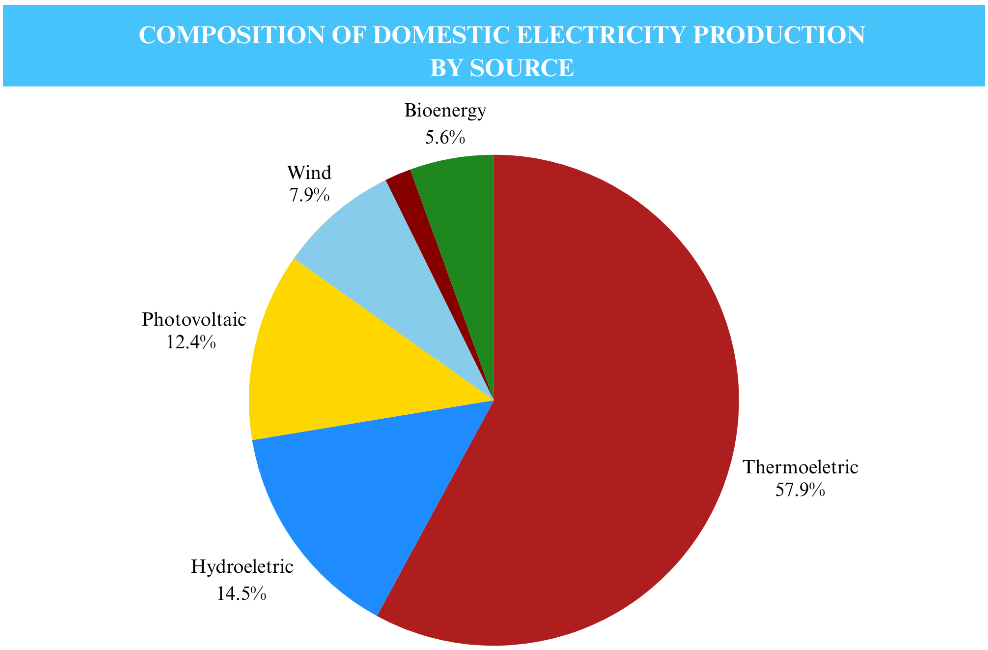

Figure 1: Composition of domestic electricity production

But besides the total production, in Italy the production is highly unbalanced; about half of the energy produced comes from Northern Italy, a good portion from the

[2] TERNA S.P.A. (2024). Produzione Nazionale Italiana 2023. https://download.terna.it/terna/05_PRODUZIONE_8dd07bd5bba8a9e.pdf

Centre, with Lazio and Tuscany having large amounts of geothermal and thermoelectric, and the South being the most prominent hub of renewable energy production. This disparity in both the amount of energy produced and the method of production gives rise to problems that especially with the phase out will increase in magnitude the regions in the North of the country are the most industrialised and, thus, most energy intensive, making it necessary to have a highly efficient transmission grid to send the energy where it is needed.

The previously mentioned phase out from coal, which is expected to be completed by 2025[3], has not been followed by serious policies to renew energy production, making Italy an even higher importer and with prices even more unstable and deriving from the foreign market. In addition, the energy we import often comes from countries that do not meet the stringent anti-pollution standards we have given ourselves in Europe, thus displacing the problem rather than solving it. Shortsighted policies and unstable governments have prevented a serious strengthening of domestic production. As a result, Italy remains heavily dependent on fossil fuel imports. This dependence exposes the country to vulnerability related to international price fluctuations and the geopolitical dynamics of supplier countries. In this context, transitioning to renewable energy sources and energy efficiency is a key strategy to reduce foreign dependence and increase national energy security. This choice to remove coal from the Italian energy mix has consequences; coal-fired power plants still account for 10 per cent of national electricity production, the main ones being those of Monfalcone, Fusina, Torrevaldaliga Nord (Civitavecchia), Brindisi, Fiume Santo (Porto Torres), and La Spezia. The power

[3] Sebastiano Torrini. (2024, March 26). Finisce (quasi) l'era del carbone in Germania. In Italia il phase out nel 2025 - Energia Oltre. Energia Oltre. https://energiaoltre.it/finisce-quasi-lera-del-carbone-in-germania-in-italia-ill-phase-out-nel-2025/

plants in question are among the largest in Italy, so to make up for the lack of this production once the phase out is completed, we will necessarily have to turn to natural gas, which remains a fossil source with a significant ecological impact and, as we will see later, places Italy in a weak position in the geopolitics of energy, but more importantly causes Italy to increase its investment in natural gas, risking binding the country in the long term and calling into question its decarbonisation goals.

In short, Italy's energy system is highly dependent on foreign countries, with about 75 per cent of primary energy imported. Although renewables now account for about 45 per cent of domestic electricity production, significant regional imbalances between production and consumption remain. The decommissioning of coal plants by 2025 is a critical challenge, as adequate replacement policies have not accompanied it. All this makes the country vulnerable to supplier countries' instability, transmission grid inefficiency, and weak energy and infrastructure policies. From this snapshot, it becomes essential to delve into the role of natural gas, particularly LNG, to understand whether and how much it can be a credible answer in the short term.

1.2. Natural gas and the role of LNG in Italy.

We have seen that Italy's energy dependence, mainly related to natural gas, carries significant geopolitical risks. It is therefore necessary to delve into the specific role that natural gas and LNG play in this scenario, considering the present and especially the future implications for the country.

Before the Russian invasion of Ukraine, Italy, like many other European countries, was heavily dependent on Russian gas. In 2021, in Europe, about 40 per cent of gas and 27 per cent of oil were imported from Russia[4], demonstrating the fact that not even Moscow's annexation of Crimea had made Europe's major importers (as well as major powers) verge on a change in the way we produce energy. In 2011, after years of negotiations and subsequent construction of the Nord Stream 1 pipeline, Germany began to have a direct underground pipeline with Russia; from that moment on, the energy policies of most European countries would be shaped by using a cheap and continuous raw material.

These include Italy, which tried years earlier to complete the South Stream with Russia, which would also come directly from Russia. Still, after Moscow annexed Crimea, it came to a halt. The warnings, however, as mentioned above, did not change Europe’s energy plans, particularly Italy, which as of 2021 is a net importer of about 80 per cent[5] of its total energy supply. It has come to February 24, 2022, with the beginning of the Russian-Ukrainian conflict to have a shift. The West's response is strong from the beginning and progressively more punitive toward the Russian federation, Italy for its part with Draghi as Prime Minister runs for cover to solve the energy criticality, signing an agreement in July 2022 with Algeria, which becomes the leading supplier of Italian gas thanks to the TRANSMED pipeline that arrives in Mazara del Vallo and makes agreements with various countries such as Azerbaijan, Qatar, Egypt, Angola, Congo and Mozambique. After that, with SNAM directly, Italy acquires two regasifier ships (floating storage and regasification units): one in Ravenna and one in Piombino[6], creating quite a bit of controversy, especially in the second location, because of the famous and very present, in Italy, NIMBY (Not In My Back Yard) is citizens' opposition

---

[4] DA DOVE VIENE LA NOSTRA ENERGIA? (n.d.). https://italyforclimate.org/wp-content/uploads/Da-dove-viene-la-nostra-energia-Italy-for-Climate.pdf
[5] Ibidem
[6] Prontera, A. (2023). Winter is coming: Russian gas, Italy and the post-war European politics of energy security. West European Politics, 47(2), 382–407. https://doi.org/10.1080/01402382.2023.2225987

to the construction of works that are useful to the community when planned near their homes. It does not challenge the project itself, but its location. We will discuss this in depth later.

As we have seen, LNG is of growing importance in Italy. Its importance due to its ability to perform and transport from anywhere in the world has been and will be very useful in the short term after the start of the conflict; however, there are some critical issues to consider in the long term. The main critical issue is dispersed efficiency, that is, the amount of resources lost during the various steps required to achieve the result, due to the methods used.

For example, once the gas has been extracted, it must be liquefied to be transported in an expensive and energy- and cooling-intensive process: cryogenic liquefied gas must reach -162° C to be transported[7]. After the liquefaction process is completed, we move on to transport by ship, which introduces another possible dispersion; finally, once the LNG reaches its destination, which could be Piombino, it must be regasified and fed into the national energy grid. We well understand how all these steps, while necessary, make this method really inefficient and highly wasteful.

Moreover, if we talk about environmental impact, we have to consider that the footprint of LNG is 33% larger than that of coal, with an emission of 160 g of CO2 compared to 120 g of coal[8]. However, gas emits less during combustion and is used by many European countries as a clean energy source compared to other fossil sources.

[7] Padova, U. di. (2017). Gas Naturale Liquefatto e Rigassificatori: cosa sono e come funzionano | Università di Padova. Unipd.it. https://levicases.unipd.it/gas-naturale-liquefatto-e-rigassificatori-cosa-sono-e-come-funzionano

[8] Barretta, V. (2024, November 15). L’impronta del GNL supera del 33% quella del carbone. Lo studio e l’interrogazione in Commissione UE. Energia Italia. https://www.energiaitalia.news/news/gas/limpronta-del-gnl-supera-del-33-quella-del-carbone-lo-studio-e-linterrogazione-in-commissione-ue/46507/?utm_

More and more studies show that methane released during the extraction, transportation and regasification phases is very important when it comes to liquefied gas.

After these considerations, the risk is therefore that of lock-in on gas[9], in fact, after the many investments implemented on this source in Italy during the time of emergency, the possibility of gas becoming a stable source of supply is high, a point also confirmed by the Italian industrial policy documents that set as a goal to stabilise as the country's pivotal source gas for about a quarter of the total sources, as we will see in more detail later.

In Short, natural gas has historically been one of the primary energy sources for Italy, particularly Russian gas, now partially replaced thanks to rapid diversification activated after the conflict in Ukraine. LNG has emerged as a crucial resource in the short term. Still, it has structural problems related to energy dispersion, environmental impact, and the risk of “technological lock-in” that could undermine decarbonization goals. Against this backdrop, it becomes urgent to explore how renewables can offer an authentic, sustainable and self-sustaining alternative.

1.3. Renewable sources in Italy

If natural gas, and LNG in particular, is a short-term solution, the future of Italy's energy system must necessarily look beyond fossil fuels. Renewable sources play a central role in the decarbonisation strategy, despite some technological and infrastructural criticalities that have yet to be resolved. It becomes essential to consider the sustainable alternatives available, first and foremost, renewable energy. These are

[9] Prontera, A. (2023). Winter is coming: Russian gas, Italy and the post-war European politics of energy security. West European Politics, 47(2). https://doi.org/10.1080/01402382.2023.2225987

clean and safe sources to produce energy; of course, no renewable source can cover 100 percent of a state's energy demand to date, for inherent reasons such as the intermittency.

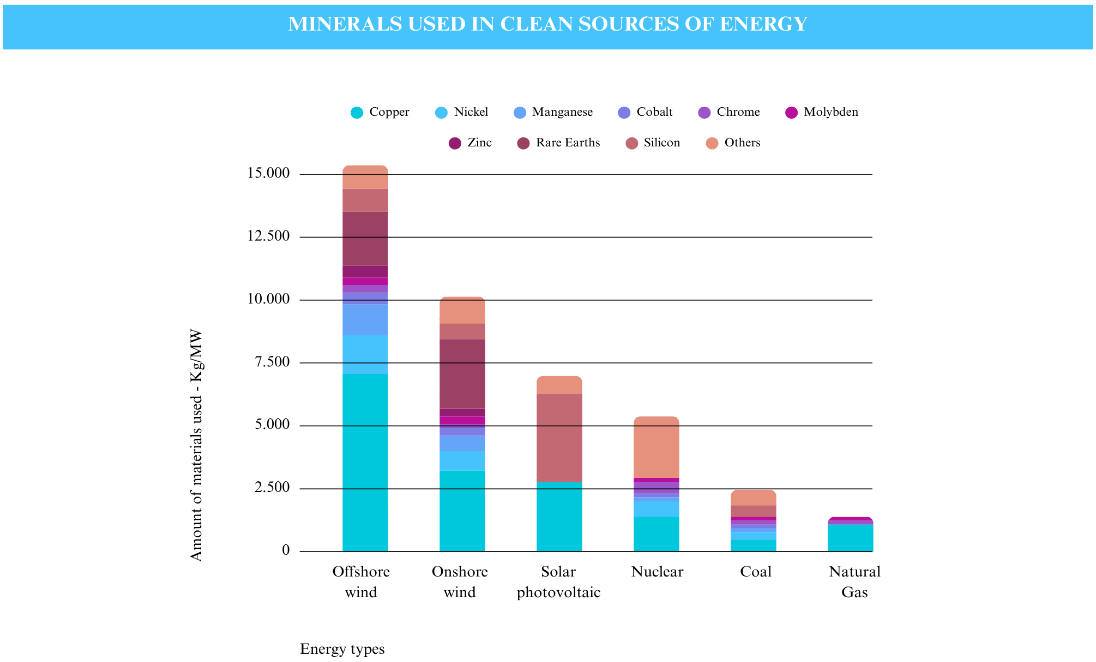

Figure 2: Minerals used in clean sources of energy, an author adaptation by: Gattei, F. (2024, March). We World Energy. Www.eni.com; ENI.

Renewable sources are also those most in need of critical raw materials, however, these are the technologies of the future. Thus, let us take a closer look at the positives and negatives of these sources in the Italian context to have a general understanding of these technologies.

1.3.1. Photovoltaics

Italy has a significant amount of photovoltaics, which is gradually growing yearly. The Gestore dei Servizi Energetici,[10] in its latest report, explains that from 2022 to

[10] Gestore dei Servizi Energetici. (2024). SOLARE FOTOVOLTAICO RAPPORTO STATISTICO 2023. https://www.gse.it/documenti_site/Documenti%20GSE/Rapporti%20statistici/Solare%20Fotovoltaico%20-%20Rapporto%20Statistico%202023.pdf?utm_

2023, there was an increase of about 20 per cent in total installed capacity but an increase of about 9 per cent in energy produced from photovoltaics. This is also because, as we read in the report, 30 per cent of the installations are located between Veneto and Lombardy. In Italy, solar energy accumulates yearly, mainly in the South.

Figure 3: Average annual insolation over the Italian peninsula: intensity and geographical distribution by Atlante Solare e Previsioni Meteo, S. (2024). RSE - Ricerca Sistema Energetico. SunRISE; RSE. https://sunrise.rse-web.it/

In most Italian regions, except for Apulia and Basilicata, photovoltaic installations are predominantly non-ground-mounted. These systems, typically installed on rooftops or existing structures, offer a good balance between functionality and environmental impact. However, they come with certain limitations: they are not optimally inclined toward the sun and are often partially obstructed by elements such as antennas, satellite dishes, or the structural orientation of the building itself. Despite these drawbacks, non-ground-mounted systems are generally less invasive than ground-mounted solar panels, which are often installed on agricultural land. The latter can contribute to land consumption, reducing areas available for food production and potentially disrupting local ecosystems by altering natural ground cover and habitats.

Another critical aspect concerns the geographical distribution of the plants: the fact that most of them are installed in areas with less sun exposure highlights a problem of accessibility to photovoltaics in southern Italy. Thus, although it will be important to increase the number of plants in southern regions, it would be necessary to invest in an electric grid capable of transferring the energy produced to the areas where it is most in demand at a given time, considering that, at the moment, large-scale energy storage is not yet implementable in a systemic way.[11]

1.3.2. Wind power can be divided into two types: onshore and offshore.

The **onshore** one is the most common. It consists of installing turbines on flat or hilly terrain with more wind, and it is easier to connect with the national grid and install and maintain. However, it has negatives that can be limited efficiency compared to offshore since the wind in the onshore is erratic compared to that on the sea, increase its intermittency.

Offshore turbines are those installed not on land but on the sea, and there are those on fixed foundations, installed in places where the water can reach about 50 meters and floating ones, where the water is over 50 meters deep, and the floating platforms are anchored to the seabed. Their advantages are the opposites of inshore, thus, more constant and strong winds reducing intermittency in addition to the fact that the acoustic and visual impact is minimal, as for the negatives, they have high costs to be installed compared to onshore and the implementation time is much longer, especially in Italy with a significant bureaucratic process. Most importantly, marine

[11] Davey, R. (2023, July 18). AZoNano. AZoNano. https://www.azonano.com/article.aspx?ArticleID=6513&utm

grids are needed to transport the energy to onshore, so an investment in infrastructure is required.[12]

More fortunate European countries use this technology; the North Sea region is Europe's green powerhouse, with more than 25 GW of fixed-foundation offshore plants already connected to the grid and many more planned. This compares to the only 30 MW that exists in the Beleolico wind farm in Italy to date, with a forecast by the PNIEC (National Integrated Energy and Climate Plan) of 2.1 GW by 2030[13].

Italy, however, has a problem, which is the depth of the seas that starts rapidly near the coasts, it could exploit its Adriatic and Tyrrhenian seas with floating offshores, however, as of today their development is still limited, the only operational plant is the one in Taranto, but a study by the Polytechnic University of Turin speculates that with this infrastructure about 207 GW could be obtained[14] from Italian coasts, nearly 2/3 of the annual national energy demand.

1.3.3. Hydropower

As for hydropower, Italy is full of possibilities. In 2024, according to TERNA data, it generated about 50 TWh, the most important among RES (renewable energy sources). In recent years, new hydropower plants have continued to be built, and it can be said that the fruits continue to be reaped. The first half of 2024 saw a major increase

---

[12] Bottoni, C. (2020, July 2). Eolico offshore e onshore: un'analisi comparata. ESG360. https://www.esg360.it/sustainability-management/eolico-offshore-e-onshore-unanalisi-comparata/?utm

[13] Sportello Vaielettrico, & Sportello Vaielettrico. (2025, March 25). Eolico off shore, si sveglia l'Italia: impianti per 2,4 GW dalla Puglia alla Romagna - Vaielettrico. Vaielettrico. https://www.vaielettrico.it/eolico-off-shore-galleggiante-mediterraneo-floating/?utm

[14] Redazione. (2023, September 20). Eolico off shore flottante, il tesoro italiano dimenticato - Vaielettrico. Vaielettrico. https://www.vaielettrico.it/eolico-off-shore-flottante-il-tesoro-italiano-dimenticato/?utm

in RES, led by hydropower, which marked a +64%[15]. However, that six-month period was marked by frequent rainfall, especially in the North Central region, where most power plants reside. This is because the increase in hydropower generation is not directly related to the quantity of power plants, but to the weather conditions in the country. Most of the new hydropower plants are mini-hydro power plants, meaning those that are small in size and below 500 kW in capacity, while large hydro power plants were built in the early 1900s. Given that most of Italy's exploitable hydropower potential has already been developed, the strategic focus has shifted from building new plants to the revamping of existing ones. Revamping refers to the modernisation and optimisation of power plants through the upgrading of key components such as turbines and control systems. According to Enel, which manages over 500 hydroelectric plants in Italy, these interventions have led to significant improvements in both efficiency and overall energy output. Moreover, revamping contributes to greater operational reliability by reducing the risk of unexpected shutdowns, thanks to enhanced predictive and preventive maintenance systems tailored to ageing infrastructure.[16]. When we think of possible shortcomings we have to refer to the Failure Curve, which follows the trend of a bathtub the peak of failures is when the construction is new and when it is dated, so, for the same reason that it is necessary for twentieth century power plants, revamping is important for mini-hydro power plants, making the country's power system more resilient and efficient.

---

[15] Comunicati stampa consumi elettrici. (2024). Terna: nei primi sei mesi del 2024 le rinnovabili superano per la prima volta la produzione da fonti fossili - Terna spa. Terna.it. https://www.terna.it/it/media/comunicati-stampa/dettaglio/consumi-elettrici-primi-sei-mesi-2024-rinnovabili-superano-produzione-fonti-fossili?utm

[16] Tutti i vantaggi del repowering. (2024, December 16). Enel.com. https://www.enel.com/it/azienda/storie/articles/2024/12/vantaggi-repowering-centrali-idroelettriche?utm

1.3.4. Geothermal

Another form of renewable energy in Italy is geothermal; it produces about 5 per cent of the national renewable energy and 2 per cent of the national energy demand, with about 6 TWh. Italy was the first country to use geothermal energy to produce electricity. The first geothermal generator was in Larderello in 1904, in the province of Pisa, still the largest geothermal plant in Europe. Tuscany, in particular, is the region where most geothermal activity is concentrated, with Pisa, Siena and Grosseto as the most exploited provinces[17]. Currently, excavations are made about 4km underground to directly tap the geothermal mix of gas and steam underground to power turbines that generate power. One thing differentiating it from other renewable energies is its stability and continuous production over time, regardless of weather conditions. Moreover, according to Enel estimates, geothermal in Italy would have a capacity ranging from 5800 TWh to 116,000 TWh[18]. Let's remember that the national energy demand, although growing year by year, is about 310 TWh.

1.3.5. Hydrogen

When discussing renewables, we often hear about hydrogen. However, a distinction should be made. Hydrogen, in fact, is a so-called energy vector, so it is not found in nature in free form but must be extracted, and this can be done using various methods. Let's say it is more of a vehicle for storing and transporting energy.

[17] Redazione. (2020, November 25). L'energia geotermica in Italia: dove viene prodotta e come. Enelgreenpower.com; Enel Green Power. https://www.enelgreenpower.com/it/learning-hub/energie-rinnovabili/energia-geotermica/italia?utm

[18] Ibidem

There are three main methods for producing hydrogen, each with different environmental impacts and production costs. The most common is **grey hydrogen**, which is also the cheapest. It is produced through steam methane reforming, a process in which natural gas is heated with water vapor in the presence of a catalyst. However, this method results in significant CO_2 emissions, making it the most polluting option. **blue hydrogen** is produced using the same process, but incorporates carbon capture and storage (CCS) technologies to reduce emissions. Finally, **green hydrogen** is generated by electrolyzing water using electricity from renewable sources. While it is the most environmentally sustainable option, it is also the most expensive due to the current costs of renewable energy and electrolysis infrastructure.

Although green hydrogen is increasingly recognised as a key vector for decarbonisation, its current use in Italy remains very limited, especially when compared to the strategic role it could play in sectors that are difficult to electrify, such as steel, cement, and heavy transport; according to a report by the Politecnico di Milano, to advance decarbonisation goals and decrease the impact of hard-to-abate companies, such as the most energy-intensive ones, it is necessary to start producing it massively[19].

The pros of hydrogen as an energy vector are that it emits zero greenhouse gases, only water vapor during use, and it has a higher energy density by weight compared to batteries. This makes it especially advantageous for transportation sectors where long range, high payload, or fast refueling are required, such as heavy-duty trucks, ships, and

[19] Bellini, M. (2024, July 13). Idrogeno verde: all'Italia servono 7,5Mt all'anno, per la decarbonizzazione di industria e trasporti pesanti. ESG360. https://www.esg360.it/esg-world/idrogeno-verde-allitalia-servono-75mt-allanno-per-la-decarbonizzazione-di-industria-e-trasporti-pesanti/?utm_

airplanes, where batteries would be too heavy or inefficient.[20], however it's a double-sided factor, in fact, transportation of hydrogen, although it can be done with short routes through the same pipelines or by road/rail, in the long routes it needs to be liquefied and transported by ship, to liquefy hydrogen one has to reach a temperature of -253C°, making the transportation highly energy intensive and impactful[21]. Clean or green hydrogen is currently the most expensive, but it is a technology to watch in the coming years. Although it is not currently part of Italy's energy strategy, it could become essential to its long-term system vision.

prima di capitoletto dopo inserire parte sul nucleare che spiega che fino ad ora non è stato fatto in Italia spiegando brevemente perché dato che questa per ora è solo la fotografia dell'Italia, ma essendo anche una foto delle possibilità da poter sfruttare per l'Italia è doveroso dirlo.

1.3.6. Nuclear

Although nuclear power is not currently part of Italy's energy mix, following the results of national referendums and the subsequent political decisions to decommission existing plants, it remains relevant in the broader strategic conversation.

This chapter does not aim to assess only the current state of the Italian system, but also to explore possible future developments, including new technologies such as floating offshore wind, large-scale green hydrogen production, and long-duration

[20] L'idrogeno rinnovabile: quali vantaggi per l'UE? | Tematiche | Parlamento europeo. (2021). Tematiche | Parlamento Europeo. https://www.europarl.europa.eu/topics/it/article/20210512STO04004/idrogeno-rinnovabile-quali-sono-i-vantaggi-per-l-ue?utm

[21] Dematteis, E., & Baricco, M. (2021). LA VIA DELL'IDROGENO: DALLA PRODUZIONE ALL'USO. La Chimica E l'Industria Online, 4. https://doi.org/10.17374/CI.2021.103.4.27

storage solutions. In this context, it is appropriate to consider nuclear energy not as a present option, but as a potential strategic pathway.

Its inclusion here serves an analytical purpose: to evaluate all viable technologies that could contribute to Italy's long-term energy security and decarbonisation goals. The reference to nuclear power is thus made in prospective terms only, and its feasibility will be examined based on technical, geopolitical, and regulatory conditions that would need to be addressed for any future reintroduction.

1.3.7. Risks and limitations

Renewable Source	Pros	Cons	Enviromental Impact	Economic Impact
Photovoltaic	Low environmental impact (if rooftop); growing capacity; widely applicable in urban areas	Intermittency; reduced efficiency on rooftops due to obstructions and orientation	Low (rooftop); moderate if ground-mounted on agricultural land	Affordable installation; lower efficiency can limit return
Onshore Wind	No emissions during operation; moderate costs; good resource in Southern Italy	Visual and acoustic impact; land use; limited space; intermittency	Moderate (land use and fauna impact)	High capital costs; early stage in Italy
Offshore Wind	High potential in floating systems; stable wind conditions offshore	Very limited installed capacity (30 MW); high costs; slow bureaucracy; marine grid limits	Moderate to high (marine ecosystems; visual impact)	High capital costs; early stage in Italy
Hydropower	Stable and mature technology; high production (50 TWh); already well integrated	Dependent on rainfall; large-scale expansion saturated; aging infrastructure	Moderate (affects river ecosystems and flow)	Cost-effective but diminishing returns; revamping needed
Geothermal	Stable energy production; already used in some regions; low emissions	High upfront costs; geographically limited; local resistance	Low during operation; possible local disturbance	Expensive initial investment; stable long-term costs
Green Hydrogen	Useful for hard-to-abate sectors; supports energy storage and transport flexibility	Very high cost; low scalability; energy-intensive production; low current presence	Low at use stage; high during production and conversion	Very expensive; high R&D needs; not yet competitive

Figure 4: Comparison of different renewable energy sources based on advantages, disadvantages, environmental and economic impacts

To better assess the potential and limitations of renewable energy in the Italian context, it is essential to compare the main sources currently in use. The table below provides a concise overview of the key strengths and weaknesses of photovoltaic, wind (onshore and offshore), hydroelectric, geothermal, and green hydrogen technologies. Each source is evaluated in terms of its environmental impact, economic implications, and specific technical challenges. Having this comparative snapshot in a single table is particularly valuable at this stage of the analysis: it offers a clear picture of where each technology stands, and sets the foundation for understanding the systemic risks and constraints that will be addressed in the following sections. This framework supports a more integrated interpretation of the trade-offs involved in shaping Italy's future energy strategy. Although nuclear energy is discussed in this chapter as a potential strategic option, it is not included in the table below. The purpose of the table is to provide a snapshot of the current Italian energy landscape, focusing exclusively on technologies that are already part of the national mix. This allows for a more accurate assessment of the present situation, which is necessary to inform the next steps of the analysis.

In Short, despite the rapid expansion of renewables in Italy, significant challenges remain related to the intermittency of production and storage difficulty. The environmental and social issues associated with their implementation make it clear that technological development alone is insufficient: incentive policies and greater social acceptance are needed. In addition, the availability and management of critical raw materials are key elements in making this transition sustainable in the long run. In this regard, analysing the infrastructure and technologies that could enable the Italian energy system to become more resilient and efficient is necessary.

1.4. Infrastructural and technological challenges

After analysing the crucial role of renewable sources in the Italian energy landscape, it becomes clear that their development cannot be separated from a significant infrastructural strengthening. The main technological and infrastructural challenges Italy will face in ensuring an effective and sustainable energy transition will be explored below. Considering energy efficiency, buildings, especially civil buildings, are significant in the country's total energy consumption. According to the European Fit for 55 legislation, which we will see later, member states will have to ensure a decrease in average primary energy consumption of residential buildings of about 16 per cent by 2030 and 20 per cent five years later. In addition, a directive, Green Homes, within the European Green Deal stipulates that old buildings already constructed must achieve energy class D by 2030 and E by 2033, while public buildings built from 2028 onward must all be zero-emission type. For private ones, there is time until 2030[22]. Zero-emission buildings are defined as those with minimal emissions, high efficiency and consumption of only renewable energy.

Efficiency upgrading would lead to a big reduction in energy demand annually by Italians, since, according to Terna's earlier data, the residential sector is an important part of Italy's national consumption, and many buildings are of a low energy class. Energy-efficient upgrading of a house, with modern insulation and new windows and doors or a heat pump or ground-source heating, would significantly reduce this, dispersing less energy and thus decreasing the demand for it.

[22] Redazione. (2024, April 15). *La direttiva europea sulle "case green", spiegata bene*. Il Post. https://www.ilpost.it/2024/04/15/direttiva-europea-case-green/

The direction taken by the Superbonus (a government incentive introduced in 2020 that covers up to 110% of expenses for energy-efficient or earthquake-resistant work on buildings. It allowed people to renovate their homes “for free,” thanks to the transfer of credit or a discount on the invoice. It had a strong economic impact but also sustainability problems for public accounts) was to increase the energy class of residential buildings, however, it was one of many short-term, unstructured proposals, but most importantly without economic coverage typical of Italian politics, moreover, it was done more to try to boost GDP and national production post COVID-19, trying to drug demand, to give oxygen to supply.

Another of the infrastructural challenges facing Italy concerns Italy's power grid, which needs a major renovation to handle the growing energy burden. The country's infrastructure requires upgrading to ensure an efficient balance between energy production and consumption throughout the peninsula, in fact very often there is a high capacity of renewable generation in the South and a high industrial demand in the North and the demand is not automatically covered by the grid, however, there are technologies that can help us, smart grids. Smart grids are intelligent electricity grids, meaning they can monitor, manage and optimise energy distribution throughout Italy in real time based on the demand of the moment. In this way, there is a two-way communication between producer and consumer, improving the efficiency of consumption, with less risk of not taking advantage of the energy produced by renewables, which, to date, is difficult to store.

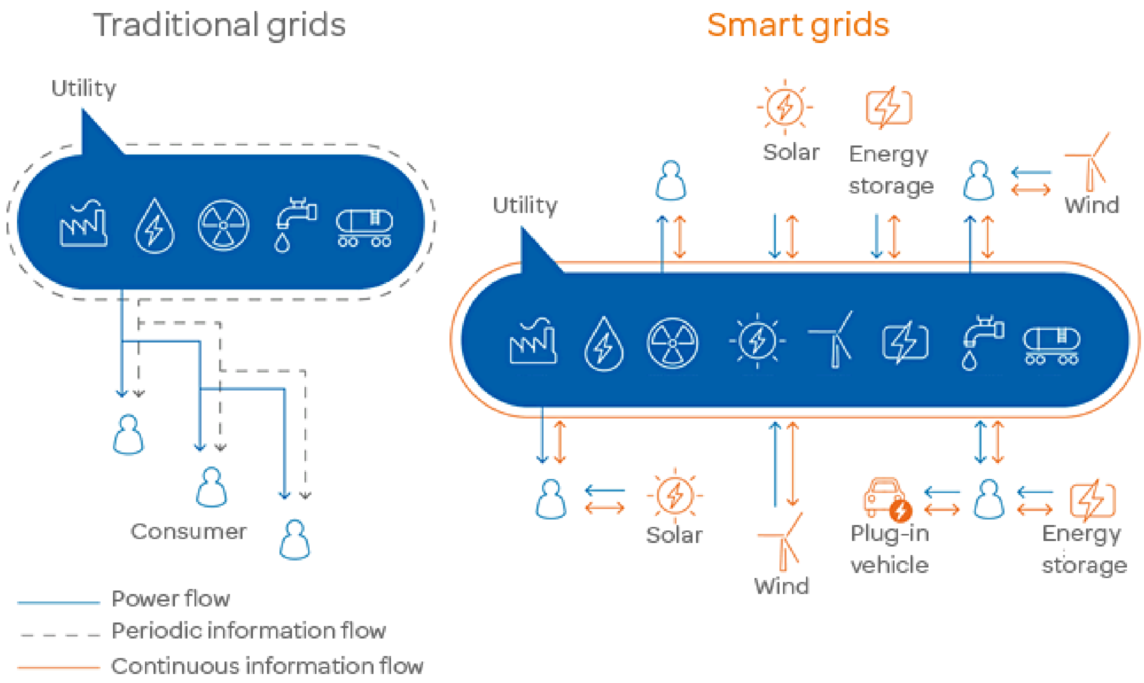

Figure 5: Comparison between traditional power grids and Smart Grids: energy flows and information by Ballocchi, A. (2023, February 3) https://www.lumi4innovation.it/smart-grid-cose-e-come-funziona/

As of today, there are already working, although small, projects that should set an example. First of all, the one in Puglia, Enel's Puglia Active Network, has introduced “smart” primary transformer substations; moreover, the PNRR and RePowerEU fully support these kinds of projects and generally forage these investments, especially if they are built in the most economically depressed areas of the country[23]. Making the entire national grid smart would make the country highly efficient and able to respond to moment-to-moment drops or rises in demand.

However, what happens when even the smart grid fails to use all the energy produced for peak renewable energy? There are technologies to be developed in Italy for energy storage that are useful to the cause. We have described the positives and

[23] Ibidem

negatives of each renewable, and the most crucial downside is intermittency. However, this problem can be mitigated; methods can be developed to help store the energy produced and not used at that time and increase the consistency of supply. There are several ways already, each with its costs, space and features.

The most popular batteries for storage are lithium-ion batteries; they have high energy density and fast response times, yet they have high costs, including environmental costs during lithium extraction, and a limited lifetime. The growing demand for electric vehicles, and consequently for lithium-ion batteries, is creating quite a few concerns in this regard, especially the risk of decreasing availability of the critical materials needed in the long term.

Another possible avenue is to lead to sodium-ion batteries. Sodium is a more common material easily acquired at lower costs. They are one of the best promises in storage, especially for large-scale applications[24].

In more general terms, apart from these two important market examples, one because of its vastness of use and the other because of its great development possibilities, we can say that the storage market is divided into five macro sectors: chemical, mechanical, thermal, electrical, and electrochemical.

Globally, the non-battery energy storage segment (NBES) currently accounts for about 85% of total installed storage capacity. This is mainly due to its significant long-term storage potential and lower dependence on rare earths. Among these mechanical solutions, pumped hydro storage is the most common: it stores energy by moving water between reservoirs at different elevations, pumping it up during low

---

[24] *Sistemi di stoccaggio energetico*. (2025). Eni.com. https://www.eni.com/it-IT/azioni/tecnologie-transizione-energetica/energie-rinnovabili/stoccaggio-energetico.html?utm

demand and releasing it to generate electricity during peak demand. However, battery energy storage systems (BES) are expected to overtake NBES in the coming years, due to their scalability and modularity.[25].

It is important to distinguish between different types of recycling. In Italy, industrial material recycling, referring to the reuse of raw materials in production cycles, represents a strong point: in 2023, about 20% of the materials used by industry came from recycled sources, double the EU average. Additionally, Italy leads the recycling of special and industrial waste, with a rate of around 70% recorded in 2022. However, when it comes to urban waste recycling, linked to separate waste collection from households, the picture is less positive: the rate stands at 49%, still below the EU 2025 target of 55%. Moreover, the increase in sorted collection has led to more residues or non-recyclable fractions, pointing to inefficiencies in how materials are separated at source[26].

In Italy, high-efficiency waste-to-energy incinerators play a strategic role in waste management, as they allow the recovery of energy from waste combustion, significantly reducing landfill use. Currently, just under 40 such plants operate across the country, mostly in the North, treating approximately 6 million tons of waste per year[27]. However, despite this capacity, in 2022 Italy still had to export around 5 million tons of waste abroad, with notable environmental and economic costs: Italy pays for the export, while other countries, Germany above all, exploit that waste to generate energy. According to

---

[25] Intesa San Paolo Innovation Center. (2024, June). INDUSTRY TRENDS REPORT ENERGY, ENVIRONMENT & UTILITIES ENERGY STORAGE. https://www.intesasanpaoloinnovationcenter.com/content/dam/digitalhub/documenti/2024%2007%20Energy%20Storage_ITA_abstract.pdf

[26] Ronchi, E. (2024, December). Il Riciclo in Italia 2024. Fondazione per Lo Sviluppo Sostenibile. https://www.ricicloinitalia.it/wp-content/uploads/2024/12/il-RICICLO-in-ITALIA-2024.pdf

[27] Rifiuti, in Italia 37 termovalorizzatori: ecco dove sono e come funzionano. (2022, April 21). https://www.ilsole24ore.com/art/rifiuti-italia-37-termovalorizzatori-ecco-dove-sono-e-come-funzionano-AEAtnGTB?refresh_ce&nof

a study by The European House Ambrosetti[28], Italy would need at least seven additional high-efficiency plants to close this capacity gap. While in everyday language they are often called 'thermal incinerators', the more accurate classification distinguishes between high-efficiency and low-efficiency incinerators, the former being prevalent across most of Europe. One only has to look at the Danish plant with the ski track on top to see that they are useful plants and bring wealth. If we talk about pollution, know that the PM10 release contribution of incinerators is about 0.03% compared to 53.8% of commercial and residential combustion.[29]

1.5. Social challenges

Everything we have discussed so far has one constant problem: NIMBYs. The Not In My Back Yard phenomenon is relevant in Italy, and we see it every day at every major facility under construction or planned throughout the peninsula. It slows and sometimes blocks the country's development. Nimbysm is one of the most critical issues in developing strategic infrastructure, especially energy and transportation.

This phenomenon occurs when local communities oppose the implementation of works of national interest for fear of negative impacts on the local environment, health or quality of life, often without considering the overall benefits to the country. What nimbysm frequently implies, however, is that the work is opposed by locals just because it is built near where they live, bringing potential harm to their loved ones or interests,

---

[28] Stefano, D. D. (2021, November 2). “Termovalorizzatori sempre meno inquinanti, ma occhio agli aspetti sociali.” Economiacircolare.com. https://economiacircolare.com/termovalorizzatori-inceneritori-inquinamento-emissioni-efficienza-sostenibilita-sociale/?utm

[29] Rifiuti, in Italia 37 termovalorizzatori: ecco dove sono e come funzionano. (2022, April 21). https://www.ilsole24ore.com/art/rifiuti-italia-37-termovalorizzatori-ecco-dove-sono-e-come-funzionano-AEAtnGTB?refresh_ce&nof

as if it were built somewhere else, that project would not be a problem[30]. Alongside these local opponents, NIMEY (Not In My Electoral Yard) and NIMTOO (Not In My Term Of Office, not as long as I rule) should also be added[31], that is, more simply, the regional presidents themselves, or sometimes mayors, trying to slow down that work for electoral reasons. This is a way of doing things that has become so fashionable in Italy and slows down, in no small measure, national institutions that have to deal not only with citizen resistance, but also with their political representatives.

An emblematic example of this dynamic is the Trans Adriatic Pipeline (TAP), a strategic infrastructure to diversify Italy's gas supply sources and reduce dependence on Russia. Despite the strategic importance of the work, the project has encountered strong opposition from local communities in Puglia, supported even by the region's president, Michele Emiliano, who proposed alternatives such as a landfall in Brindisi, which were later discarded due to higher costs and environmental impacts[32]. The Renzi government, aware of the strategic need for the pipeline, maintained a firm stance, deciding to proceed with the project despite the protests. Work began in May 2016 and the pipeline became operational in December 2020, about a year later than originally planned . In the first quarter of 2025, the TAP delivered 37.9 billion cubic meters of gas to Italy[33]. This

[30] Spina, F. (2017, December 7). Sociologia dei Nimby. I conflitti di localizzazione tra movimenti e istituzioni. Academia.edu. https://www.academia.edu/35366963/Sociologia_dei_Nimby_I_conflitti_di_localizzazione_tra_movimenti_e_istituzioni

[31] Brunno, A. (2019). UNIVERSITÀ DEGLI STUDI DI CATANIA DIPARTIMENTO DI GIURISPRUDENZA MASTER IN DIRITTO DELL'AMBIENTE E GESTIONE DEL TERRITORIO. https://www.masterdirittoambiente.unict.it/sites/default/files/files/Projects/I-edizione/Brunno_Alessia.pdf

[32] *Italian Delays in TAP's Construction Weaken the EU and Russia Alike*. (2016, October 19). Jamestown.org. https://jamestown.org/program/italian-delays-taps-construction-weaken-eu-russia-alike/?utm

[33] *TAP reveals volume of gas supply to Italy in Q1 2025*. (2025, April). Trend.Az. https://en.trend.az/business/energy/4024219.html

project has contributed significantly to the reduction of Russian gas imports from 40 per cent of the total in 2021 to 19 per cent in 2022[34].

Another iconic case is the TAV Turin-Lyon, where the No-TAV movement has, for decades and continues to obstruct work on the high-speed rail line that is supposed to connect Italy with France. While in France, work has been going on without any particular hitches, in Italy, the construction site has been continually slowed down by protests, occupations, and bureaucratic resistance.

This leads to a paradox: Italy has strong renewable generation capacity but cannot fully exploit it due to a lack of adequate infrastructure to transport the energy to where it is needed. Especially now that the country is installing more renewable energy plants, which have much less intermittency and capacity than conventional generation plants, and therefore need to be in higher numbers to cover energy demand, this phenomenon needs to be addressed structurally.

Other European countries have adopted more effective strategies to manage the phenomenon. In Germany, the development of renewables has been accompanied by a strong involvement of local communities through models such as energy cooperatives, which allow citizens to invest in the plants and benefit directly from them economically. In France and the Netherlands, on the other hand, the permitting process for large-scale projects includes a highly structured public consultation phase, but with specific and mandatory deadlines, preventing protests from blocking projects indefinitely.

---

[34] Andreolli, F., Bellisai, F., Bienati, M., Giordano, G., Governatori, M., & Panzeri, D. (2023). *Energy Without Russia The Consequences of the Ukraine war and the EU Sanctions on the Energy Sector in Europe COUNTRY REPORT ITALY.* https://library.fes.de/pdf-files/bueros/budapest/20542.pdf?utm

To overcome the Nimby problem in Italy, therefore, it would be necessary to adopt a structured approach for each work with a reform of the authorisation procedures that would reduce decision-making time and make it more difficult for essential works to be blocked. Greater involvement of local communities and community engagement is the answer.

Communication is essential and necessary; the state should explain the timing, the reasons for the work, the economic return over time, and the costs of the public work. Also, suppose facilities impact ordinary people in any way. In that case, it is only fair to inform them, explain the reasons, and compensate them for potential damages so that NIMBYsm can be changed into rational participation.

One thing is sure: national policy must take a clear and decisive stand, preventing any strategic decisions from being second-guessed by local administrators. Politicians must take responsibility, explain the rationale behind their choices, and build the necessary facilities for the country to achieve their intended goals.

In Short, Energy efficiency in buildings, the development of smart grid and storage technologies, and wise management of the NIMBY phenomenon emerge as central challenges for Italy's energy future. The country's ability to effectively invest European funds and innovate in resource storage and recycling will be crucial to sustain a balanced and lasting energy transition. These structural conditions are complemented by the regulatory and strategic framework, which needs to be analysed to understand whether Italian industrial policies align with the goals described.

1.6. Italian regulations and industrial policies

Once the main technological and infrastructural issues have been outlined, it is also essential to analyse the regulatory framework and industrial policies adopted in Italy and Europe to understand whether and how these instruments adequately address the challenges outlined so far. Therefore, we will analyse some key documents to understand italian energy policy and the government's direction in the energy sector.

PNIEC: National Integrated Energy and Climate Plan. This document is essential because it outlines the country's energy goals up to 2030. The strategy is one of progressive decarbonisation equal to that carried out and required of member countries by the European Union, the general ways in which this decarbonisation is to be carried out are to: diversify energy sources; invest heavily in renewables; and improve energy efficiency (a topic we will discuss later, which is very often unknown or sometimes underestimated).

As previously mentioned, Italy relied for many years on a single country—Russia—for the majority of its energy imports. This overdependence exposed the country to significant geopolitical risks and is a clear example of how European instruments such as the Critical Raw Materials Act (CRMA) aim to prevent such self-sabotaging dynamics in the future. Following the outbreak of the Russian-Ukrainian conflict, however, Italy shifted its energy policy towards greater diversification. In particular, the country has increased gas imports from Algeria and Azerbaijan, using both pipeline infrastructure and LNG terminals. In the short term, this approach is endorsed by the National Integrated Energy and Climate Plan (PNIEC), which also promotes the reinforcement of existing renewable energy sources. Regarding long-term targets, the PNIEC sets the objective of generating approximately 40% of total energy consumption from renewables by 2030, with a significant focus on expanding wind and solar power capacity.

Another goal, which is seen again for the first time in an Italian PNIEC, is the hypothetical return of nuclear power to the Italian energy mix. By evaluating the use of technologies such as fourth-generation, that is, fission power plants, instead of fusion power plants, still in the development phase, which have the goal of efficiency in consumption and safety, while significantly reducing waste, but their entry into large-scale commercialisation is expected in no short time. The other option is SMRs: the modular reactors we mentioned earlier, reduced in size and therefore faster to build and less expensive, but most importantly, they can be placed closer to industrial centres, decreasing the need for large transmission infrastructure.

Regarding critical raw materials, such as lithium and cobalt, which we discussed a great deal above, the PNIEC recognises the need to secure supplies from geopolitically stable nations. It also talks about the European Critical Raw Materials Act, with the goal, outlined by it, of reducing dependence on needed materials from China and increasing intra-European extraction. On the international relations level, it defends the Mattei Plan, rightly we add, since the same government that drafted the PNIEC drafted it. On the investment side, it plans to increase LNG infrastructure, develop the Austrian and German hydrogen corridor, and invest in CCS (carbon capture and storage) coal storage projects in collaboration with France and Greece[35].

---

[35] MIT (Ministero delle Infrastrutture e dei Trasporti), MASE (Ministero dell'Ambiente e della S. E.) (2024). PIANO NAZIONALE INTEGRATO PER L'ENERGIA E IL CLIMA.

Green Book/White Book: The Green Book is an industrial policy document developed by MIMIT (Ministry of Enterprise and Made in Italy) with the aim of launching a national consultation process. It outlines preliminary guidelines on key areas such as energy, technological transformation, and geopolitical transition. This document serves as the basis for structured discussions with stakeholders, including business associations and industry experts. Following the conclusion of this consultation phase, the Green Book will evolve into the White Book, which will constitute Italy's official strategic industrial plan. Many of the themes addressed in the Green Book are directly relevant to this thesis and will now be analysed in greater detail.

The Book identifies three transitions that it deems crucial for the country's improvement: with the first, the energy transition, it points to diversifying sources of supply, investing in renewables and considering nuclear technology as a likely part of the solution if included in the national energy mix, with a specific focus on SMRs; with the geopolitical transition, it explains how non-European companies have a lower cost of production given by the cost of energy and therefore an advantage to produce, hence, it calls for harmonised European strategies to reduce the cost of energy.

After that, it addresses the issue of critical raw materials as a critical and important issue, explaining that the country is highly dependent on China. It identifies two strategies, one of which is CRMA, namely, expanding intra-European extraction of critical raw materials and investing in new extractive technologies such as deep-sea mining.

As for PNIEC, a small note is made about the need to cooperate with African countries for strategic resources, although without adopting a predatory approach.

Regarding Europe, a standard plan for energy infrastructure is called for, to ensure security of supply and industrial competitiveness. And for the technological-industrial transition, there is a goal to use public funds, such as the PNRR, and private funds to ensure significant investments that keep us on track.

Among the many industry issues that the book discusses that are less relevant to our thesis, there is, however, the investment that is required regarding the green transition to be considered, explaining that the transition, as it is set up now, will be challenging to manage by the individual state or the European Union, we need a public-private union of purpose.

The Green Book, which serves as the debate for the white book, tells us three things: Italy has to decide whether or not to go for nuclear power; it has to balance the green transition and the need for industry to remain competitive in the world; and the government wants to promote a broad strategy for critical raw materials: not to depend on a few unstable foreign suppliers.

Its transformation into a white book will be crucial to understanding how these issues will be addressed and the solutions the Italian government will offer.[36]

It must be said that the PNIEC and the Green Book, despite being from different ministries, are similar because they come from the same government and were made at the same geopolitical and technological moment. The issues are the same, which also helps us understand how, even though taken from different lenses (the Ministry of Environment or the Ministry of Business), the critical issues identified are the same, as are the solutions required.

---

[36] MIMIT, M. delle I. e del M. in I. (2024, October 16). Libro Verde. MIMIT. https://www.mimit.gov.it/it/libro-verde

Government Law on Nuclear Power: On January 23, 2025, Environment Minister Gilberto Pichetto Fratin signed the draft proxy law on nuclear power.[37] According to the minister, this is supposed to be the beginning of a path that will see completion by 2027. The draft enabling act does not mention what type of nuclear power is referred to, but it leaves all the doors open for us to decide later. This could be seen by many as a first opening to the real nuclear power today, which is the third generation. Among the other positives of this proposed enabling bill is a single ministerial authorisation to replace all local authorisations, except for environmental impact authorisations, of course, so that authorisation procedures will be much quicker by avoiding a lot of bureaucracy. Another point where bureaucracy is cut is that if a reactor has been licensed in another European nation, we can issue a license to that reactor without going through the whole process again; European laws are the same for everyone. Also, we talk about reprocessing for the first time, which we will see in the second chapter, and what it involves.

1.6.1. European regulatory framework

After examining the main national strategies, it is essential to consider the European regulatory framework, which significantly shapes Italy's energy and industrial policy. As a Member State, Italy must align its plans with broader EU directives and objectives. Therefore, we now turn to the most relevant European initiatives that directly influence the Italian context

[37] Dominelli, C. (2025, January 23). Pichetto: "Nucleare, Italia pronta. Testo unico e programma nazionale entro il 2027." Il Sole 24 ORE. https://www.ilsole24ore.com/art/pichetto-nucleare-italia-pronta-testo-unico-e-programma-nazionale-entro-2027-AGwu9NTC?refresh_ce=1

Draghi Report on Europe: the report of Mario Draghi, former president of the ECB from 2011 to 2019, the one who carried out the “Whatever it takes” economic policies, saving the euro from the crisis, among other things, Italian Prime Minister 2021-2022, who led the country during a strategically focal moment, the recovery from COVID - 19.

He was commissioned by European Commission President Ursula Von der Leyen to write a report on European competitiveness in relation to the world in which it finds itself, to identify its problems, and to propose solutions.

The Report focuses on European competitiveness in today's geopolitical and economic scenario, discussing energy in various capacities.

It talks about the fact that European decarbonisation policies, which we have already discussed, may penalise industry in the 27 countries. For Draghi, the EU needs to lower the price of energy without affecting the transition for this, this stance was also seen in practice within his role as Prime Minister, where he tried (and succeeded) to diversify the countries on which Italy depends for gas, closing deals with Azerbaijan, Algeria and beyond. He also points out in the report how European clean energy companies (hydrogen, batteries, wind) are not competitive with their Chinese and U.S. cousins. It also highlights the effectiveness of nuclear power in France without taking a real position.

After pointing out these problems, the report proposes reducing dependence on foreign suppliers for critical raw materials such as lithium, cobalt, and rare earths, over which China has almost total dominance (as we have already seen in the first part of the chapter). It talks about uranium and how critical this is for nuclear power, and the fact that it is in Russian hands. After that, it discusses the problem of semiconductors and how Europe imports about 80 per cent of this product from countries outside Europe, reducing its security of supply of a material that is now critical for most of the tools in the country.

It proposes two ways to take Europe in a different direction: investment and policy change.

Mario Draghi outlines a comprehensive strategy to enhance European competitiveness, structured along two main axes: economic investment and institutional reform. On the economic front, he advocates for strong and long-term investments in research and innovation, with a particular emphasis on advanced technologies. He also calls for deeper integration of European financial markets to better attract private capital and proposes the adoption of common European debt instruments, similar to those used during past crises, to finance large-scale strategic projects.

In terms of governance, Draghi stresses the need for greater political integration in energy and industrial policy, arguing that only a more unified European decision-making process can effectively respond to global economic powers such as China and the United States. He also supports increased investment in common European defence, as well as cohesive innovation and talent policies aimed at retaining the best European researchers and attracting talent from abroad. These proposals are designed to reverse the current trend of talent drain and technological dependency, and to position the European Union as a leader in strategic autonomy.[38]

[38] Draghi, M. (2024). The future of European competitiveness.

This report can be regarded as the foundational framework for many subsequent European policy documents. For instance, both the PNIEC and the Green Paper, previously discussed in this thesis, draw extensively from its analyses and recommendations, aligning their strategic objectives with the priorities outlined by Draghi.

Compass for European Competitiveness: On January 29, 2025, the European Commission published a document closely aligned with the Draghi Report: the Compass for Competitiveness, a policy document presented to revitalise the continent that aims to turn the recommendations of the Draghi report into a roadmap.[39]

The paper starts with a stagnation of European productivity caused by the innovation deficit and the fragmentation of the single market. Europe is far behind in advanced technologies, those for which Draghi calls for large investments, depending on value chains that come from outside Europe. Finally, businesses suffer from high energy prices and regulatory overload.

An important point is the Commission's willingness to reconcile decarbonisation and industrial competitiveness. As we said, Europe has set significant targets, such as reducing emissions to 90 per cent in 2040 and cutting them down completely ten years later. However, it was realised that they must be done while maintaining economic-industrial competitiveness. The document then introduces the Clean Industrial Deal, a strategy to support energy-intensive industries in the transition and create a market for low-carbon products. How? Strengthening the Critical Raw Materials Act and creating a joint procurement platform for critical materials.

---

[39] Bortoletto, F. (2025, January 29). Con la Bussola della competitività, la Commissione punta a semplificare le regole per imprese. Eunews. https://www.eunews.it/2025/01/29/bussola-competitivita-vdl-sejourne/

Reducing dependence on China and its critical materials would be done through strategic stockpile projects for critical raw materials (somewhat like the two-year Russian-Ukrainian gas war) and with the enhancement of recycling and development of European extractive capacity (the Mattei Plan also involved Europe from the earliest steps, with Ursula Von der Leyen and Giorgia Meloni traveling often together among African countries[40]). Moreover, since the Draghi report had spoken of some 800 billion euros between now and 2030 to revitalise Europe, Compass proposes a union of savings and investments to direct them to strategic projects. This competitiveness fund would bring together public and private funds to finance strategic sectors (primarily energy, semiconductors and defence) and a simplification of regulations.

And finally, he proposes a competitiveness coordination tool, that is, a way to coordinate each European country's "white books," thus their industrial policies.

In Short, the Italian regulatory framework, articulated between PNIEC, White Book and European guidelines, demonstrates a growing awareness of the strategic nodes of the energy transition. However, consistency between national policies and European objectives, the ability to attract public and private investment, and the timeliness of choices on nuclear and critical raw materials remain the real discriminators of success. It is from these premises that it becomes essential to broaden the analysis to the international geopolitical context to assess Italy's positioning and its vulnerabilities.

[40] Carli, A. (2024, March 16). Migranti, Meloni e von der Leyen da al-Sisi. Siglata l'intesa Ue-Egitto da 7,4 miliardi. La premier: ... Il Sole 24 ORE. https://www.ilsole24ore.com/art/meloni-domani-cairo-vede-al-sisi-e-firma-memorandum-migranti-modello-tunisia-AFdik63C

Chapter 2

Geopolitics and Global Energy Strategies.

After outlining the national picture, it becomes clear that Italy cannot develop coherent and effective energy policies without a careful assessment of the international context. The global energy landscape is undergoing rapid transformation, shaped by geopolitical tensions, supply chain disruptions, and competing industrial strategies. This chapter explores these dynamics, focusing on how international competition for energy sources and critical raw materials affects Italy's energy security and strategic positioning.

The analysis begins with fossil fuels, still a cornerstone of the global energy mix, examining the geopolitical and environmental implications of liquefied natural gas (LNG), which has become a key element of Italy's energy diversification strategy following the crisis in relations with Russia. From there, attention shifts to renewable energy, highlighting emerging dependencies on critical materials; to nuclear power, with its complex global supply chains; and finally, to the broader impact of US trade policy and protectionist measures on Europe's energy and industrial landscape.

2.1. Fracking and the return of fossils

Among the various extraction techniques, hydraulic fracturing, commonly known as fracking, has played a significant role in transforming the United States into a leading global energy exporter. However, this achievement comes with notable environmental and economic trade-offs. Fracking is an advanced method used to extract gas or oil from low-permeability geological formations, such as clay shales, which are the source of so-called shale gas and shale oil.

This process differs from other extraction processes because it uses a mix of water, sand, and high-pressure chemicals to release the hydrocarbons present. So, the process is done through the following steps: drilling the ground vertically from which we then extend horizontally once the hole is created; injection of the hydraulic fracturing fluid mentioned before, mainly composed of water at high pressure that makes the cracks in these clay rocks; from these cracks the fluid comes out and is collected.

The efficiency of this practice is very low; when we talk about efficiency, we refer to the amount of resources lost during the various steps required to achieve the final result, due to the methods used. In the multiple steps, fracking loses a lot of efficiency compared to other methods. First, it must be said that often the gas trapped in clay rocks is contained in small pockets within the pores of the stones, which causes some of the gas to be lost during the process, and this process requires high amounts of water and sand, resulting in a high environmental impact.

As for transportation, once the gas has been extracted, it must be liquefied to be transported in an expensive and energy-intensive process. To be transported, cryogenic liquefied gas must reach -162° C[41]. After the liquefaction process is completed, we move on to ship transport, which introduces other possible dispersion.

Once it reaches its destination, the LNG must be regasified and fed into the national energy grid.

We understand how these necessary steps make this method inefficient and highly wasteful. As far as environmental impact is concerned, this method entails a high demand for water. According to a recent study,[42] water used by each well between 2011 and 2016 increased by 770 per cent, and water contaminated by chemical components increased by 550 per cent. In terms of emissions, the greenhouse gas footprint left by this method would be 33% greater than that left by coal, emitting 160 g of CO2 compared to 120 from coal[43], in addition to the fact that in the long run, most emissions do not occur at the time of extraction or final combustion, but in the transition of transportation and production[44].

Another consideration must be made in the possibility of induced earthquakes, i.e., earthquakes due to anthropogenic causes; in fact, the injection of fluids into the earth's soil can destabilise geological aquifers and cause earthquakes. Most of these have caused low-magnitude quakes[45].

---

[41] Padova, U. di. (2017). Gas Naturale Liquefatto e Rigassificatori: cosa sono e come funzionano | Università di Padova. Unipd.it. https://levicases.unipd.it/gas-naturale-liquefatto-e-rigassificatori-cosa-sono-e-come-funzionano
[42] Kondash, A. J., Lauer, N. E., & Vengosh, A. (2018). The intensification of the water footprint of hydraulic fracturing. Science Advances, 4(8), eaar5982. https://doi.org/10.1126/sciadv.aar5982
[43] Barretta, V. (2024, November 15). L'impronta del GNL supera del 33% quella del carbone. Lo studio e l'interrogazione in Commissione UE. Energia Italia. https://www.energiaitalia.news/news/gas/limpronta-del-gnl-supera-del-33-quella-del-carbone-lo-studio-e-linterrogazione-in-commissione-ue/46507/?utm_
[44] Ibidem
[45] Stefano Gandelli. (2022, February). Fracking, è questo il futuro dei combustibili fossili? Geopop. https://www.geopop.it/fracking-cose-a-cosa-serve-conseguenze-e-rischi-per-l-ambiente/

If it has all these problems, why is fracking still being used? Hydraulic fracturing is a method that has enabled the U.S. to break away from the OPEC countries, a hot topic since the '73 oil crisis, and has made them major oil and gas exporters. As for Europe, many countries, such as France, Germany and Italy, have banned it, among others. Other European countries, such as Spain, Portugal, and the United Kingdom, practised it if we consider pre-Brexit Europe. The European Union, once again, is divided on the issue within EU countries, while as a Union, it tries to advise against the use of unconventional methods of extraction.

In Short, the fracking technique has turned the United States into a net exporter of energy, but at the cost of huge environmental and energy costs. European concerns about this technology remain high, with contrasting positions among member states. The Union's future choices on mining regulation, environmental impacts and global price stability will be decisive in determining whether fracking will remain a marginal option or return to prominence.

2.2. The strategic role of critical raw materials

The global energy transition poses new challenges, such as competition for lithium, cobalt, rare earths and uranium. The EU is trying to decrease this problem of dependence on non-European countries by regulating, Italy is one of the founding countries of the union and as such has the duty to keep Europe united at a time when it is essential to start traveling all together. Another branch of policy to consider is the European one, where clarity needs to be made.

The Clean Energy Package 2030 was launched by the European Union in 2016 and adopted in 2019. It was a set of regulations aimed at making Europe's energy system more sustainable, the main goal being to achieve 32 per cent renewable energy and improve energy efficiency by 32.5 per cent by 2030. This package was overtaken, but it set the stage for many subsequent policies, such as the Fit for 55[46], adopted in 2021, which is an EU plan to reduce net greenhouse gas emissions by 55 per cent, hence the name, by 2030 compared to 1990 levels. It is part of the European Green Deal and includes measures such as expanding the ETS (Emission Trading System), introducing new carbon taxes and incentives for renewables and sustainable mobility[47]. The RePowerEU was created in response to the Russian invasion of Ukraine and the energy crisis that was shaping up. The primary goal was, and still is, to reduce European dependence on Russian fossil fuels, and is given as an ambition to achieve zero imports by 2030.

On the other hand, the CRMA (critical raw materials act) seeks to address the issue regarding the supply of raw materials needed for the use of renewables, it is part of larger European projects such as the Green Industrial Plan and the Net Zero Industry Act, the aim is to make the European Union more independent from imports of strategic critical materials especially from countries such as China and Russia, but more generally by promoting intra-European raw materials developments to avoid other price and energy supply shocks due to geopolitical issues. This is why CRMA is calling for large investments in mines and refining plants in Europe, advanced recycling

[46] Clean energy for all Europeans package. (2023). Energy. https://wayback.archive-it.org/12090/20241209144917/https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en

[47] European Council. (2022). Fit for 55 - the EU's Plan for a Green Transition. Consilium. https://www.consilium.europa.eu/en/policies/fit-for-55/

technologies, and the creation of supply chains less dependent on China, which currently keeps 90 per cent of rare earth processing under its control.[48]

The adoption of European policies such as REPowerEU and Fit for 55 has significantly reshaped Italy's energy planning and objectives. These initiatives have prompted the Italian government to diversify its energy supply sources rapidly, leading to the establishment of bilateral agreements with producing countries like Algeria and the promotion of investments in renewable energy and LNG infrastructure.

A pivotal component of this strategic shift is the Critical Raw Materials Act (CRMA), which aims to reduce the European Union's dependence on imports of critical raw materials. The CRMA sets ambitious targets for 2030: at least 10% of the EU's annual consumption of critical raw materials should be met through domestic extraction, 40% through processing within the EU, and 25% via recycling activities. Additionally, the Act stipulates that no more than 65% of the EU's annual consumption of each strategic raw material should be sourced from a single non-EU country. These measures are designed to enhance the resilience and sustainability of the EU's supply chains for critical raw materials[49].

Despite these efforts, the EU faces significant challenges in achieving these goals, particularly when compared to global powers like China and the United States. China currently dominates the global supply chain for many critical raw materials, including rare earth elements, lithium, and magnesium, often exceeding the 65% import threshold

[48] Hool, A., Helbig, C., & Wierink, G. (2023a, September 20). Challenges and opportunities of the European Critical Raw Materials Act.
https://link.springer.com/content/pdf/10.1007/s13563-023-00394-y.pdf
[49] Critical Raw Materials Act. (2022). Internal Market, Industry, Entrepreneurship and SMEs.
https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en?utm

set by the CRMA. This dependency underscores the urgency for the EU to invest substantially in the exploration, mining, and recycling of critical raw materials. Bernd Schaefer, CEO of EIT RawMaterials, emphasized the need for the EU to allocate over €10 billion to promote these activities, suggesting that with private-sector involvement, total investment could reach €100 billion[50].

Furthermore, the International Energy Agency (IEA) has criticized Europe's historical reliance on Russian gas and its retreat from nuclear energy, labeling these as 'monumental mistakes.' These decisions have contributed to Europe's lag behind China and the US in clean technology manufacturing, due in part to higher energy costs and stringent regulations. To regain competitiveness, the IEA advocates for a new industrial master plan that includes substantial investments in renewable energy and energy efficiency.

While these measures represent an attempt to strengthen Europe's strategic position in the global market for critical raw materials, several issues emerge that call into question their real applicability. One of the main limitations of CRMA is that it does not solve the problem of foreign dependence. The 65 percent limit imposed on a single non-EU supplier does not prevent Europe from continuing to be dependent on imports, also because if a single non-European country accounted for 65 percent of imports alone, it would still be a cause for European destabilisation, and this aspect for a country like Italy, which is highly dependent on foreign supplies and lacks significant natural resources, would be truly problematic.

[50] Blenkinsop, P. (2025, May 14). EU must set aside over 10 billion euros for key minerals, says agency head. *Reuters*. https://www.reuters.com/markets/commodities/eu-must-set-aside-over-10-billion-euros-key-minerals-says-agency-head-2025-05-14/

Another problem concerns the difficulties of extraction and refining in Europe, which make it extremely complex to achieve the CRMA goals. Although the Union has identified several mineral deposits on its territory, their actual extraction is hindered by extremely stringent environmental regulations and the resistance of local communities, as mentioned earlier.

A representative example is the Norra Kärr rare earth mine in Sweden, a project that was supposed to ensure Europe's domestic production of key materials for the technology and renewables industries, but which has been obstructed for years by environmental protests. Or the one at the Barroso lithium deposit in Portugal, where opposition from local communities has slowed work, showing how difficult it is to reconcile industrial needs with environmental and social ones.

Lastly, a critical aspect of CRMA is the need to establish strategic agreements with African countries to diversify supply, a goal that, on paper, could reduce dependence on China and Russia. However, the European Union has not yet developed a standard policy in this area, and the lack of a coordinated approach risks thwarting efforts to build solid partnerships.

In Short, the growing global competition for lithium, cobalt, rare earths, and uranium has made clear the need for the European Union to reduce its dependence on dominant players such as China and Russia. With the Critical Raw Materials Act, Brussels has initiated an ambitious strategy, but it is still uncertain in its implementation. The success of this plan will depend on the geopolitical stability of supplier countries, Europe's real internal mining and refining capacity, and the effective management of relations with non-EU partners. In the face of these challenges, analysing the power logics that drive global competition over raw materials, with particular attention to China's growing role in Africa, becomes essential.

2.3. Global competition for raw materials

The strategic centrality of critical raw materials makes it necessary to delve deeper into the global geopolitical context in which Italy fits. Indeed, the international competition for these resources defines the framework within which our country will have to operate to ensure energy security and economic competitiveness. The geopolitics of the energy sector is extremely important; in fact, the Russian-Ukrainian conflict must teach us not to depend on almost all raw material supply from a non-European nation. Those who deal with energy must, in fact, also know the basics of geopolitics. With the oil crisis of '73, a conflict that had nothing to do with oil, the Yom Kippur War opened a scenario of an energy crisis. So, especially today with such a globalised world where even the value chain broken up around the world is a problem, having raw materials out of one's control turns out to be, at the strategic and security level for the country, a considerable risk and for the citizens a substantial economic cost. China knows this. In fact, not only does it have large reserves of lithium at the national level, but it has invested heavily around the world, so much so that it owns about a third of the production of lithium, the so-called white gold, and half of that of cobalt[51] called blue gold on the other hand.

[51] Bellomo, S. (2023). Metalli strategici, la Cina rafforza il predominio sul litio e sul cobalto. *Il Sole 24 ORE*. https://doi.org/10/2023/03/AEwUmW3C/images/9229cd68-c1da-11ed-8910-bb75ddcfd55d-fotohome0

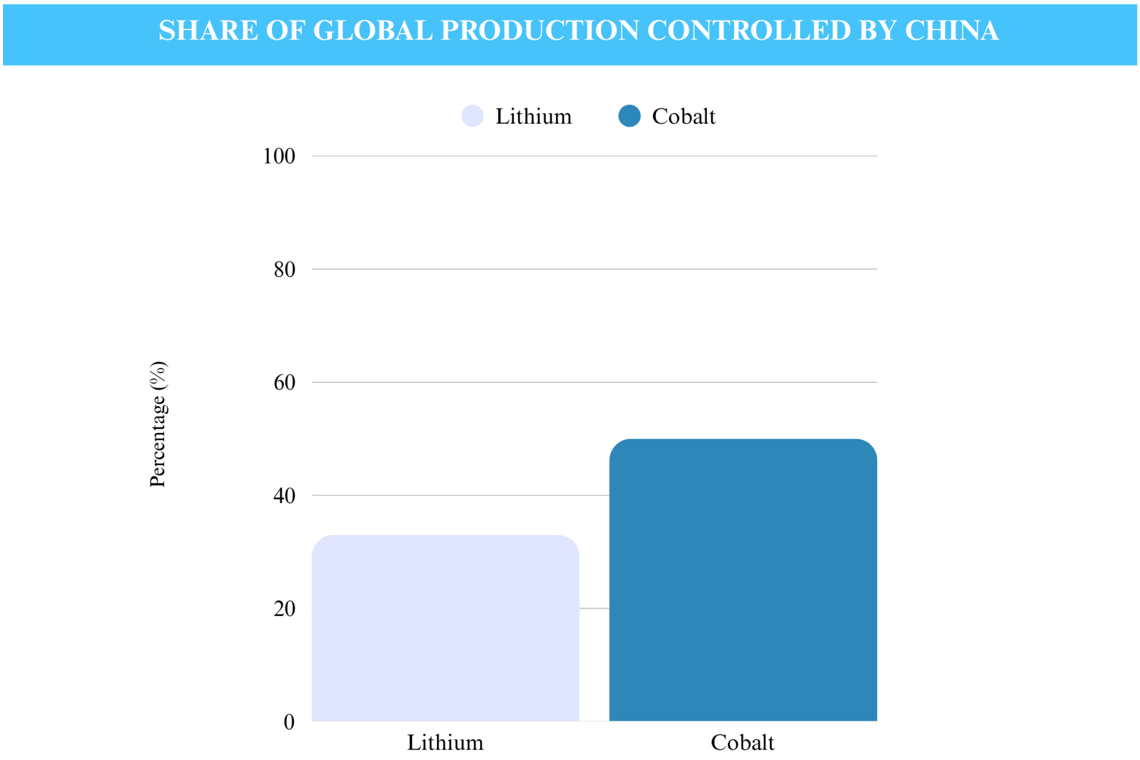

Figure 6: Share of global production controlled by China

For example, the relationship between Zimbabwe (a country with abundant lithium underground) and China is essential in Africa. China not only exports the mineral but also supports the Country in developing a local industry to process it, thus creating added value locally. By increasing its development, it increases its technology and productivity; in 2023, trade between the two countries reached $3.12 billion, a 30 per cent increase over 2022. In addition, in 2023, it obtained licenses worth $2.8 billion.[52]

Since 2003, Zimbabwe has been under sanctions by the United States, the European Union, and the United Kingdom. Sanctions increased after the 2023 elections that reappointed President Mnangagwa. For its part, China, with its policy of

[52] Brando. (2024, January 24). *Zimbabwe: la rivoluzione del litio passa sempre per la Cina*. Nigrizia. https://www.nigrizia.it/notizia/zimbabwe-la-rivoluzione-del-litio-passa-sempre-per-la-cina

non-interference in the internal affairs of partner countries, manages to have excellent trade contracts both with countries deemed by Western democracies to be inadequate and worthy of sanctions and with democratic countries, thus having a huge advantage at the trade level by not having to be accountable in elections.

However addition to investment in mining, China is becoming a major player in investment in strategic infrastructure needed for transportation. Indeed, one example may be the Tazara railway line, which connects Zambia to the Tanzanian port of Dar es Salaam. This infrastructure, financed by Mao's China in the 1970s, is now crucial for moving resources such as Copperbelt copper to the Indian Ocean. In more modern times, Beijing signed a memorandum with Zambia and Tanzania to modernise them, thus consolidating its central role in African commodity trade. Or even the Lobito Corridor, a rail line connecting Angola to the Zambian mining region, which is crucial for transporting copper and cobalt to the Atlantic.

This is all within the framework of a global economic trade policy, the New Silk Road, through which China aims to seize key energy supply routes.

The European Union, on the other hand, is having great difficulty coordinating its response to growing Chinese influence. The lack of a common policy on infrastructure and critical raw materials limits the European bloc's ability to compete effectively in Africa.

Italy is trying to map out a more incisive role; for example, Giorgia Meloni has announced an investment of 320 million euros for the development of the Lobito

Corridor itself[53], contributing to the upgrading of mineral transport infrastructure and seeking to strengthen the European presence in a highly strategic area, has brought and is still bringing forward the Mattei Plan, that is, an Italian strategy to renew relations with Africa through an approach based on equal and non-predatory partnerships, at least that is what it says at the outset.

This plan is structured around six main pillars: education, health, water resource management, agriculture, energy, and infrastructure. It has an initial duration of four years, with the possibility of renewal, and its implementation is monitored by a mission structure and a control room headed by the prime minister.

To date, Italy has allocated €5.5 billion for the plan from various sources, including the Italian Climate Fund (€3 billion) and development cooperation resources (€2.5 billion). Part of the investments focus on energy infrastructure and industrial development, which aim to support both African development and Italy's national interest in diversifying energy sources and establishing a lasting economic presence on the African continent.

As mentioned above, the European Union has a problem with its ability to remain united in foreign policy. If the central body tries to dedicate half of the 300 billion of the Global Gateway program to Africa, the countries within it fail to cooperate.

The Global Gateway is a plan created to counter countries like China in their trade expansionist policy. Let's say it is supposed to resemble a “New European Silk Road.”

---

[53] Nadler, C. D. (2024, June 20). Angola: anche l’Italia investe nel Corridoio di Lobito - Africa e Affari. Africa E Affari. https://www.africaeaffari.it/angola-anche-litalia-investe-nel-corridoio-di-lobito/; Sadden, E. (2024). *Italy pledges $320 million for Africa’s Lobito corridor under G7 infrastructure plan*. S&P Global Commodity Insights. https://www.spglobal.com/commodity-insights/en/news-research/latest-news/metals/061424-italy-pledges-320-million-for-africas-lobito-corridor-under-g7-infrastructure-plan?utm

However, unlike the EU, the Chinese government does not have the problem of trying to democratically agree with all 27 countries that are part of the Union. In addition to the natural slowness of a democratic decision-making structure, compared to a structure like China's, there is also the problem that some European countries continue to follow divergent strategies in Africa.

France, for example, has a historically anchored policy in its former colonies, lately frowned upon, however, so much that it is finalising its withdrawal from Chad and Senegal[54] and will stay only with Gabon. At the same time, China goes in where Europeans go out[55]. Thus, France would have to understand that to re-enter Africa, it would have to go under the EU name; Germany focuses on economic partnerships and renewable energy initiatives[56]; other countries, such as Spain and the Nordic countries, have their strategies, often focused on specific sectors or regions, none of which are continental in outlook or from the broader European lens[57].

This fragmentation makes it difficult for the EU to present itself as a single, coherent partner for Africa. The Mattei Plan, in theory, should be one of the first to do so. When we talk about a non-predatory plan, we mean interventions in infrastructure such as the ELMED Submarine Cable for energy transmission between Tunisia and

[54] Vincent, E., & Roger, B. (2024, November 30). *French army's forced retreat from Africa continues*. Le Monde.fr; Le Monde. https://www.lemonde.fr/en/international/article/2024/11/30/french-army-s-forced-retreat-from-africa-continues_6734677_4.html?utm
[55] Calabrese, L. (2024, September 30). *Why China is seeking greater presence in Africa*. ODI: Think Change. https://odi.org/en/insights/why-china-is-seeking-greater-presence-in-africa-the-strategy-behind-its-financial-deals/?utm
[56] Bank, D. (2023, November 22). *Germany pledges 4 billion Euros in Africa's green energy: AfDB President calls for enhanced partnership*. African Development Bank Group. https://www.afdb.org/en/news-and-events/press-releases/germany-pledges-4-billion-euros-africas-green-energy-afdb-president-calls-enhanced-partnership-66107?utm
[57] Chilamphuma, E. (2025, January 8). Spain Unveils New Africa Strategy for 2025-2028. FurtherAfrica. https://furtherafrica.com/2025/01/08/spain-unveils-new-africa-strategy-for-2025-2028/?utm

Italy (850 million euro investment), or support for energy transition through the Africa Plafond (500 million euro) and the Growth and Resilience Platform for Africa (750 million euro)[58]. With these, the goal is to make it possible for African peoples to exploit their rich raw materials and have them processed within their nations through productive industries. In return, cooperative trade contracts should be created that are beneficial to both sides. This explains the reason for the dedication to Enrico Mattei.

The struggle to secure critical raw materials such as lithium, cobalt, and rare earths reflects not only the intensifying global rivalry between Europe, China, and other powers, but also the persistent lack of cohesion within the European Union in shaping a common energy and industrial strategy.

While the EU seeks to reduce its dependence on external suppliers of critical raw materials through the Critical Raw Materials Act (CRMA), internal divergences between Member States continue to hindering a truly unified industrial strategy. It is important to note that natural gas and LNG—although central to national energy security—do not fall under the scope of the CRMA, as they are not classified as critical raw materials. Nevertheless, competition for gas supplies remains a source of friction within the EU. Since the beginning of the Russian-Ukrainian conflict, Italy has diversified its sources by securing imports from Azerbaijan and Algeria via the Transmed pipeline. Spain, on the other hand, has long enjoyed a privileged position with Algeria thanks to the Medgaz pipeline. With Italy emerging as a major importer, Madrid fears a loss of influence. Furthermore, the addition of new regasification

[58] Carbone, G., Ragazzi, L., Antil, A., Erforth, B., & Magnani, A. (2024). *Rebooting Italy's Africa Policy Making the Mattei Plan Work*. https://www.ispionline.it/wp-content/uploads/2025/01/policy-paper-ISPI-rebooting-Italys-africa-policy-2024_compressed.pdf

terminals in Ravenna and Piombino could further challenge Spain's competitiveness in the LNG market.[59]

Nuclear power is another divisive issue in Europe, with France leading those who would like the EU to consider nuclear power as green so that it can be added to its mix while also using European money and offsets, while Germany, which in 2023 permanently shut down all its nuclear power plants[60], would like to aim for a renewables-only energy mix. This is no doubt where Italy fits in, willing, at least in words, to reintroduce nuclear power into its energy mix. France might well see an Italian deployment in its favour, but would it really be happy with that, or would it want to remain the hegemonic leader of nuclear energy within the Union so it could sell it, similar to what Germany did with the Nord Stream pipeline without being in favour of South Stream?

These are just two of the possible divergences within the European Union. In these stormy times, it is important to be able to keep the helm of the ship straight and try to mediate between the various countries and their needs to create a functioning common energy policy, free of extremist ideologies of one or the other faction and directed toward the common welfare.

In Short, China's control of strategic African resources and the fragmentation of European policies are reshaping the global geopolitical balance. Europe attempts to respond with plans such as the Global Gateway and Mattei Plan, but a lack of cohesion

[59] Prontera, A. (2023). Winter is coming: Russian gas, Italy and the post-war European politics of energy security. West European Politics, 47(2). https://doi.org/10.1080/01402382.2023.2225987

[60] Redazione di Rainews. (2023, April 16). La Germania dice addio al nucleare: chiuse le ultime tre centrali atomiche. RaiNews. https://www.rainews.it/articoli/2023/04/la-germania-dice-addio-al-nucleare-chiuse-le-ultime-tre-centrali-atomiche-50d1c875-d093-41fb-b4e8-2b3a37bca0a2.html

among member states continues to limit their effectiveness. The coherence and coordination of European strategies toward Africa, as well as Italian and European capacity to implement competitive infrastructure projects and build geopolitically balanced relationships, are crucial variables today. This is the background against which one of the most controversial issues of the energy transition is set: the return of nuclear power.

2.4. The geopolitics of nuclear power

In addition to the challenge for critical raw materials, a specific aspect of geopolitical competition needs to be explored: nuclear power. Understanding the international dynamics governing this energy source is crucial to assessing whether and how it can be a practical solution for Italy.

In the U.S., the Biden administration has maintained an ambiguous line. Many resources have been invested in testing and research of SMRs; more than 600 million has been invested in research in the U.S. since 2014[61]. On the other hand, expansion of existing power plants, those of the third generation, has had little room given political pressure from environmental groups. With the advent of the second Trump administration, nuclear power is resurgent even in Washington, D.C. The newly elected president declared a national energy emergency, stressing the need to return to investment in energy infrastructure, including nuclear power. However, the part that has

[61] *NRC Certifies First U.S. Small Modular Reactor Design*. (2023, January 20). Energy.gov. https://www.energy.gov/ne/articles/nrc-certifies-first-us-small-modular-reactor-design

remained most famous in his speeches is not about the return of nuclear power, but the return to fossil fuels, with the phrase "Drill, baby drill."[62]

As far as Europe is concerned, as addressed above, the Green Deal faces both external and internal challenges, and it will be up to political leadership, at both European and national levels, to find a solution that serves the common European interest. Nuclear power plants, as we know, require uranium to produce energy, and their supply chain is both complex and geopolitically sensitive. Approximately 42 per cent of the uranium mined globally each year originates from Kazakhstan.[63]. Although the Kazakh nation is not the first in terms of amount possessed (Australia holds 28 per cent of the world's uranium[64]), it is by quantity mined and sold. As of today, therefore, the key material to operate a nuclear power plant comes under the control of Putin's Russia; in fact, although mining takes place on Kazakh territory, the country's nuclear sector is heavily influenced by Russia. This is due to historical and economic ties between the two nations, a legacy of the Soviet era, and strategic agreements with Rosatom, Russia's state-owned nuclear energy company.

According to the World Nuclear Association, uranium is an abundant resource, but despite growing demand, the market is already showing signs of an imbalance between supply and demand. If not bridged by new mining and investment in the supply chain, this gap will be critically felt from 2030 onward. When discussing nuclear power, therefore, it is not enough to talk about reactors and advanced technologies; we must

---

[62] *Climate and energy in Trump's Day One executive orders*. World Nuclear News. https://www.world-nuclear-news.org/articles/climate-and-energy-in-trumps-day-one-executive-orders

[63] Il grande balzo in avanti del prezzo dell'uranio - RSI. (2023, November 24). Rsi; RSI Radiotelevisione svizzera. https://www.rsi.ch/info/mondo/Il-grande-balzo-in-avanti-del-prezzo-dell%E2%80%99uranio--1998145.html

[64] Fabbri, F. (2024, May 16). Uranio, chi ne produce di più al mondo? Energia Italia. https://www.energiaitalia.news/news/nucleare/uranio-chi-ne-produce-di-piu-al-mondo/32206/

also consider the problem of fuel supply, because owning functioning power plants is useless without a secure and stable source of uranium.

Uranium is the first link in an articulated value chain, including highly specialised industrial processes. After mining, the ore must be converted to uranium hexafluoride (UF_6), enriched to reactors' levels, and finally turned into fuel rods. In the enrichment phase, Russia has built a dominant position: Moscow controls nearly 45 per cent of global uranium enrichment capacity, making many countries, including several members of the European Union, heavily dependent on its facilities. This dominance is an economic advantage and a powerful geopolitical lever that the Kremlin can exploit in its international relations.

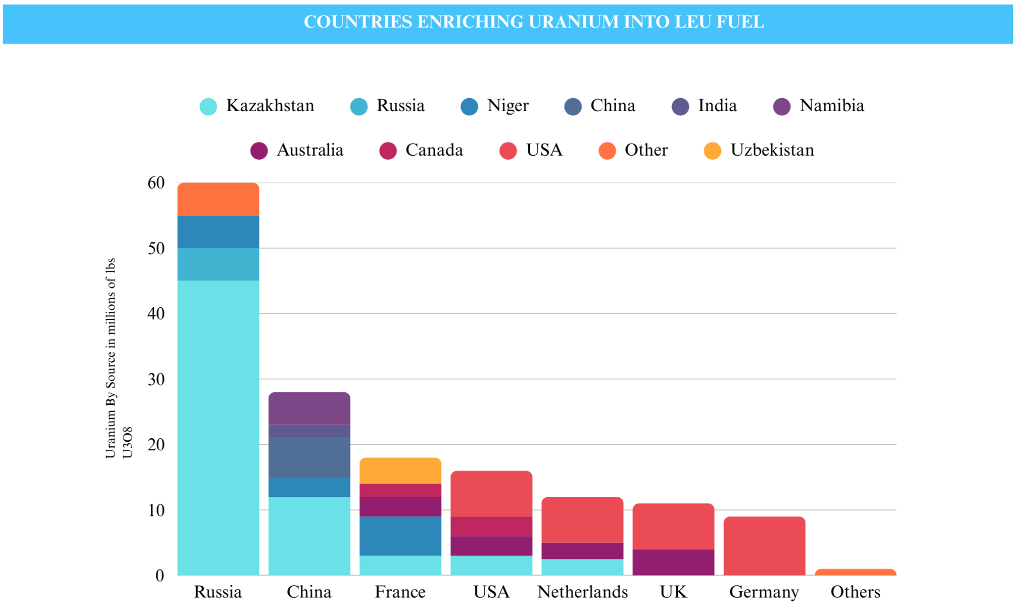

Figure 7: Countries enriching uranium leu fuel, an author adaptation by *Uranium enrichment: by country, by company, by facility?* (2024, December 5). Thunder Said Energy.

With this situation, the United States has decided to reduce its dependence on Russia with a targeted investment plan. Washington has allocated $2.7 billion to strengthen its enrichment capacity and introduced an embargo on Russian enriched uranium imports starting in 2024. The European Union, on the other hand, is trying to diversify its sources of supply, although with much difficulty. France and China, for their part, are adopting different strategies but with a common goal: to consolidate their control over the uranium market.

France, which depends heavily on nuclear power for its energy mix, is Europe's largest uranium consumer. However, its loss of influence over former African colonies, particularly in Niger, is jeopardising its energy security. The recent revocation of the license to the French company Oran for the Imouraren field, one of the richest in the world, is a significant blow to Paris, which now has to turn to countries such as Canada and Australia to compensate for this loss.

Conversely, China has adopted a long-term strategy based on massive investments in Central Asia and Africa. Beijing controls uranium mines and finances the construction of nuclear reactors in emerging countries, such as Uzbekistan, thus consolidating its influence in the sector. This strategy allows it to tie entire nations to its nuclear supply chain, securing a lasting strategic advantage.[65]

In addition to the mining, conversion and enrichment processes, fuel production is another key step in the nuclear value chain. After enrichment, uranium is converted into uranium oxide tablets, which are then inserted into the fuel rods that feed the reactors. All these steps require highly specialised skills and advanced infrastructure. Regarding the geopolitics of nuclear energy, one cannot ignore the fact that possessing the know-how necessary to manage this supply chain is as strategic as access to raw materials.

Should Italy decide to re-enter nuclear power, it will face a complex challenge. Beyond technological and environmental safety, the country will need to establish a reliable and diversified nuclear fuel supply chain, in order to avoid excessive dependence on geopolitically unstable actors. While uranium extraction is geographically concentrated in countries like Kazakhstan, Canada, and Australia, much of the global enrichment and reprocessing capacity remains in Russian hands. For this reason, any Italian nuclear strategy will have to carefully balance the sourcing of raw

[65] Uranio: geopolitica di un revival obbligato | ISPI. (2024, July 25). ISPI. https://www.ispionline.it/it/pubblicazione/uranio-geopolitica-di-un-revival-obbligato-180788

uranium with the political implications of relying on Russia for its processing—making strategic partnerships with democratic and stable countries even more critical.

Another option involves the adoption of Small Modular Reactors (SMRs). This technology could reduce the need for large quantities of enriched uranium and make implementing nuclear power in Italy more flexible. Notably, both China and Russia have already achieved significant milestones in SMR deployment.

China has successfully connected its first commercial SMR. This marks the world's first commercial land-based SMR prototype, highlighting China's leadership in this field[66].

Russia, on the other hand, has been operating a floating nuclear power plant equipped with SMRs. Additionally, Russia is constructing its first land-based SMR[67].

However, whichever path the country takes, it will be crucial to develop a sound and realistic strategy that considers the current geopolitical framework and the value chain of the necessary raw materials. The return to nuclear power is not just a matter of technological innovation and environmental sustainability but a real strategic dossier, in which energy security is intertwined with major global dynamics.

In this context, Italy must carefully assess its role in the global nuclear supply chain. Without a clear uranium supply strategy and efficient waste management, nuclear power could be more of a challenge than an opportunity.

---

[66] Weiwei, G. (2025). *EconoScope | China's nuclear power development gaining momentum*. Ecns.cn. https://www.ecns.cn/cns-wire/2025-02-27/detail-ihepcskv6108813.shtml?utm

[67] *Small modular reactors (SMR) | IAEA*. (2016, April 13). Iaea.org. https://www.iaea.org/topics/small-modular-reactors?utm;*Nuclear Power in Russia - World Nuclear Association*. (2025). World-Nuclear.org. https://world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power?utm

One possible response to one of the main criticisms of nuclear power, namely, the issue of radioactive waste, is the technique of reprocessing. This approach allows for part of the spent nuclear fuel to be treated so that materials such as uranium and plutonium can be separated and recovered for reuse as fuel in other reactors. This is particularly relevant in the Italian context, given the long-standing issue of national nuclear waste currently stored abroad, which will eventually need to be returned and managed domestically[68]. This process offers significant advantages, it allows as we have already mentioned to recover fissile materials, making the process efficient and thus reducing the need for new uranium mining, it decreases the amount of waste to be disposed of reducing its environmental impact, and it gives the possibility to create

MOX or mixed oxide fuel a mixture of uranium oxides and plutonium that can be used in specific reactors. This MOX successfully regains 25-30% more energy from recycled products than has already been produced[69]. However, the reason why we do not hear much about it, reprocessing has a very high cost that to date exceeds that of uranium, making reprocessing a practice to date that is not competitive, it is a process found in very few power plants in the world, the most famous being La Hague in France. In addition, the plutonium separated in this process could be used to build nuclear weapons, increasing the risk of proliferation.

In Short, the nuclear supply chain is closely intertwined with complex geopolitical dynamics. The dominance of Russia and Kazakhstan in uranium production and enrichment, combined with the divergent strategies of the United States, France and

---

[68] IAEA. (n.d.). Development of Advanced Reprocessing Technologies. https://www.iaea.org/sites/default/files/gc/gc52inf-3-att4_en.pdf

[69] World Nuclear Association. (2020, December 18). *Processing of Used Nuclear Fuel - World Nuclear Association*. World-Nuclear.org. https://world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/processing-of-used-nuclear-fuel

China, makes it clear that access to nuclear fuel is first and foremost a political issue. For Italy, any return to nuclear power would require a clear and diversified supply strategy that considers geopolitical security of sources, domestic technological capability, and overcoming social opposition. Understanding these factors is essential to assessing the strategic feasibility of any national energy scenario. In this context, the recent wave of U.S. protectionism raises further questions about the security of supply chains and Europe's ability to respond united to new global economic challenges.

2.5. The return of U.S. protectionism: impacts on the energy transition

With Donald Trump's election to the White House in 2024 and his inauguration in January 2025, the U.S. is embarking on a new phase of economic protectionism, intensifying its policy of tariffs and trade restrictions against several countries, including historical allies. This shift risks triggering a global trade war, with major consequences for the European economy and the energy transition, which depends on access to critical raw materials and advanced technologies.

In fact, during his first term (2017-2021), Trump had already initiated a policy of punitive tariffs against China, with duties on hundreds of billions of dollars of imported products, particularly semiconductors and strategic raw materials.

Now, however, with his return, this strategy is being extended to key sectors of the global economy and, more significantly, to some of the United States' closest and most longstanding partners, including Canada, Mexico, and Europe, with whom the U.S. shares not only defence commitments, but also deep historical, economic, and political ties.

As of today, there is a lot of back-and-forth and little clarity, we don't know if it may be a flash in the pan or if Trump is serious, with Canada and Mexico he has reached a one-month truce from tariffs after having just inserted them[70], those with Europe has repeatedly promised them, but there is no sign of them yet. Among the most affected sectors could be critical metals and raw materials, advanced technologies, such as batteries, microchips and components for the digital industry, which Europe lacks and needs in large quantities and the automotive and manufacturing industries, which are already in the midst of a crisis.

The primary concern for Europe is that these policies may alter the balance of global supply chains, hindering access to materials that are crucial for decarbonisation, the other doubt, however, is that all this may once again lead to the 27 European countries each choosing the method by which to approach Trump, to escape these tariffs as individual states, this would once again de-emphasise European power and make differences and the European inability to team up even more apparent[71]. One of the methods that Italy could implement to maintain high industrial capacity is to follow the German model[72], which, after the automotive crisis, reshaped its production chain by increasing investment in the war industry and transforming the automotive workforce into a specialised war workforce.

Another critical element in the new U.S. economic strategy could be Greenland, an autonomous territory under the sovereignty of Denmark but heavily influenced by

---

[70] Sole, I. (2025, February 4). Usa, Trump sospende dazi a Messico e Canada per un mese. Il Sole 24 ORE. https://stream24.ilsole24ore.com/video/italia/usa-trump-sospende-dazi-messico-e-canada-un-mese/AGsp1UiC

[71] Tenev, M. (2025, May 7). *MAGA goes global: Trump's plan for Europe*. ECFR; European Council on Foreign Relations (ECFR). https://ecfr.eu/publication/maga-goes-global-trumps-plan-for-europe/

[72] Carboni, T. (2025, March 10). *In Germania l'industria della difesa sta assumendo operai licenziati per la crisi dell'automotive*. Forbes Italia. https://forbes.it/2025/03/10/in-germania-industria-difesa-assume-operai-licenziati-crisi-automotive/?utm

the United States. Greenland is one of the wealthiest areas for strategic mineral resources, with vast deposits of: rare earths, uranium, lithium and cobalt.

In 2019, Trump made a proposal, which was later rejected, to buy Greenland[73] from Denmark, a clear signal of Washington's strategic importance to the territory.

In Short, the return of economic protectionism in the United States risks undermining European access to advanced technologies and critical raw materials, putting pressure on the entire system of global supply chains. In the face of these risks, Europe's ability to adopt a coordinated response and diversify sources of supply becomes strategic. More generally, international geopolitical and trade stability is confirmed as an essential prerequisite for a safe, sustainable and competitive energy transition. From this complex and changing global scenario, we now turn to a more focused analysis of possible choices for Italy, through the construction of strategic scenarios.

[73] brahim maarad. (2019, August 17). Perché Trump vuole comprare la Groenlandia. Www.agi.it; AGI - Agenzia Italia. https://www.agi.it/estero/news/2019-08-17/trump_groenlandia-6035287/

Chapter 3

Analysis and Construction of a Cross-Impact Scenario

In the third chapter of this thesis, we will analyse and construct an energy scenario using cross-impact analysis. After having deeply examined the Italian energy structure and global geopolitical conditions in previous chapters, this chapter introduces the more analytical part, and we will try to assess the interaction between several key variables through this.

3.1. Method Introduction:

Cross Impact Analysis is an advanced method of analysis that allows for a structured understanding and evaluation of the mutual interaction between different factors or events that may influence the future of a complex scenario. This approach has evolved over the years to become one of the most refined and widely used tools for studying scenarios today, mainly when the future depends on the combination and interaction of multiple and diverse variables, as will be the case here. Underlying cross-impact analysis, we find a straightforward concept: the future is not determined by a single variable but by many interacting variables. This method is, therefore, a practical response to the need to analyse precisely what mutual influences the various elements of a system exert on each other, helping to predict more effectively which scenarios might materialise and which would be less likely.

The procedure for this analysis starts by clearly identifying the key variables of the system we want to study in the specific case of this thesis, these variables concern geopolitical and technological aspects that define the current Italian energy scenario. Once the key variables have been selected, we move on to a more detailed phase to determine how each variable influences all the others. This stage usually employs cross-impact matrices (hence the name cross-impact) that allow the interdependencies to be visualised. Through these matrices, experts assign values that express the strength and direction of the influence of one variable on the others. The stronger the impact of a variable, the greater its weight in determining the future scenario. In this way, Cross Impact makes it possible to quickly identify which factors are most relevant and decisive in the construction of future scenarios and which, on the other hand, are marginal.

One of the greatest strengths of this methodology is its ability to integrate expert opinion combined with the rigorous use of quantitative models, making the method as scientific as it is intuitive. This allows it to offer more accurate, complete and realistic forecasts than other purely qualitative or quantitative approaches. By applying this methodology to the Italian energy system, we can explore alternative scenarios for the country's development, such as accelerated decarbonisation, natural gas continuity through LNG or a return to strategic nuclear power. Through Cross-Impact Analysis, it will thus be possible to highlight which combinations of factors may lead to one scenario rather than another, making it easier for policymakers and companies to develop effective and informed strategies.

3.2. Cross Impact

The main variables considered in this analysis reflect the strategic pressures that Italy faces within both the geopolitical and technological domains. On the geopolitical front, the focus is on four key actors, each representing a specific and impactful dynamic: Russia, primarily viewed through its role as a dominant energy exporter and as a central player in the uranium supply chain; China, which holds global leadership in critical raw materials and the production of clean technologies; the European Union, whose regulatory framework and green policy agenda directly shape Italy's energy strategy; and the United States, which exerts strong influence over global innovation, industrial policy, and trade dynamics, particularly under the renewed leadership of Donald Trump.

These geopolitical dimensions interact with a second set of variables, those tied to technological development. The analysis thus also considers nuclear energy, especially in the form of Small Modular Reactors (SMRs), which are emerging as a stable, low-emission energy source; energy storage, which is critical to managing the intermittency of renewables and ensuring system stability; and energy saving, a strategic lever for reducing consumption and enhancing efficiency across sectors. By exploring how these actors and technologies influence each other, the matrix offers a comprehensive view of the possible scenarios Italy may face in navigating its future energy strategy.

	Russia (energy exports and uranium chain)	China (tech and critical raw materials)	EU (green policies and regulation)	USA (innovation and trade influence)	Nuclear	Energy storage	Energy saving
Russia (energy exports and uranium chain)	X	-/+	-	-	+ +	0	+
China (tech and critical raw materials)	-/+	X	+	-	+	++	++
EU (green policies & regulation)	-	+	X	+	+	++	++
USA (innovation and trade influence)	-	-	+	X	+	+	+
Nuclear	++	+	+	+	X	+	0
Energy storage	0	++	++	+	+	X	++
Energy saving	+	++	++	+	0	++	X

Where:

++ = High impact

+ = Positive impact

0 = no significant impact

- = negative impact

-/+ = ambivalent impact

3.3. Explanation of the matrix

Russia (energy exports and uranium chain)

Russia plays a structurally relevant role for Italy and Europe due to its dominance in the global uranium enrichment process and its past centrality as an energy supplier. The impact of a nuclear revival would be highly positive for Moscow (++) because of its control over the upstream nuclear fuel cycle. However, its geopolitical isolation post-Ukraine invasion has made its relations with the EU and USA overtly negative (-), and its position vis-à-vis China is ambivalent (-/+), as the two countries cooperate tactically but diverge in Central Asia and long-term interests. Russia has no significant stake in energy storage (0), due to its abundant supply of fossil and nuclear resources, but energy saving holds moderate interest (+), as reduced domestic consumption increases potential for export.

China (tech and critical raw materials)

China is central to global supply chains of renewable technologies and critical raw materials. It maintains strong influence over both energy storage (++), as the global leader in battery production, and energy saving (++), through mass production of efficient technologies and green tech exports. While geopolitical tensions with the USA are growing (-), its trade relationship with the EU remains cautiously positive (+), offering Italy both opportunities and dependencies. Nuclear remains an area of strategic interest (+), though not a priority compared to renewables. Its relationship with Russia is marked as ambivalent (-/+), shaped more by tactical alignment than strategic convergence.

EU (green policies and regulation)

The European Union is the primary driver of Italy's energy transition. Through regulatory instruments like the Green Deal and Fit for 55, the EU is positively influencing the deployment of energy storage (++) and energy saving technologies (++). The EU supports nuclear as a component of energy security and emissions reduction, particularly via investment in Small Modular Reactors (+). Relations with Russia are currently negative (-) due to the breakdown of energy ties, while those with China (+) and the USA (+) remain positive but require careful management in light of trade dependencies and security concerns.

USA (innovation and trade influence)

The United States remains a benchmark in terms of technology and R&D. Its approach to nuclear, storage, and efficiency is uniformly positive (+), reflecting its diversified investment strategy. However, geopolitical frictions, particularly with China (-) and Russia (-), and the Trump administration's protectionist tendencies, introduce uncertainties. Relations with the EU are generally positive (+), but can become strained over trade and defence autonomy. For Italy, the U.S. represents both a partner in innovation and a source of potential industrial fragmentation.

Nuclear

Nuclear technology, although not currently part of Italy's energy mix, is a potential strategic option. It interacts positively with all geopolitical contexts (+) and would strongly benefit Russia (++) due to its fuel chain dominance. It is moderately complementary to energy storage (+), offering baseload capacity, while its relation to energy saving is neutral (0), since it addresses energy supply rather than demand. Within Europe, interest in nuclear, especially SMRs, is rising as a low-carbon, high-stability energy source.

Energy Storage

Storage is a cornerstone of renewable integration. It is especially linked to China's technological and raw material supply chains (++) and is a major EU priority (++). It has positive interdependence with all actors and technologies in the matrix, including the USA (+), nuclear (+), and energy saving (++). Russia, due to its abundance of primary energy, shows little strategic interest (0).

Energy Saving

Efficiency technologies are crucial for lowering demand and increasing energy system resilience. China and the EU are both deeply engaged in this field (++), with the USA playing a supportive role (+). Russia could benefit indirectly from domestic reductions in energy use (+). The synergy with energy storage is high (++), while interaction with nuclear remains neutral (0), as both operate at different stages of the energy chain.

3.4. Proposed scenarios

This analysis has allowed us to understand what factors may influence each other positively, negatively, or ambivalently, outlining a map of possible future developments. Now, we can imagine three alternative scenarios for Italian energy policy, each with pros and cons that we will discuss in detail. After that, we will use our analysis to see how plausible and consistent these scenarios are with the data we had from this one. The scenarios are: accelerated decarbonisation, short-term dependence on liquefied natural gas, and strategic nuclear.

Accelerated decarbonisation:

This scenario envisions a significant increase in investment in renewable energy sources, far beyond current levels, coupled with a substantial expansion of energy storage systems and energy-saving technologies. It is fully consistent with the Cross-Impact Matrix: the impact is strongly positive with the European Union (++) and China (++), particularly concerning storage and efficiency, where there is strong political and industrial support. The United States also represents a positive interaction (+), favouring technological collaboration. The relationship with Russia as an energy exporter and uranium supplier is largely neutral (0 for storage) or only moderately relevant (+ for saving), which aligns with the fact that the EU has significantly reduced its energy dependence on Moscow.

The dynamics of this scenario involve Italy rapidly implementing the objectives of the European Green Deal, boosting renewable energy production in coordination with its European partners, and deploying storage infrastructure to stabilise electricity availability during demand fluctuations. However, in doing so, Italy and the EU would increasingly depend on China, whose control over the supply chain for critical materials would become even more central. This would enhance China's commercial leverage and geopolitical influence over Europe, replicating some of the vulnerabilities previously experienced with Russia.

The United States, under a renewed Trump mandate, may not welcome this strategic rapprochement between Europe and China. Yet, its own inconsistent trade policies and the underexploitation of critical material reserves in regions such as Greenland may further distance it from its European allies. Russia, on the other hand, remains marginalised in this scenario, redirecting its energy exports toward Africa and Asia.

The advantages for Italy would include rapid decarbonisation of its energy sector, near-complete independence from fossil fuels, and sustainable growth in industrial capacity. The downside would be a significant increase in dependence on China for critical technologies and materials, raising the risk of a new asymmetric geopolitical relationship, reminiscent of Italy's past dependence on Russian gas.

Dependence on LNG

In this scenario, the government opts for a strategic delay, prolonging Italy's dependence on liquefied natural gas (LNG), originally adopted to mitigate the energy crisis, without committing decisively to long-term structural change. This path is consistent with the Cross-Impact Matrix: given the deteriorated relationship between the EU and Russia as an energy exporter and uranium chain supplier (-), Europe is pushed to consolidate alternatives to Moscow. At the same time, moderately positive ties with the United States (+) make it a stable and strategic LNG provider, especially when compared to more unstable global suppliers. In this context, both energy storage and energy-saving technologies remain present, but receive less attention and funding compared to fossil infrastructures.

The dynamics of this scenario would revolve around the central role of the United States as Italy's and Europe's principal energy partner, not only in terms of security and defence but also with regard to energy supply. The U.S. would consolidate its geopolitical position by supplying LNG and might even soften its tariff policy toward the EU, as bilateral trade flows would increase. Reducing the trade imbalance (which under Trump's approach has historically justified tariff retaliation) could lead to a more balanced commercial relationship, at least temporarily.

In this framework, China would remain marginal with respect to LNG-related infrastructure and trade, while continuing to expand into other markets more aligned with its strategic interests. The European Union would gain immediate energy security but at the cost of significantly delaying progress toward decarbonisation targets. Russia, although initially marginalised, would remain a potential competitor by offering lower prices for natural gas and testing Europe's internal cohesion—especially in more vulnerable states such as Italy.

The short-term benefits of this scenario include enhanced energy security and temporary macroeconomic stability. However, the long-term consequences are less favourable: a structural lock-in to gas infrastructure, increased dependence on the U.S., and growing difficulty in meeting climate goals. It is also important to remember that U.S. LNG production is largely based on environmentally controversial extraction methods, such as fracking, which would expose Europe to new contradictions in its climate diplomacy.

Strategic nuclear:

The third scenario involves the reintroduction of nuclear power in Italy as a strategic solution to guarantee energy stability and complement the growth of renewables. In this scenario, the country would invest in the construction of new-generation plants, with a focus on Small Modular Reactors (SMRs), which are considered safer, more flexible, and suitable for Italy's energy context. This scenario is strongly aligned with the Cross-Impact Matrix. Russia's role as the global leader in the uranium value chain represents a key factor (++), while the EU and the U.S. both show positive interest in the development of advanced nuclear technologies (+). China, although less central in this specific segment, would also maintain a moderately positive engagement (+) by supporting the supply of critical materials required for the reactors.

The implementation of this scenario would see Italy and potentially other European partners reactivate or build new nuclear plants, relying on EU-level incentives and bilateral technological collaboration with Washington. A key element would be the diversification of uranium sourcing to avoid renewed dependence on Russia. Italy would therefore have to forge strategic agreements with suppliers in Canada, Australia, and certain African countries. Russia, aware of its leverage on uranium processing and supply, would likely attempt to use this control as a geopolitical tool to regain influence in Europe.

China would remain a marginal but valuable player, supporting the upstream side of the transition through critical materials and certain technology components. The EU, meanwhile, would likely support nuclear not only as an industrial opportunity, but as a stabilising factor for its ambitious decarbonisation targets. The United States would reinforce its leadership role, particularly if partnerships focus on SMRs developed by U.S. firms.

The advantages of this scenario are considerable: fixed and predictable energy prices, high stability in production, significant reductions in fossil fuel dependency, and full alignment with climate goals. Moreover, it would allow Italy to combine nuclear baseload capacity with renewables and advanced storage and efficiency technologies. The disadvantages are not negligible: potential dependence on Russian uranium, high initial capital costs, and the need to manage public acceptance, especially in regions historically opposed to nuclear infrastructure (NIMBY phenomena).

3.5. Conclusion of the chapter

Concluding this analysis and this chapter, we can say that after having described the energy and geopolitical factors in the first two chapters, we have, through Cross Impact, brought out the complexity of the interactions between geopolitical and technological factors in outlining plausible energy scenarios for Italy. Our country faces critical strategic choices that can steer the future of national energy toward different development models.

Among the various options considered, however, the one that stands out for its long-term potential, economic and environmental sustainability and geopolitical stability is the so-called strategic nuclear power. This scenario promises to effectively combine energy security with decarbonisation, complementing the already widely deployed renewable sources in the country.

The next chapter will discuss this possibility in detail, specifically addressing the role of nuclear power in the Italian context.

Chapter 4

Building a specific case: The role of nuclear power

This chapter will begin differently than planned. We will start with a news story, an event that happened a few days ago, the Spanish blackout: on April 28, 2025, at lunchtime, millions of people were powerless. We are not talking only about Spain, but about the entire Iberian Peninsula and parts of southern France. In a few seconds, about 15 Gigawatts were lost, which is about 55 per cent of Spain's electricity demand, equivalent to the energy produced in Spain by solar panels. The reasons are unknown; investigations are ongoing, but let's focus on another issue. This news, in fact, especially after reading the first two chapters, reminds us that renewable energy, like all methods of energy production, has specific critical issues. It is the responsibility of politicians to know these limitations so that the country can react to any eventuality. Like a doctor, a politician should read the instruction leaflet for every choice before implementing it.

Briefly summarising what we have already written in the first two chapters, renewable energies, in the event of imbalances or disturbances in the power grid, are unable to maintain stable production because they do not provide electromechanical inertia to the grid; in contrast, thermal power plants, thanks to their internal turbines, can produce power even when they experience a reduction in supply by using residual kinetic force. This enables them to deal effectively with grid fluctuations, called disruptions. In a country with high renewable energy production, grid-forming inverters could be used, enabling renewable plants to contribute to grid stability. However, this is a promising but still uncommon technology. In addition, thermal power plants have the advantage of being programmable. In previous chapters, we have observed that renewables produce energy mainly during peak times, that is, when the factor powering them is present. Currently, batteries for storing excess energy produced are not usable on a large scale, as they are still too expensive and technologically immature. To understand this technological limitation, by way of example, we can think of laptops, which need to be recharged after a few hours. Therefore, significantly basing a national electricity system solely on renewable energy at the current state risks increasing the country's energy insecurity. Another essential point that the recent blackout confirms for us is that to avoid such incidents, it is crucial to have a highly efficient smart grid that can quickly stabilise the national power system. The blackout was caused by a sudden reaction of the grid that lasted a few seconds, similar to what happens with the life preserver in our homes, which intervenes quickly to avoid greater damage.

These situations are predictable and manageable. The ancient Greeks thought of the timeline in a manner opposite to our current perception: in fact, what we know with certainty is the past, while the future remains uncertain because it has not yet happened. It is as if we are walking backwards, looking toward what we already know. Therefore, to ensure the stability of the national power grid, energy production cannot be based solely on unstable sources; it is necessary to put them side by side with more stable energy production methods, such as fossil fuels or nuclear power.

And now, since we have realised throughout the study that we want to abandon fossil fuels, let's discuss other possible solutions.

4.1. Relevance of nuclear power for Italy:

Italy's energy situation requires a pragmatic political vision that plans in the long term by choosing for the country the best possibilities of energy production, to be combined with renewables that do not preclude the goals we have set for ourselves as the West, but rather strengthen our commitment and the possibility of achieving them. Italy imports about three-quarters of its primary energy from other countries to produce energy, has no domestic gas production, thus depending on foreign countries, among which are, in the vast majority, non-EU, which makes Rome unstable and unable to plan for the long term. In this context, nuclear energy is a stable, programmable, and very low-emission choice that can make Italy autonomous in energy production. A study by EY[74] shows how, by 2050, nuclear power could cover about 22 per cent of Italian demand and would also be able to generate a market of 46 billion euros for the industrial supply chain. In addition, the company Newcleo says it is ready to commercialise its SMRs by 2033[75], which, as we have already had ample opportunity to analyse, are innovative, modular reactors that are smaller in size compared to the old power plants, this gives us an idea of when we might start using this new type of facility, meanwhile there is to think about how to solve the grain of consensus, since in Italy, the ruling class rarely takes responsibility for choosing before public opinion is already primarily in favor of it. Instead of representing a beacon guiding the people, it often appears in Italy as a consensus-drawn bandwagon, destined to follow what the

[74] EY Italy. (2025, March 3). *Energia nucleare in Italia: un mercato da 46 miliardi entro il 2050*. Ey.com; EY.
https://www.ey.com/it_it/newsroom/2025/3/energia-nucleare-in-italia-un-mercato-da-46-miliardi-entro-il-2050

[75] Neri, A. (2025, February 18). *Istituzioni e aziende italiane tracciano la via per il nuovo nucleare sostenibile - Energia Oltre*. Energia Oltre.
https://energiaoltre.it/istituzioni-e-aziende-italiane-tracciano-la-via-per-il-nuovo-nucleare-sostenibile/

population wants, thus making decisions that are always behind the times, in addition to the fact that there are two referendums against nuclear power.

However, as with any energy technology, nuclear power involves vulnerabilities related to the supply of raw materials. Uranium, an indispensable element for reactor power, is sourced mainly from outside Europe, as we have discussed extensively in previous chapters, particularly from Kazakhstan and Canada. In addition, a significant share of enrichment capacity is still in Russian hands. In this context, the political risk related to supply chains is clear: Italy, to reintroduce nuclear power, would have to build a national, or even better, European strategy of uranium diversification, supply, and storage, consistent with what is outlined in the Critical Raw Materials Act. Regarding waste from a nuclear power plant, we are helped by a public statement by Sogin CEO Gian Luca Artizzu, who explained that we are probably miscommunicating what nuclear waste from nuclear power is. Given that it is waste placed in safe, confined, multi-barrier technological locations and that it releases to the environment a level of radioactivity equal to that of a thousand bananas, that is, a volume that cannot be perceived against the background radiation[76].

Considering now, as an example, another European country, we can understand the difference between a long-term vision and a short-term vision. France, for example, has always had a significant amount of energy produced by nuclear power, which forms the foundation of France's modulable and programmable national production, on top of which are renewables that will instead grow to their full potential every day.

[76] Ibidem

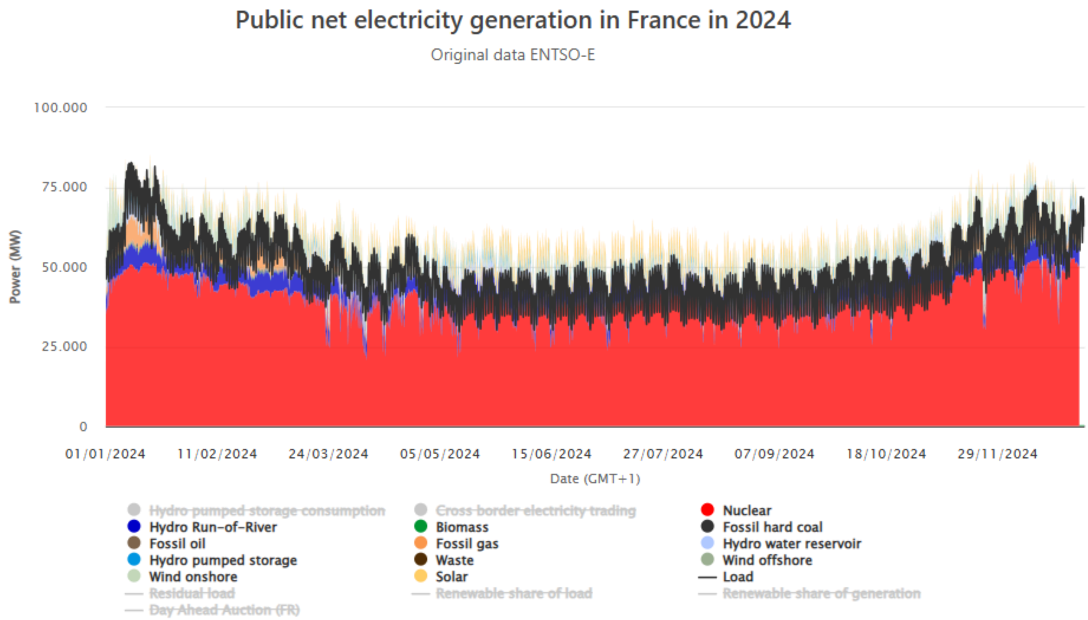

Figure 8: Public net electricity generation in France in 2024 by Burger, B. (2025). *Energy-Charts*. Energy-Charts.info.

In addition, the French are among the few nations that manage to export produced energy, while so many other European countries, especially among the major ones, are energy importers. As for Germany, however, we have the extremely opposite model. It closed its nuclear power plants after Fukushima and had to rely on its fossil resources for a stable form of energy, such as lignite, which is much more polluting than coal.

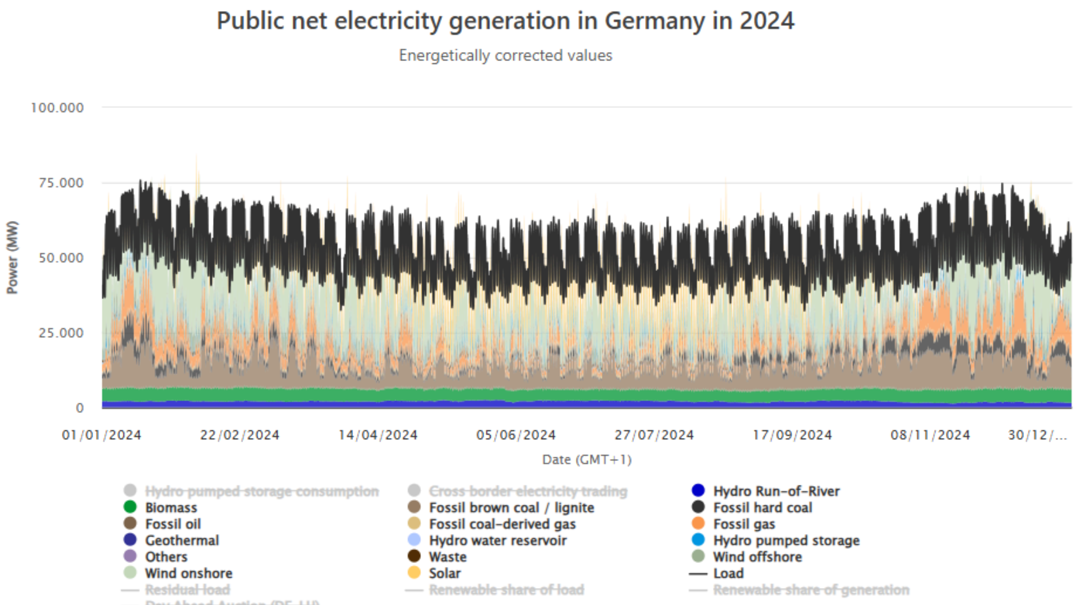

Figure 9: Public net electricity generation in Germany in 2024 by Burger, B. (2025b). *Energy-Charts*. Energy-Charts.info.

In fact, in Germany, although renewable energy is used a lot, when not present, fossil fuels are used extensively, having no other stable and programmable form of energy. All this shows us that an adjustable and programmable base, such as nuclear power, is very important and would make the country capable of achieving its pre-determined climate goals, but more importantly, of achieving safe, stable and very low-pollution power generation based on a mix of renewables and nuclear in the long term.

4.2. Operational proposals

A number of issues need to be addressed to make nuclear power a concrete and integrated component of the Italian energy mix. These mainly concern social acceptance, economic sustainability, and infrastructural integration with existing renewables.

4.2.1. Strategies to accelerate social acceptance and financing.

One of the main obstacles to the return of nuclear power in Italy is undoubtedly public opinion. The two referendums crystallised a cultural attitude often opposed to this technology, based on fears about safety, waste, and traumatic historical events such as Chernobyl and Fukushima. However, as comparative studies show, nuclear power has a much lower mortality per TWh produced than fossil sources, and a largely manageable environmental impact in modern technologies.

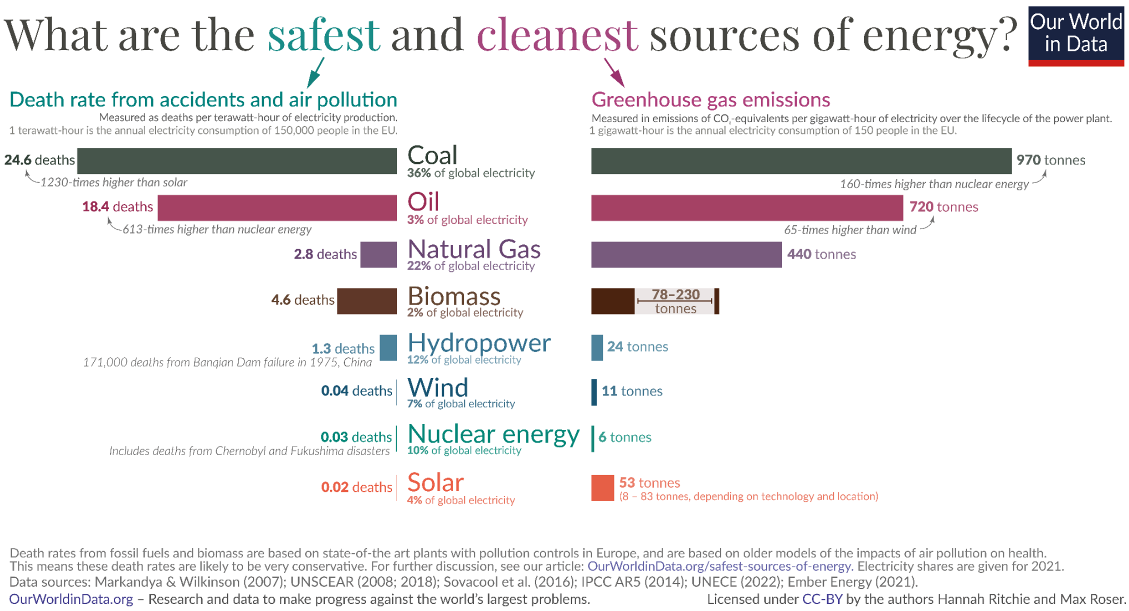

Figure 10 Safest and cleanest sources of energy by Our World in Data.

To change the collective perception, it is essential to engage in an institutional communication campaign based on transparency, data, and comparison. This effort should include the active involvement of local communities in the planning of facilities, accessible and ongoing scientific information on costs, risks and benefits, compensation, offsets, and rebalancing measures for host territories.

Indeed, managing the NIMBY phenomenon, which is historically very present in Italy and already covered in previous chapters, is crucial. Local reluctance to energy facilities, even strategically, is a structural brake on the country's infrastructure development. In this regard, it is useful to look to the French model, which has demonstrated an ability to combine political decision-making and civic involvement.

In France, before constructing a new nuclear plant, the government implements an evident and structured public communication process. It informs the local population with accessible and transparent materials about the plant's technical data, safety, waste management, and the international standards adopted. After that, a phase of direct dialogue is opened with local citizens and institutions, during which comments are collected, doubts are answered, and a reasonable compromise is sought. Only at the end of this process is permission granted, and work begins.

If adapted to Italian reality, such a method could help transform rejection into active and informed participation. Transparency and respect for local communities are not obstacles to development but indispensable tools for building consensus and democratic legitimacy around the country's major energy choices.

In parallel, the issue of financing must be addressed. Nuclear power requires very high initial capital and long payback periods, so it is often considered unattractive by the private market. One possible solution is to create public-private partnerships supported by a specific regulatory framework, public guarantee mechanisms, and European instruments such as the Green Deal or the Connecting Europe Facility.

Regulatory stability and a simplified, single authorisation structure that reduces planning time and avoids slowdowns due to conflicts between local, state and community authorities must also be ensured.

4.2.2. Integrating nuclear power with renewables for a sustainable transition

Therefore, nuclear power's real potential in Italy lies not in replacing renewables, but in their complementarity, as we have discussed in this chapter. While solar and wind are intermittent sources, nuclear offers stable and predictable generation that can compensate for generation gaps and ensure continuity of service.

An effective model should, therefore, include a stable and programmable base of nuclear power, an increasing share of renewable energy, geographical distribution, an advanced, smart, digitised, and interconnected grid system across Europe, and storage and demand management technologies to regulate peaks. This approach would reduce dependence on fossil fuels and improve energy security without having to give up climate goals. In this sense, nuclear power should be seen not as an alternative but as an enabler of the transition.

Conclusions

Throughout this thesis, it has become clear that the growing centrality of the energy issue is not only a technical-industrial matter, but also a political and strategic one. Italy, as highlighted in the first chapter, is characterised by a high dependence on foreign energy sources—an enduring structural weakness that exposes the country to economic and geopolitical vulnerability. The choices made in recent decades have often been late, fragmented, or dictated by emergency logic, and they have failed to strengthen long-term national energy security.

In the second chapter, we examined how global competition for critical raw materials is redefining international power relations. Countries such as China, guided by long-term strategies, have secured control over entire supply chains, while Europe and Italy still struggle to respond in a coherent and operationally effective manner. If not addressed strategically, the energy transition risks merely replacing one form of dependency with another.

The third chapter outlined three potential strategic scenarios for Italy—accelerated decarbonisation, reliance on LNG, and strategic nuclear power—through the application of cross-impact analysis. Among them, the nuclear option emerged as the most promising in terms of ensuring energy security, geopolitical resilience, and climate alignment. It stands out as a stable and low-emission complement to renewable energy, capable of compensating for its intermittency and volatility.

Chapter four delved into the feasibility of nuclear power, considering technical, economic, social, and communicative aspects. The 2025 blackout in Spain served as a warning sign of the risks associated with a grid relying solely on intermittent renewables. Nuclear energy, if managed with foresight and broad social consensus, represents a credible and sustainable solution. However, its reintroduction in Italy requires a clear regulatory framework, strategic site selection, and a supply chain consistent with the European CRMA's goals. Yet to date, no national decision has been made on nuclear waste storage, nor have strategic areas for new plants been identified—issues that demand urgent political responsibility.

More broadly, a recurring tension has emerged throughout this analysis between Europe's regulatory capacity and its ability to act strategically. For too long, Europe has limited itself to being a "regulator" while the United States has led on innovation and China on replication and expansion. This passive posture is no longer sustainable. The EU's future relevance depends on its ability to shift from rule-making to strategic investment and decision-making. As Draghi has argued, only through coordinated action in research, advanced technologies, energy integration, and common defence can Europe regain competitiveness and autonomy.

If this shift does not occur, Europe risks becoming irrelevant in the energy and industrial domains it once dominated. For this reason, Italy's national strategy must not only align with European priorities but actively shape them—by embracing innovation, assuming responsibility for difficult choices such as nuclear power, and contributing to a shared, forward-looking vision of integration. It is now up to both institutions and citizens to decide whether they are willing to support this transition—not only in principle, but in practice.

References

A Piombino sono iniziati i lavori per installare il rigassificatore. (2022, November 10). Il Post. https://www.ilpost.it/2022/11/10/inizio-lavori-rigassificatore-piombino/

A. De Filippo, T. (2025). Minerali e terre rare, Cina e Occidente allo scontro sull'Africa - ItaliaOggi.it. Italiaoggi.it. https://www.italiaoggi.it/economia-e-politica/politica-estera/minerali-e-terre-rare-cina-e-occidente-allo-scontro-sullafrica-ye6y1ti5?refresh_cens

Andreolli, F., Bellisai, F., Bienati, M., Giordano, G., Governatori, M., & Panzeri, D. (2023). Energy Without Russia The Consequences of the Ukraine war and the EU Sanctions on the Energy Sector in Europe COUNTRY REPORT ITALY. https://library.fes.de/pdf-files/bueros/budapest/20542.pdf?utm

Archivio Storico. (n.d.). L'energia dell'acqua La storia e il futuro dell'idroelettrico. Enel. Retrieved May 27, 2025, from https://archiviostorico.enel.com/it/scopri/storia-rinnovabili.html?utm

Atlante Solare e Previsioni Meteo, S. (2024). RSE - Ricerca Sistema Energetico. SunRISE; RSE. https://sunrise.rse-web.it/

Ballocchi, A. (2023, February 3). Smart Grid: Cos'è e Cosa Significa - La Rete Intelligente. Lumi. https://www.lumi4innovation.it/smart-grid-cose-e-come-funziona/

Bank, D. (2023, November 22). Germany pledges 4 billion Euros in Africa's green energy: AfDB President calls for enhanced partnership. African Development Bank Group. https://www.afdb.org/en/news-and-events/press-releases/germany-pledges-4-billion-euros-africas-green-energy-afdb-president-calls-enhanced-partnership-66107?utm_

Barretta, V. (2024, November 15). L'impronta del GNL supera del 33% quella del carbone. Lo studio e l'interrogazione in Commissione UE. Energia Italia. https://www.energiaitalia.news/news/gas/limpronta-del-gnl-supera-del-33-quella-del-carbone-lo-studio-e-linterrogazione-in-commissione-ue/46507/?utm_

Bellini, M. (2024, July 13). Idrogeno verde: all'Italia servono 7,5Mt all'anno, per la decarbonizzazione di industria e trasporti pesanti. ESG360. https://www.esg360.it/esg-world/idrogeno-verde-allitalia-servono-75mt-allanno-per-la-decarbonizzazione-di-industria-e-trasporti-pesanti/?utm_

Bellomo, S. (2023). Metalli strategici, la Cina rafforza il predominio sul litio e sul cobalto. Il Sole 24 ORE. https://doi.org/10/2023/03/AEwUmW3C/images/9229cd68-c1da-11ed-8910-bb75ddcfd55d-fotohome0

Blenkinsop, P. (2025, May 14). EU must set aside over 10 billion euros for key minerals, says agency head. Reuters. https://www.reuters.com/markets/commodities/eu-must-set-aside-over-10-billion-euros-key-minerals-says-agency-head-2025-05-14/

Bortoletto, F. (2025, January 29). Con la Bussola della competitività, la Commissione punta a semplificare le regole per imprese. Eunews. https://www.eunews.it/2025/01/29/bussola-competitivita-vdl-sejourne/

Bottoni, C. (2020, July 2). Eolico offshore e onshore: un'analisi comparata. ESG360. https://www.esg360.it/sustainability-management/eolico-offshore-e-onshore-unanalisi-comparata/?utm

brahim maarad. (2019, August 17). Perché Trump vuole comprare la Groenlandia. Www.agi.it; AGI - Agenzia Italia. https://www.agi.it/estero/news/2019-08-17/trump_groenlandia-6035287/

brando. (2024, January 24). Zimbabwe: la rivoluzione del litio passa sempre per la Cina. Nigrizia. https://www.nigrizia.it/notizia/zimbabwe-la-rivoluzione-del-litio-passa-sempre-per-la-cina

Brunno, A. (2019). UNIVERSITÀ DEGLI STUDI DI CATANIA DIPARTIMENTO DI GIURISPRUDENZA MASTER IN DIRITTO DELL'AMBIENTE E GESTIONE DEL TERRITORIO. https://www.masterdirittoambiente.unict.it/sites/default/files/files/Projects/I-edizione/Brunno_Alessia.pdf

Burger, B. (2025a). Energy-Charts. Energy-Charts.info. https://energy-charts.info/charts/power/chart.htm?l=en&c=FR&interval=year&year=2024

Burger, B. (2025b). Energy-Charts. Energy-Charts.info. https://energy-charts.info/charts/power/chart.htm?l=en&c=DE&interval=year&year=2024

Calabrese, L. (2024, September 30). Why China is seeking greater presence in Africa. ODI: Think Change. https://odi.org/en/insights/why-china-is-seeking-greater-presence-in-africa-the-strategy-behind-its-financial-deals/?utm

Carbone, G., Ragazzi, L., Antil, A., Erforth, B., & Magnani, A. (2024). Rebooting Italy's Africa Policy Making the Mattei Plan Work. https://www.ispionline.it/wp-content/uploads/2025/01/policy-paper-ISPI-rebooting-Italys-africa-policy-2024_compressed.pdf

Carboni, T. (2025, March 10). In Germania l'industria della difesa sta assumendo operai licenziati per la crisi dell'automotive. Forbes Italia. https://forbes.it/2025/03/10/in-germania-industria-difesa-assume-operai-licenziati-crisi-automotive/?utm

Carli, A. (2024, March 16). Migranti, Meloni e von der Leyen da al-Sisi. Siglata l'intesa Ue-Egitto da 7,4 miliardi. La premier: ... Il Sole 24 ORE. https://www.ilsole24ore.com/art/meloni-domani-cairo-vede-al-sisi-e-firma-memorandum-migranti-modello-tunisia-AFdik63C

Chilamphuma, E. (2025, January 8). Spain Unveils New Africa Strategy for 2025-2028. FurtherAfrica. https://furtherafrica.com/2025/01/08/spain-unveils-new-africa-strategy-for-2025-2028/?utm

Clean energy for all Europeans package. (2023). Energy. https://wayback.archive-it.org/12090/20241209144917/https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en

Comunicati stampa consumi elettrici. (2024). Terna: nei primi sei mesi del 2024 le rinnovabili superano per la prima volta la produzione da fonti fossili - Terna spa. Terna.it. https://www.terna.it/it/media/comunicati-stampa/dettaglio/consumi-elettrici-primi-sei-mesi-2024-rinnovabili-superano-produzione-fonti-fossili?utm

Critical Raw Materials Act. (2022). Internal Market, Industry, Entrepreneurship and SMEs. https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en?utm

DA DOVE VIENE LA NOSTRA ENERGIA? (n.d.). https://italyforclimate.org/wp-content/uploads/Da-dove-viene-la-nostra-energia-Italy-for-Climate.pdf

Davey, R. (2023, July 18). AZoNano. AZoNano. https://www.azonano.com/article.aspx?ArticleID=6513&utm

Dematteis, E., & Baricco, M. (2021). LA VIA DELL'IDROGENO: DALLA PRODUZIONE ALL'USO. La Chimica E l'Industria Online, 4. https://doi.org/10.17374/CI.2021.103.4.27

Dominelli, C. (2023, March 19). Rigassificatore Piombino: tutto quello che c'è da sapere, dalla sicurezza al primo gas. Il Sole 24 ORE. https://www.ilsole24ore.com/art/rigassificatore-piombino-tutto-quello-che-c-e-sapere-sicurezza-primo-gas-AEh8wX6C

Dominelli, C. (2025, January 23). Pichetto: "Nucleare, Italia pronta. Testo unico e programma nazionale entro il 2027." Il Sole 24 ORE. https://www.ilsole24ore.com/art/pichetto-nucleare-italia-pronta-testo-unico-e-programma-nazionale-entro-2027-AGwu9NTC?refresh_ce=1

Draghi, M. (2024). The future of European competitiveness.

European Council. (2022). Fit for 55 - the EU's Plan for a Green Transition. Consilium. https://www.consilium.europa.eu/en/policies/fit-for-55/

EY Italy. (2025, March 3). Energia nucleare in Italia: un mercato da 46 miliardi entro il 2050. Ey.com; EY. https://www.ey.com/it_it/newsroom/2025/3/energia-nucleare-in-italia-un-mercato-da-46-miliardi-entro-il-2050

Fabbri, F. (2024, May 16). Uranio, chi ne produce di più al mondo? Energia Italia. https://www.energiaitalia.news/news/nucleare/uranio-chi-ne-produce-di-piu-al-mondo/32206/

Ferrante, F. (2023). Panorama energetico italiano -. Symbola.net. https://symbola.net/approfondimento/panorama-energetico-italiano/

Frilingou, N., Xexakis, G., Koasidis, K., Nikas, A., Campagnolo, L., Delpiazzo, E., Chiodi, A., Gargiulo, M., McWilliams, B., Koutsellis, T., & Doukas, H. (2023). Navigating through an energy crisis: Challenges and progress towards electricity decarbonisation, reliability, and affordability in Italy. Energy Research & Social Science, 96, 102934. https://doi.org/10.1016/j.erss.2022.102934

Gattei, F. (2024, March). We World Energy . Www.eni.com; ENI. https://www.eni.com/static/it-IT/world-energy-magazine/the-race-for-critical-minerals.html. Page 16.

Gestore dei Servizi Energetici. (2024). SOLARE FOTOVOLTAICO RAPPORTO STATISTICO 2023. https://www.gse.it/documenti_site/Documenti%20GSE/Rapporti%20statistici/Solare%20Fotovoltaico%20-%20Rapporto%20Statistico%202023.pdf?utm_

Hool, A., Helbig, C., & Wierink, G. (2023a, September 20). Challenges and opportunities of the European Critical Raw Materials Act. https://link.springer.com/content/pdf/10.1007/s13563-023-00394-y.pdf

Hool, A., Helbig, C., & Wierink, G. (2023b). Challenges and opportunities of the European Critical Raw Materials Act. Mineral Economics, 37(3), 661–668. https://doi.org/10.1007/s13563-023-00394-y

https://www.facebook.com/WorldNuclearNews. (2025). Climate and energy in Trump’s Day One executive orders. World Nuclear News. https://www.world-nuclear-news.org/articles/climate-and-energy-in-trumps-day-one-executive-orders?

IAEA. (n.d.). Development of Advanced Reprocessing Technologies. https://www.iaea.org/sites/default/files/gc/gc52inf-3-att4_en.pdf

Il grande balzo in avanti del prezzo dell’uranio - RSI. (2023, November 24). Rsi; RSI Radiotelevisione svizzera. https://www.rsi.ch/info/mondo/Il-grande-balzo-in-avanti-del-prezzo-dell%E2%80%99uranio--1998145.html

Intesa San Paolo Innovation Center. (2024, June). INDUSTRY TRENDS REPORT ENERGY, ENVIRONMENT & UTILITIES ENERGY STORAGE . https://www.intesasanpaoloinnovationcenter.com/content/dam/digitalhub/documenti/2024%2007%20Energy%20Storage_ITA_abstract.pdf

Italian Delays in TAP's Construction Weaken the EU and Russia Alike. (2016, October 19). Jamestown.org. https://jamestown.org/program/italian-delays-taps-construction-weaken-eu-russia-alike/?utm

Jones, S. (2025, April 30). Minister warns against blaming Spain's blackout on renewable energy. The Guardian; The Guardian. https://www.theguardian.com/world/2025/apr/30/environment-minister-warns-against-blaming-spain-blackout-on-renewable-energy?

Kondash, A. J., Lauer, N. E., & Vengosh, A. (2018). The intensification of the water footprint of hydraulic fracturing. Science Advances, 4(8), eaar5982. https://doi.org/10.1126/sciadv.aar5982

Lelieveld, J., Klingmüller, K., Pozzer, A., Burnett, R. T., Haines, A., & Ramanathan, V. (2019). Effects of fossil fuel and total anthropogenic emission removal on public health and climate. Proceedings of the National Academy of Sciences, 116(15), 7192–7197. pnas. https://doi.org/10.1073/pnas.1819989116

L'idrogeno rinnovabile: quali vantaggi per l'UE? | Tematiche | Parlamento europeo. (2021). Tematiche | Parlamento Europeo. https://www.europarl.europa.eu/topics/it/article/20210512STO04004/idrogeno-rinnovabile-quali-sono-i-vantaggi-per-l-ue?utm

Mesisca, S. (2025, January 8). Anche la Costa d'Avorio chiede il ritiro dei soldati francesi - Aliseo Editoriale. Aliseo Editoriale. https://aliseoeditoriale.it/anche-la-costa-davorio-chiede-il-ritiro-dei-soldati-francesi/

MIMIT, M. delle I. e del M. in I. (2024, October 16). Libro Verde. MIMIT. https://www.mimit.gov.it/it/libro-verde

MIT (Ministero delle Infrastrutture e dei Trasporti), M. (Ministero dell'Ambiente e della S. E. (2024). PIANO NAZIONALE INTEGRATO PER L'ENERGIA E IL CLIMA.

Nadler, C. D. (2024, June 20). Angola: anche l'Italia investe nel Corridoio di Lobito - Africa e Affari. Africa E Affari. https://www.africaeaffari.it/angola-anche-litalia-investe-nel-corridoio-di-lobito/

Neri, A. (2025, February 18). Istituzioni e aziende italiane tracciano la via per il nuovo nucleare sostenibile - Energia Oltre. Energia Oltre. https://energiaoltre.it/istituzioni-e-aziende-italiane-tracciano-la-via-per-il-nuovo-nucleare-sostenibile/

NRC Certifies First U.S. Small Modular Reactor Design. (2023, January 20). Energy.gov. https://www.energy.gov/ne/articles/nrc-certifies-first-us-small-modular-reactor-design

Nuclear Power in Russia - World Nuclear Association. (2025). World-Nuclear.org. https://world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power?utm

Padova, U. di. (2017). Gas Naturale Liquefatto e Rigassificatori: cosa sono e come funzionano | Università di Padova. Unipd.it. https://levicases.unipd.it/gas-naturale-liquefatto-e-rigassificatori-cosa-sono-e-come-funzionano

Pozniak, H. (2025, February 4). "Denmark is showing the world what is possible": how the North Sea became the "green power plant of Europe." The Guardian; The Guardian. https://www.theguardian.com/delivering-the-energy-transition/2025/feb/04/denmark-showing-world-possible-north-sea-green-power-plant-europe?utm

Prontera, A. (2023). Winter is coming: Russian gas, Italy and the post-war European politics of energy security. West European Politics, 47(2), 382–407. https://doi.org/10.1080/01402382.2023.2225987

Raihan, A., Rahman, J., Tanchangtya, T., Ridwan, M., & Islam, S. (2024). An overview of the recent development and prospects of renewable energy in Italy. Renewable and Sustainable Energy. https://doi.org/10.55092/rse20240008

Redazione. (2023, September 20). Eolico off shore flottante, il tesoro italiano dimenticato - Vaielettrico. Vaielettrico. https://www.vaielettrico.it/eolico-off-shore-flottante-il-tesoro-italiano-dimenticato/?utm

Redazione. (2024, April 15). La direttiva europea sulle "case green", spiegata bene. Il Post. https://www.ilpost.it/2024/04/15/direttiva-europea-case-green/

Redazione . (2020, November 25). L'energia geotermica in Italia: dove viene prodotta e come. Enelgreenpower.com; Enel Green Power. https://www.enelgreenpower.com/it/learning-hub/energie-rinnovabili/energia-geotermica/italia?utm

Redazione di Rainews. (2023, April 16). La Germania dice addio al nucleare: chiuse le ultime tre centrali atomiche. RaiNews. https://www.rainews.it/articoli/2023/04/la-germania-dice-addio-al-nucleare-chiuse-le-ultime-tre-centrali-atomiche-50d1c875-d093-41fb-b4e8-2b3a37bca0a2.html

Redazione Sky TG24. (2023, September 21). Draghi in Algeria, primo nostro fornitore di gas: da rinnovabili a grandi opere, 15 intese. Tg24.Sky.it; Sky TG24. https://tg24.sky.it/politica/2022/07/18/draghi-algeria-gas#08

Rifiuti, in Italia 37 termovalorizzatori: ecco dove sono e come funzionano. (2022, April 21). https://www.ilsole24ore.com/art/rifiuti-italia-37-termovalorizzatori-ecco-dove-sono-e-come-funzionano-AEAtnGTB?refresh_ce&nof

Ronchi, E. (2024, December). Il Riciclo in Italia 2024. Fondazione per Lo Sviluppo Sostenibile. https://www.ricicloinitalia.it/wp-content/uploads/2024/12/il-RICICLO-in-ITALIA-2024.pdf

Sadden, E. (2024). Italy pledges $320 million for Africa’s Lobito corridor under G7 infrastructure plan. S&P Global Commodity Insights. https://www.spglobal.com/commodity-insights/en/news-research/latest-news/metals/061424-italy-pledges-320-million-for-africas-lobito-corridor-under-g7-infrastructure-plan?utm

Sebastiano Torrini. (2024, March 26). Finisce (quasi) l’era del carbone in Germania. In Italia il phase out nel 2025 - Energia Oltre. Energia Oltre. https://energiaoltre.it/finisce-quasi-lera-del-carbone-in-germania-in-italia-ill-phase-out-nel-2025/

Sistemi di stoccaggio energetico. (2025). Eni.com. https://www.eni.com/it-IT/azioni/tecnologie-transizione-energetica/energie-rinnovabili/stoccaggio-energetico.html?utm

Small modular reactors (SMR) | IAEA. (2016, April 13). Iaea.org. https://www.iaea.org/topics/small-modular-reactors?ut

Sole, I. (2025, February 4). Usa, Trump sospende dazi a Messico e Canada per un mese. Il Sole 24 ORE. https://stream24.ilsole24ore.com/video/italia/usa-trump-sospende-dazi-messico-e-canada-un-mese/AGsp1UiC

Spina, F. (2017, December 7). Sociologia dei Nimby. I conflitti di localizzazione tra movimenti e istituzioni. Academia.edu. https://www.academia.edu/35366963/Sociologia_dei_Nimby_I_conflitti_di_localizzazione_tra_movimenti_e_istituzioni

Sportello Vaielettrico, & Sportello Vaielettrico. (2025, March 25). Eolico off shore, si sveglia l’Italia: impianti per 2,4 GW dalla Puglia alla Romagna - Vaielettrico. Vaielettrico. https://www.vaielettrico.it/eolico-off-shore-galleggiante-mediterraneo-floating/?utm

Stefano Gandelli. (2022, February). Fracking, è questo il futuro dei combustibili fossili? Geopop. https://www.geopop.it/fracking-cose-a-cosa-serve-conseguenze-e-rischi-per-l-ambiente/

Stefano, D. D. (2021, November 2). “Termovalorizzatori sempre meno inquinanti, ma occhio agli aspetti sociali.” Economiacircolare.com. https://economiacircolare.com/termovalorizzatori-inceneritori-inquinamento-emissioni-efficienza-sostenibilita-sociale/?utm

TAP reveals volume of gas supply to Italy in Q1 2025. (2025, April). Trend.Az. https://en.trend.az/business/energy/4024219.html

Tenev, M. (2025, May 7). MAGA goes global: Trump's plan for Europe. ECFR; European Council on Foreign Relations (ECFR). https://ecfr.eu/publication/maga-goes-global-trumps-plan-for-europe/

TERNA S.P.A. (2024). Produzione Nazionale Italiana 2023 . https://download.terna.it/terna/05_PRODUZIONE_8dd07bd5bba8a9e.pdf

Terna: nel 2024 consumi elettrici in aumento del 2,2% - Terna spa. (2024). Terna.it. https://www.terna.it/it/media/comunicati-stampa/dettaglio/consumi-elettrici-2024

Tutti i vantaggi del repowering. (2024, December 16). Enel.com. https://www.enel.com/it/azienda/storie/articles/2024/12/vantaggi-repowering-centrali-idroelettriche?utm

Uranio: geopolitica di un revival obbligato | ISPI. (2024, July 25). ISPI. https://www.ispionline.it/it/pubblicazione/uranio-geopolitica-di-un-revival-obbligato-180788

Uranium enrichment: by country, by company, by facility? (2024, December 5). Thunder Said Energy. https://thundersaidenergy.com/downloads/uranium-enrichment-by-country-by-company-by-facility/?utm

Vincent, E., & Roger, B. (2024, November 30). French army's forced retreat from Africa continues. Le Monde.fr; Le Monde. https://www.lemonde.fr/en/international/article/2024/11/30/french-army-s-forced-retreat-from-africa-continues_6734677_4.html?utm

Weiwei, G. (2025). EconoScope | China's nuclear power development gaining momentum. Ecns.cn. https://www.ecns.cn/cns-wire/2025-02-27/detail-ihepcskv6108813.shtml?utm

World Nuclear Association. (2020, December 18). Processing of Used Nuclear Fuel - World Nuclear Association. World-Nuclear.org. https://world-nuclear.org/information-library/nuclear-fuel-cycle/fuel-recycling/processing-of-used-nuclear-fuel

Acknowledgements

I would like to thank my supervisor Dr. Manfredi Valeriani, for his valuable advice and helpfulness. Thanks for providing key insights in the writing of this paper and for directing me in moments of indecision.

After that, I want to thank all the people who supported me during my university and thesis writing journey, which you just read.