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Course of Economics and Management of Energy Businesses

ENERGY COMMUNITIES: ANALYSIS OF THE ECONOMIC BENEFITS ON MEMBERS AND ROLE OF ELECTRIC UTILITIES AS FACILITATORS

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Introduction

In a global scenario, whose equilibriums are currently damaged and harmed by the **energy crisis**, therefore by the **scarcity of primary energy sources** and by the consequent uncontrollable **price increase**, the main and most impactful solution that has been identified consists in fostering the **energy transition** throughout all countries worldwide.

Through the energy transition it will be possible to decrease or even abandon the employment of fossil fuels in favor of alternative energy sources, namely renewables.
These sources present several advantages, for instance, they can be freely exploited by every country without the need to import them. Then, differently from fuels, they are also unlimited for the most part, and they do not emit CO_2, therefore they positively impact on the environment.
The diffusion of renewable energy sources can consequently **end numerous dependency relations** among countries, and, on a smaller scale, it can also lead to a **greater autonomy and empowerment** of single individuals within the same country. These sources, in fact, also enable single users to self-produce electricity and, so, to progressively purchase less from the energy and electricity markets.

In this framework, it is important to analyze the growing commitment of the European Union towards the achievement of the transition and the switch to RES. Particularly, an important instrument to foster the process consists in the establishment of **renewable energy communities (RECs)** throughout all Member States. They are organizations of individuals and other subjects aimed at self-generating and self-consuming the electricity coming from renewable sources. The main objective of these projects consists in providing economic, social and environmental benefits to their members, and in generating positive externalities.

The objectives of the study are principally two, and they consist in verifying if RECs can actually lead to an improvement of the economic conditions of the participants, and in analyzing the role of electric utilities as facilitators, for what concerns the establishment and management of the projects.

The **first chapter** is centered on the history and on the progressive evolution of the electricity industry and market, in order to provide a general background and to underline the criticalities and the consequent progressive switch towards new energy sources.
Then, the **second chapter** is centered on the study of RECs; it provides the legislative and regulatory framework that, up until now, has defined their structure, functioning and purposes. Moreover, in the chapter is also analyzed the degree of advancement of the projects considering the different Member States, with a particular focus on the Italian case.

Following, in the **third chapter** is conducted the analysis of the economic benefits that RECs may be able to generate. To properly do that, three different models, identified by the recent study «**Community Energy Map**» were considered, namely: the pluralist model, the community energy builders model (CEB) and the public lead model.

Finally, the **fourth chapter** provides an in-depth analysis of the CEB model, considering that it is the one that foresees the active and significant participation of electric utilities. Therefore, the objective of the chapter consists in identifying the advantages that RECs would be able to obtain if allowing a greater contribution of electricity companies in the establishment and management of the projects. The chapter also includes the analysis of a case study: the renewable energy community of Solisca that has been funded by a municipality in Lombardy with the contribution of Sorgenia.

Chapter 1: history and structure of the electricity industry and analysis of the functioning of its market

1.1 History of the electricity industry over time with a focus on the Italian case

It is possible to begin to talk about the electricity sector and its history starting from the 18th and 19th Centuries when key experiments and studies led to the achievement of revolutionary discoveries that drastically changed the previous functioning and equilibriums of the power system[1], leading to its enlargement and to a greater efficiency, fairness and sustainability.

The probably first most relevant experiment related to electricity can be attributed to Benjamin Franklin who demonstrated the electrical nature of lightening in 1757. Then, the British chemist and physicist Michael Faraday identified the principles of the electrolysis and of the electromagnetic induction and, thanks to its discoveries, he set the ground for both the mechanical generation of electric current and for its usage in electric motors. Other two relevant personalities that contributed to the field were the American inventor and businessman Thomas Edison and the Serbian American physicist end chemist Nikola Tesla who respectively developed the **Direct Current system (DC)** and the **Alternating Current system (AC)**.

The first system is a linear electrical current, meaning that electricity moves in a straight line. DC is more constant for what concerns voltage delivery. The following AC system consists, on the other hand, in a flow of current that can periodically change its direction (from positive to negative and vice versa). Differently from DC, AC can go through long distances, to be converted to higher or lower voltages and it is also easier and cheaper to produce due to the nature of the generators.

The competition between these two mechanisms led to the so-called **War of Currents**[2] that began in the late 1880s and that ended in 1893 when the Chicago World's Fair was electrified using AC by George Westinghouse, who was licensed to use Tesla's system.

However, both mechanisms are still widely employed but for different purposes: AC is the most used thanks to its high flexibility and efficiency, it allows to deliver large volumes of electricity and it is for instance used to power buildings. While DC is principally used to bring electricity to most of the electronic devises.

Therefore, some of the most significant discoveries were made during these two Centuries, but the real growth and the greatest development has begun in the 20th Century, when it was clear that electricity would have become the most relevant and needed power source for both households and

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[1] Source: Sonal, P. and Larson A. (2017, 2022). https://www.powermag.com/history-of-power-the-evolution-of-the-electric-generation-industry/

[2] Source: IOP. Institute of Physics (online). https://spark.iop.org/war-currents

business activities. Consequently, many countries started to largely invest in the industry leading to the structuring and definition of its value chain, particularly for what concerns the activities of generation, transmission and distribution.

The **integration of the electricity industry and market at national level** represented a crucial challenge for basically every country since it required the implementation of major changes and the availability of significant funds for the purchase of the needed technologies, for the production and delivery of the commodity, for the building of power plants, for the development of the most efficient practices and for the training of workers. Anyhow companies and countries have managed to increase their efficiency over time, for example by exploiting **economies of scale**. Moreover, generators progressively became able to purchase primary sources at lower prices and to increase the speed of production and the consequent amount of electricity to supply.

Consumers benefited from these developments as well, since the electricity prices started to progressively decrease concurrently with the raise of supply. The downside of this situation was that, at some point, the **demand of end-user overcame the supply**, meaning that producers were not able to meet the requests of consumers and to guarantee the security of the service. The industry began to require more power plants with larger and/or higher installed capacities and more capillary transmission systems to deliver electricity to every area of the country. This necessity represented an important driver for the switch from the Direct to the Alternating Current power systems, which can easier adapt to voltage changes. The management and the solution of these issues represented important challenges for many countries in the world, among which European ones.

In fact, despite the growing demand, not all the national ground was covered by the grids, resulting in important gaps among areas in the same country that needed to be quickly covered considering the indispensable nature of this source of power. The most feasible solution for countries to ensure equal access to electricity to the entire population was the **nationalization**[3] of the sector. In fact, in a condition of full competition, therefore with plenty of companies operating in multiple segments and in multiple areas, it would not have been possible to reach the target as effectively and as quickly. Without nationalization it was not possible for countries to edit a proper regulation of the industry that could have ensured its fair and transparent functioning.

Before focusing on the nationalization and on the consequent liberalization of the industry, it is convenient to briefly clarify the structure of the **electricity value chain**, that has also experienced significant changes throughout time. The value chain was initially structured into three sectors,

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[3] Source: Erdmann, G. (2007). https://www.iaee.org/en/publications/proceedingsabstractpdf.aspx?id=209

namely: generation, transmission and distribution. **Generation** consists in the purchase of primary sources, in the production of electricity, in the building and maintenance of power plants and in the injection of the commodity in the national grid. Then, **transmission** is the activity of delivering the electricity generated in all the areas of the country and of ensuring a continuous balance between demand and supply. Finally, the **distribution** segment has the responsibility to bring electricity directly to final consumers, both households and business activities.

During the years of nationalization, all these activities have been operating as monopolies, while, once the liberalization process began, the generation activity was opened to competition and two more segments were added to the value chain, namely: **trading** and **retail**. Both operated and still operate under a regime of full competition.

As previously anticipated, the nationalization process began in the early 1900s and it involved numerous countries in the world. The process was initiated after the massive electricity demand increase, with the main purpose to ensure the **security of supply**, therefore, to solve the complications related to the management of electricity that, at that time, was not properly regulated and that was characterized by the presence of too many operators that could not ensure neither the efficiency required by the system nor the equilibrium between demand and supply. Moreover, through nationalization, countries aimed at building the needed infrastructures, mainly power plants and grids and at providing the highest possible coverage on the national territory.
Particularly, the building of national grids represented a fundamental step to stabilize and to structure the sector, since these infrastructures are the only possible way to effectively connect all the area of a country to the electric system. Grids can be distinguished into two types: there is the **national grid** that transmits high-voltage electricity throughout the country and that is connected to generators, and then there are **local grids** that bring medium to low-voltage electricity directly to end-users. While the first grid operates in the transmission sector, the latter belongs to the distribution one.

The **drivers** of the nationalization process were mainly shared by all the countries involved and they consisted in the **high fragmentation**, **inefficiency**, **lack of regulation** and **complexity** of the electricity sector, whose immediate consequence was the inability to guarantee full and consistent access to the commodity to the entire population. In fact, as previously said, all the countries were affected by significant territorial gaps, meaning that the countryside area was often less or not connected to the grid differently from the cities. Moreover, due to fragmentation, the industry was characterized by the presence of too many operators that led to a lack of coordination and cooperation. In that environment it was not feasible to make the major changes that were needed, consequently nationalization represented the only possible path. The immediate consequence of the process was the **full vertical integration** of the entire electricity value chain and the introduction of a **monopoly regime**.

The process enabled countries to make many fundamental achievements such as:

- the increase and the **stabilization of the production** thanks to the building of new power plants;
- the elaboration and issuing of a proper **regulatory system**;
- the **full electrification of the national territory** through the expansion of the grid that led to a greater availability of electricity and to a price decrease.

1.1.1 The nationalization process in the world and in some European countries

Countries began the nationalization with different timing and in compliance to their specific needs, anyhow, the process can be principally located between 1930s and 1960s.

For instance, the Tennessee Valley Authority[4] was established in **US** by the Congress in 1933 as part of President Franklin D. Roosevelt's New Deal. It is a federally owned electric utility corporation that was funded for multiple purposes among which the ensuring of electricity in the area of Tennessee River. The company has built dams and numerous hydroelectric power stations to provide electricity to seven States, namely Tennessee, Alabama, Georgia, Virginia, Kentucky, Mississippi and North Carolina. The activity of power generation of TVA was extremely controversial and obstructed by private companies. However, TVA has managed to purchase all the generation activities operating in the area and became its only electricity supplier.

Then, for what concerns **Latin America**, the Mexican electricity sector[5] is an interesting case; it was fully nationalized in 1960 by Adolfo Lopez Mateos and put under the management of the Comision Federal de Electricidad (CFE)[6], a publicly owned company founded in 1934. Starting from 1940s, the CFE progressively acquired regional concessions throughout the Country until the sector was fully put under its control. Consequently, the State became the only entity allowed to operate in all the three areas of the value chain (generation, transmission and distribution). The nationalization allowed a considerable growth of supply in the following decade, moreover the government

[4] Source: Kitchens, C. (2014). https://www.cambridge.org/core/journals/journal-of-economic-history/article/abs/role-of-publicly-provided-electricity-in-economic-development-the-experience-of-the-tennessee-valley-authority-19291955/D9FD6E9C88DA66569EC1D606313DA34A
[5] Source: Bonetto, C. and Storry, M. (2010). https://www.powermag.com/power-in-mexico-a-brief-history-of-mexicos-power-sector/
[6] Source: Rodriguez Padilla, V. (2016). https://www.scielo.org.mx/scielo.php?pid=S0301-70362016000200033&script=sci_arttext&tlng=en

introduced subsidies on the price of electricity for consumers since it was considered as a primary necessity that should be guaranteed to everyone.

Then, in Europe, the cases of United Kingdom, France and Italy are particularly relevant. The nationalization in **UK** happened after the issue of the Electricity Act in 1947 that created the British Electricity Authority (BEA)[7] with the responsibility to own, to regulate and to manage the value chain in its entirety. In **France**[8] the process began in April 1946 with the primary objective to facilitate and accelerate the recovery of the Country from the damages caused by WWII. The electricity sector played a central role in this framework, since one of the first and main steps of the reconstruction was the creation of a stable and capillary electricity network that would have enabled the recovery and the growth of the industrial sector. So, the government established the Electricité de France (EDF), a nationally owned company that exerted full control over all the steps of the electricity system.

1.1.2 The liberalization process in the world and in European Union

After some decades the opposite process of **liberalization** began at global level, therefore many counties started to open some activities of the industry to competition.
This process was primarily driven by growing necessities related to both electricity demand and supply.
On the **demand side** there was the need to purchase electricity at a lower price and to have the assurance to dispose of the needed amount, while on the **supply side** single national electricity companies were progressively less and less able to meet the demand that, particularly after reaching the full electrification, experienced a fast and exponential growth.
Then, another important reason behind the privatization of the sector was the necessity to foster **national economic growths**. In fact, during 1900s many countries in the world, particularly developed ones, progressively focused more and more on industrial activities, consequently the need for electricity by businesses was extremely high and it soon became a primary necessity to operate, to grow and to be profitable. Therefore, there was a strict link between the sure availability of electricity and the economic growth of a country.
Finally, the liberalization was also implemented to **limit the State intervention** in the economic field to reestablish the appropriate boundaries between public and private and to detach the economic sphere from the political and governmental jurisdictions.

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[7] Source: Coase, R. H. (1950). https://www.jstor.org/stable/3159326
[8] Source: BNP Paribas (2023). https://histoire.bnpparibas/en/bnp-paribas-and-the-electricity-industry-1881-1950/

Competition allowed to significantly **increase the total supply** while providing **multiple pricing options** that enable consumers to reduce their electricity expenditures. Besides, it fostered the economic growth of many counties both directly in the electricity sector by drastically lowering the entry barriers, and also of many other businesses whose profits were strictly related to the availability of electricity.

The liberalization took place together with the **unbundling** of the value chain that consists in the disjunction of the different activities, in the injection of competition where possible and in the preservation of monopoly where strictly necessary[9]. Initially, the unbundling created doubts surrounding the management of transmission and distribution: these two are, in fact, activities of extreme responsibility since the former must ensure the continuous balance between demand and supply and the latter must provide the right amount of electricity to every consumer in the country. Competition in these segments did not seem the most efficient option because the presence of too many companies can lead to inefficiencies and mistakes, both of which cannot be accepted.

Chile was the "pioneer" of the liberalization with the issue of the **Electricity Act in 1982**[10]. The Country opened the electricity sector to private companies and allowed the creation of a wholesale electricity market in which power generation companies and market operators were able to freely negotiate energy supply contracts. The reform was done in compliance with what written in the Chilean Constitution regarding the importance of limiting the actions of the State in the economic sphere.

United Kingdom was the first country in Europe to liberalize the sector; also in this case the process began with the issue of the Electricity Act in 1989 and it was concluded in 1999 after the injection of full competition in the retail segment. The Electricity Act enabled the re-organization of the industry and its progressive privatization. The immediate consequence was the huge increase of generating companies, from small and independent firms to big multinational corporations[11]. The management of the transmission activity was regionally divided among four companies:

- National Grid Electricity Transmission plc (NGET).
- Scottish Power Transmission Ltd.
- Scottish Hydro Electric Transmission.
- Northern Ireland Electricity Ltd.

[9] Source: EnciclopediaTreccani https://www.treccani.it/enciclopedia/unbundling_%28Dizionario-di-Economia-e-Finanza%29/

[10] Source: Serra, P. (2022). https://www.sciencedirect.com/science/article/pii/S2211467X21001814

[11] Source: Massie, K. and England, J. (2021). https://uk.practicallaw.thomsonreuters.com/w-029-0803?transitionType=Default&contextData=(sc.Default)

Then, 14 licensed distribution network operators (DNOs) were created; each of them had the responsibility to deliver electricity to the consumers of a given and pre-established region. Lastly, as previously anticipated, the retail market was fully opened to competition in 1999, meaning that all end-users, regardless the amount of electricity consumed, were enabled to freely choose their electricity suppliers.

UK one was a particular case since the majority of Member States began the liberalization process from 1996, after the issue of three **European Directives** aimed at regulating the electricity industry and at creating a uniform and internal market.
These Directives were part of three energy packages and they were respectively released in 1996, 2003 and 2007. The EU issued them to progressively push Member States to open some segments of the electricity sector to competition and to effectively regulate those in which monopoly was the only possible choice. Alongside with competition, the objective of these Directives was to create an **interconnected and competitive internal market** in which all Member States could have the possibility to freely exchange electricity at a fair and competitive price. The need for a common market derived from the necessity to constantly guarantee the security of supply, given that electricity was progressively becoming the most used energy sources and the less replaceable. The European Union was in fact positive about the benefits that creating a competitive market could produce, namely: flexibility, innovation, production efficiency, price decrease for both industrial and residential consumers, security of supply and economic growth[12].

The provisions established by these three Directives were mainly centered on four areas: generation capacity, unbundling, retail and network access.

Firstly, the **generation capacity** needed to be increased following the growing electricity demand. The Directives aimed at properly regulating this area to facilitate new entrants in the building of power plants without the risk of being obstructed by incumbents. The **first Directive (1996/92/EC)** provided two possible ways, either by receiving an authorization by the State in compliance with national law or by tender following non-discriminatory criteria. However, the **second Directive (2003/54/EC)** abolished the tender and made the authorization the rule.

Then, it was required the **accounting unbundling**[13] of vertically integrated companies, meaning that it was no longer possible for a single company to operate at the same time in both competitive and monopolistic segments. Therefore, in order to be allowed to continue operating, they had to split their

[12] Source: Jakovac, P. (2012). https://hrcak.srce.hr/file/124667
[13] Source: European University Institute and Florence School of Regulation (2020). https://fsr.eui.eu/unbundling-in-the-european-electricity-and-gas-sectors/

activities by creating multiple firms independent from an accounting point of view. The purpose was to increase the degree of **transparency** in market operations and to avoid discriminatory behaviors. In this way entrance barriers were expected to lower because of the power reduction of incumbents that were no longer able to significantly influence the entire value chain. Therefore, new entrants were more safeguarded and had higher possibilities to operate and to grow in the market.

The unbundling was particularly controversial for what concerns the transmission and distribution activities.

The first Directive set the duty to create two independent authorities, namely **Transmission System Operators (TSOs)** and **Distribution Service Operators (DSOs)**, with the responsibility to regulate the network and to ensure the continuous balance of demand and supply. The issue was that the Directive did not require the **ownership unbundling**, consequently there was the risk that TSOs and DSOs were owned by a company operating in the electricity sector and consequently that these entities could have allowed market dominance and discrimination in terms of access to the grid. Following numerous doubts and critics, the second Directive added the obligation to pursue the **legal unbundling** that still was not enough because the ownership issue still existed. Finally, the **third Directive (2009/72/EC)** provided three possible options to solve the problem and to make sure that operators in the transmission and distribution sectors were independent from the rest of the market, namely: the **full ownership unbundling**, the **independent system operators (ISOs)** or the **independent transmission operators (ITOs)**. The first one corresponds to the higher possible degree of unbundling while the last has the lowest one.

The first solution implies the creation of fully separate companies, in which TSOs and DSOs can independently operate with the obligation of not being owned by any firm operating in the areas regulated by competition.

Then, the second option, consists of the creation of ISOs that have the responsibility to autonomously manage the network and that are not controlled by vertically integrated firms but yet are owned by them. ISOs are appointed by the relevant EU Member State and approved by the European Commission.

Lastly, there is the model of ITOs in which the operators are still part of vertically integrated firms that are consequently obliged to comply with a set of rules to guarantee the independence of the activities of production and supply[14].

The first option is the preferred and most adopted one, since it ensures a higher degree of reliability; it is, for instance, the system used in Italy.

[14] Source: RGI. Renewables Grid Initiative (2015). https://renewables-grid.eu/fileadmin/user_upload/Files_RGI/RGI_Publications/Factsheets/RGI_Factsheet_TSO.pdf

The theme of **network access** is strictly connected to the unbundling since TSOs and DSOs have the responsibility to guarantee a non-discriminatory and transparent functioning of the transmission and distribution systems. It was fundamental the independence of system operators from companies belonging to generation and supply areas to avoid that incumbents had the possibility to execute predatory behaviors and obstructions to new entrants.

Lastly, the first Directive has introduced the **retail** segment and then, the following two Directives have progressively perfectioned its structure and increased its degree of liberalization. With the creation of this activity, the EU Commission provided the possibility for end-users to **freely choose** the wanted electricity generators and suppliers. Initially only consumers with an electricity demand of over 40GWh were allowed to enter the market, then the threshold was progressively lowered allowing more and more consumers to purchase electricity without constraints.

While to the first Directive it was mainly attributed the credit for setting the roots for the opening of the industry, the second and third Directives progressively improved its functioning and regulation and complied with critics, issues and uncertainties that arose in the meanwhile.

Initially, there were some resistances among European countries towards the acceptance of the first Directive in the national legislation, and more in general, with the implementation of liberalization practices; particularly, this was the case of France. The Country, in fact, did not want to open and to privatize its electricity sector since it was positive that liberalization would have necessarily led to the prioritization of private and economic interests, profit maximization for instance, over social ones. Therefore, since France strongly believed in the necessity to ensure and to provide the commodity to everyone equally, it was initially against the injection of competition. However, the Country progressively changed its beliefs by becoming aware of the many advantages deriving from an open and competitive supranational electricity market.

1.1.3 The Italian case: from nationalization to liberalization

The Italian nationalization process started in the early 1960s following the lead of the aforementioned European countries. The process took place propaedeutically to the begin of the electrification of the Country. More specifically, it initiated in December 6th 1962, when the Italian Parliament approved the law for the establishment of **Ente Nazionale per l'Energia Elettrica (Enel)**. The main goal, that this new state-owned company had to accomplish, was the full electrification of the Country. It was an extremely complex and expensive process that required ten years to be fulfilled. The reasons behind were, similarly to the other countries, firstly related to the urgency to provide electricity to the many households and business activities that, still in 1962, were not reached by the grid; and then there were the needs to ensure stability and security of supply everywhere in Italy and to close the gaps between North and South[15].

Before 1962, the Italian electricity sector was extremely fragmented and locally managed by numerous private and public companies that were not able to reach all the areas of the Country. There were, in fact, very deep and significant geographical gaps both between North and South and between urban and rural areas; in both cases the latter were not provided with the adequate amount of electricity or, in the most extreme cases, did not have electricity at all. As a matter of fact, out of around 50mln of inhabitants, only a quarter of them was a client of the many electricity companies. The North of Italy was the most developed one and around **68.3%** of the people had access to electricity, then there was the Center with about **17.3%** of clients and lastly there were the South and the island with the lowest share of electricity: only the **14.4%** of the population was a client of the existing electric companies.

Therefore, the electrification process became indispensable to foster an equal growth of the Country; however, it required a degree of coordination and cooperation that was impossible to reach considering the large number of existing operators; so, the establishment of a single and public entity was needed. For this reason, Enel was founded, leading to the nationalization of the electricity sector that lasted almost until the end of the 20th Century.

Moreover, the electrification was also needed to foster the economic growth of the Country. During the early 1960s Italy was in fact experiencing an **economic boom** thanks to the significant improvements of the industrial sector and, in the same period, it was also ranked ninth among all European countries for what concerns the per capita electricity consumption.

Initially the establishment of a monopoly represented an effective solution to increase the supply and to provide higher security, however the growing demand became impossible to meet by a single company, leading to a progressively greater mismatch between production and consumes. Therefore, this issue represented one of the reasons behind the consequent switch to liberalization practices at the end of 1900s.

Since 1962, Enel started to electrify the Country by building new and more advanced power plants; in ten years and with an investment of around 4.500bln lire, the company managed to **double the production capacity** obtained from the previous companies.

Moreover, Enel started the building of the first national high voltage grid whose purpose was to enable long-distance energy transport. The project began with the construction of a 380 kV bridge between the high-voltage systems of Florence and of Rome in 1968, through which it was possible to create,

[15] Source: Enel Energia (2022). https://www.enel.com/company/stories/articles/2022/05/60-years-access-electricity

for the first time, a connection between the central-northern part of Italy and the southern one. Additionally, Enel built submarine cable connections between the electricity grid of the mainland and the ones located in the islands[16], which were finally provided with stable and enough electricity to satisfy their primary needs and to foster the tourism-related activities.

Prior the electrification process, **islands** were disconnected from the rest of Italy and therefore, they were autonomously organized for what concerned electricity production. They had in fact their own power plants of various capacities depending on the size and specific necessities.
After being finally connected to the mainland, the plants in smaller islands, such as Elba, were fully replaced by the cable connection, while they were kept for bigger islands. This is in fact the case of Sardinia, which was already equipped with many thermal and hydroelectrical plants and, when it was connected to the national grid through Corsica in 1967, the island decided to maintain the plants because in this way it would have been able to partially continue with self-production and, at the same time, to rely on the national grid in case of shortages.
Therefore, big island had also the opportunity to export the electricity produced whenever there was a surplus, allowing the possibility to either make profits or to solve issues of overload. Anyhow not all the islands are connected to the national grid mainly due to their distance from the peninsula; there electricity is only provided by small power plants that daily receive oil from tankers. Some examples are Eolie, Egadi, Pelagie, Pantelleria. However, these islands, following the European directions in term of environmental sustainability, are progressively switching from fossil fuels to renewable sources, mainly sun that is largely available[17].

In around ten years, at the begin of 1970s, Enel accomplished the electrification of the Country, reaching **99% of the territory**. Moreover, the company was able to double its clients: from around 13 to almost 26mln.
This project represented a real challenge for Italy since it required drastic changes in the structure of the electricity sector. However, as previously explained, this initiative was much needed since the electrification of the Country would not have been possible without the nationalization.
Moreover, the electrification was an extremely expensive project that required huge investments both in terms of capital and of time. This process implied the purchase of the newest technologies and machines available at that time and the building of many power plants.
Moreover, prior the nationalization the main energy sources used in Italy were **hydroelectrical** and **geothermal**; but after 1962 the Italian electricity sector started to rely on additional and more

[16] Source: Terna Driving Energy (2023). https://www.terna.it/en/electric-system/grid/national-electricity-transmission-grid-development-plan
[17] Source: Enel Energia (2022). https://www.enel.com/company/stories/articles/2022/05/60-years-access-electricity

powerful sources, like **nuclear** and **fossil fuels**. However, fuels, particularly natural gas and oil, are not available in Italy and are also scarce in Europe, therefore, Italy was obliged to drastically increase their import from other countries. This process progressively became more and more consistent over time and contributed to the increase of **dependency of the Country towards foreign suppliers**, which has led to numerous issues and conflicts.
For instance, there were the two **oil shocks** during 1970s that hit the global market firstly in 1973 and then in 1979; they were responsible for a drastic and unexpected shortage of oil and consequently for an enormous price increase that produced heavy market imbalances and geopolitical issues.
Another more recent problem of dependency is related to the **Russo-Ukrainian War** that has led to the cut of the contractual agreements between Europe and Russia for the purchase of natural gas. This measure was taken by the EU Commission and by the Member States in support of Ukraine, however it generated many complications due to the unexpected scarcity of natural gas and to a consequent exponential increase in the electricity prices for end-users.

Then, from 1999, Italy decided to open the electricity industry to liberalization practices. The process began three years after the issue of the first European Directive (1996/92/EU) on the internal electricity market and after the emission of the **legislative decree n. 79 of 1999**; also named **decreto Bersani**. With this decree the Italian State implemented at national level the European Directive and its objectives and rules.
As previously said, the most important implication of it was the opening of some segments of the electricity market to other operators and therefore the abolishment of monopoly and the begin of a regime centered on competition in the areas of generation, trading and retail.
While, as it was stated by the Directives, the areas of transmission and distribution continued functioning as natural monopolies and were strictly regulated by TSOs and DSOs, therefore in compliance with the **full ownership unbundling model**.

1.1.4 The liberalization of Enel and the founding of Enel Group

The Italian liberalization process has significantly impacted on the functioning and the structure of Enel, leading to a transformation from state-owned entity operating as a monopoly to **integrated multinational company** operating in a competitive and international market.
In 1992 Enel was initially converted into a **listed company**, whose sole stakeholder was still the Italian Treasury. Then, in 1999 the real transformation took place since the company was **privatized** in compliance with the legislative decree n. 79.

This measure implied the **diversification of the business activities** and the **creation of different companies** for each segment of the value chain due to the unbundling requirements.
The decreto Bersani, with the introduction of rules for the privatization of the electric industry and for the creation of a competitive market, set a maximum threshold to the volume of electricity that a single company is allowed to produce, that corresponds to **maximum 50%** of the market share. The purpose was to foster competition and to impede the exertion of market power.
So, the same year, the different activities of the company were differentiated into:

- **Enel Produzione**, for the generation activity;
- **Enel Distribuzione**, for the distribution;
- **Terna**, for the electricity transmission and to which Enel sold the entire stake in 2005[18].

Again in 1999, Enel S.p.A. was listed on the stock market selling around **a third of its shares** to over three million Italian and foreign investors.

The liberalization enabled the company to start its business operations in the international market. In fact, in 1993 Enel entered the **E7 Group**, composed by the most powerful and influential electricity companies in the world and whose primary object consisted in the development of common strategies for the global reinforcement and development of the industry.
Moreover, the E7 Group was immediately involved and active in sustainable projects and in many investments in renewable energy sources.
From that time on, Enel quickly began to operate in numerous countries, particularly in North and South America. In the latter the company also founded **Enel Américas** in the early 2000s.

More recently, in 2015, ARERA[19]issued the **deliberation 296/2015/R/COM**[20] to set additional **functional unbundling** and "**debranding**" requirements between the activities of generation and distribution of electricity. The "debranding" implies that the two activities cannot use the same brand anymore, instead they must operate under different companies and use different communication channels.
These rules must be applied to all operators in both the free and protected markets. Consequently, when the same company pursues activities in the two markets, it must provide **Conti Annuali Separati (CAS)**.

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[18] Source: Enel Energia (2022). https://www.enel.com/company/stories/articles/2022/09/new-international-dimension
[19] ARERA. Autorità di Regolazione per Energia, Reti e Ambienti is a regulatory authority independent from the electricity market and from the Italian government. Its purpose is to foster the development of competitive markets in the electricity, natural gas and drinking water industries. It was founded in 1995.
[20] Source: ARERA. Autorità di Regolazione per Energia, Reti e Ambienti (2015). https://www.arera.it/it/com_stampa/15/150703.htm

The unbundling of the multiple activities of Enel Group led to the establishment of three different companies, each of them operating in a specific segment of the electricity market, namely:

- **e-distribuzione** is the company belonging to the Group that operates in the distribution area and it is the most important in the sector.
- **Enel Energia** that operates in the retail of electricity and gas in the **free market**; this company provides electricity and gas to end-users at a price autonomously set in compliance with the market trends of the moment. Therefore, Enel Energia clients have freely chosen to purchase electricity from the company after making a comparison among the prices of the numerous companies operating in the open market.
- **Servizio Elettrico Nazionale** still operates in the retail area but, differently from Enel Energia, this company sells electricity to smaller clients; specifically, the ones that still belong to the **protected market** (Maggior Tutela) and whose electricity prices are still set by ARERA.

Enel can be considered a successful case of unbundling since, through the division of the activities, the company was firstly able to guarantee a higher degree of transparency, clarity and efficiency; but it also managed to foster competition both inside and outside the Group.

1.2 The different types of energy market

As already anticipated in the first paragraph, the liberalization process was the main contributor to the evolution and the enlargement of the electricity value chain of many countries worldwide. Two new activities were, in fact, introduced in the business process, namely **trading** and **retail**; they enabled the creation of a competitive market in which the operators involved were able to exchange electricity freely and efficiently and at a competitive price.

In this paragraph a deeper analysis of each step of the value chain will be conducted to better address its evolution and its most significant changes. After that, there will be a focus on the trading activity, therefore on the wholesale electricity market and on the multiple timeframes during which it operates.

Figure 1 is the representation of the five consequent activities foreseen by the electricity value chain after the liberalization[21].

[21] Source: Gruppo Hera (online). https://eng.gruppohera.it/group_eng/business-activities/energy/electricity

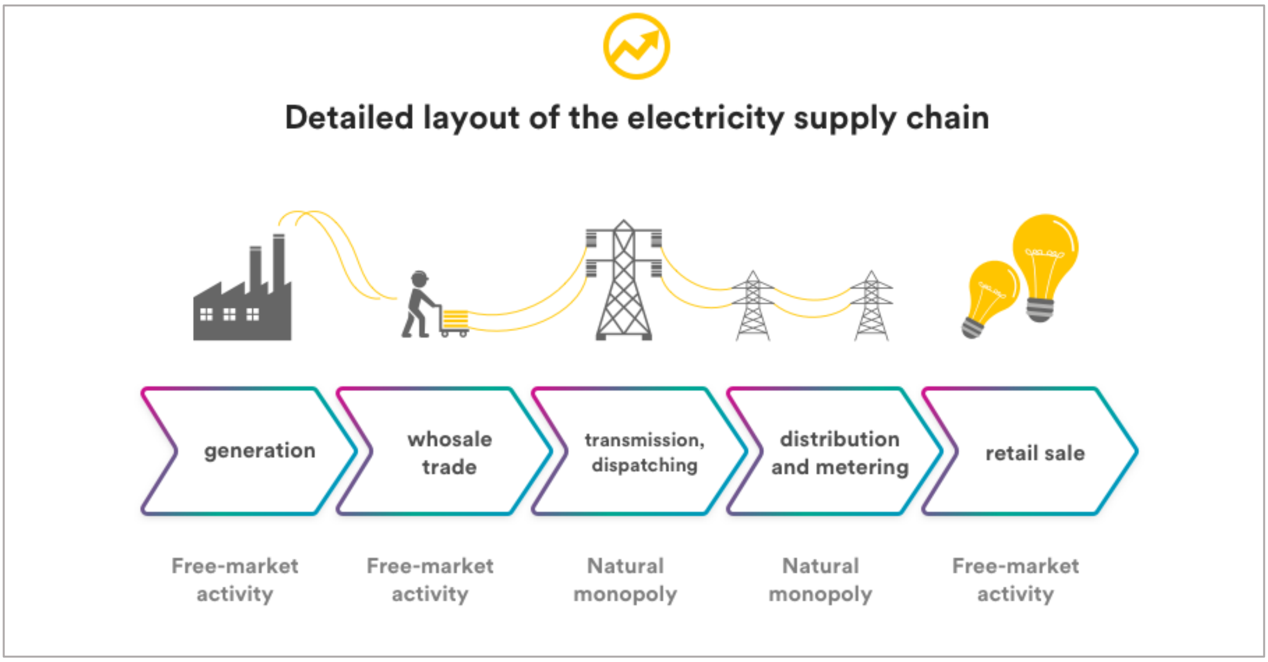

Figure 1-Source: https://eng.gruppohera.it/group_eng/business-activities/energy/electricity

Some of these segments, specifically generation, trading and retail, follow **competition** mechanisms, while transmission and distribution are still organized as **natural monopolies** due to the complexity and high responsibility of the activities pursued. In Italy, for instance, there is just one company that operates in the transmission sector, namely Terna S.p.A., while there are multiple companies that manage the distribution activity. However, their operative area is geographically limited according to pre-established criteria, therefore it is possible to talk about **local monopolies**.

The **generation** sector is involved in numerous activities, that are all finalized at the production of electricity[22]. Since it was liberalized, an uncountable number of companies entered the market and began operating as generators. Consequently, to foster their growth and to increase the degree of competition numerous countries, among which Member States, have established that it is not possible for any company in the sector to own more than 50% of the market share. This measure was taken to **limit the power of incumbents**, whose sizes, expertise and resources were significantly greater compered to new entrants, particularly if considering the fact that they operated as monopolies for decades.

Generation companies are firstly responsible for building the needed power plants and for purchasing the newest and more advanced technologies that can increase the efficiency of the service provided. Consequently, these companies must also regularly invest in the maintenance of the numerous infrastructures and machineries.

[22] Source: OECD. Organisation for Economic Cooperation and Development (2023). https://data.oecd.org/energy/electricity-generation.htm

Then, a fundamental task of generators is the **purchase of primary sources** that are then transformed into electricity. These sources can be of multiple nature: they can have different degrees of availability and obviously different costs and they can be purchased either at national level or from foreign suppliers.

It is possible to classify them into two main categories, namely **conventional** and **renewable sources**. Nuclear and fossil fuels, specifically natural gas, oil and coal belong to the first group. These sources enable a **large and stable production** of electricity, the related power plants usually have either very high or wide installed capacities; but they generate **significant CO_2 emissions** that have an extremely negative impact on the environment[23].

However, the pollution factor is only related to the use of fossil fuels, nuclear, on the other side, is a carbon free source that can generate large-scale electricity and it can be considered the best and most efficient way to produce the commodity. Anyhow, this energy source also presents a few disadvantages; for instance, the management of its wastes is quite tricky and the building of the related power plants requires many years to be accomplished and it represents a huge investment whose returns will only be earned in the long-term. Additionally nuclear energy is object of numerous issues of public acceptance due to the fear of potential accidents that begin after the Chernobyl disaster in 1986[24]. Italy can be an example of this, since in 1987, immediately after the tragedy, Italian citizens decided to shut down all the nuclear power plants operating in the national territory with a popular referendum and, besides the reopening of these plants has been often reconsidered, still nuclear is not present in the Country; instead it is mainly purchased from France.

Then, the second category consists in renewable sources which, differently from fuels, have a **low to zero impact on the environment** thanks to the lack of emissions produced, are **mostly unlimited** and are also widely available in many countries. Fossil fuels, on the other hand, are extremely concentrated in specific geographical areas and consequently their supplying can be difficult, expensive and highly influenced by the geopolitical equilibriums of the specific moment.

Among renewables there are solar, wind, hydroelectric, which is highly developed in Italy, geothermal and biomass. These sources are usually characterized by **high initial costs** related to the building of plants and to the purchase of the technologies, but, after that, they become less expensive compared to conventional sources, particularly in terms of maintenance. Renewable power plants, in fact, usually have a **long lifetime**.

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[23] Source: IEA. International Energy Agency (online). https://www.iea.org/fuels-and-technologies/electricity

[24] Chernobyl April 26th 1986. A nuclear accident generated by the explosion of reactor 4 in the city of Chernobyl in Ukraine, at that time part of the Soviet Union. The accident was rated at seven on the International Nuclear Event Scale, meaning the maximum severity. Only the 2011 Fukushima nuclear disaster was equally rated.

Conventional and renewable sources are also different in terms of the possibility to program the power generation in advance (**programmability**) and to adjust it in real time (**dispatchability**) to guarantee the equilibrium between demand and supply. All conventional sources, apart from nuclear whose production cannot be stopped once initiated, present the two properties thanks to their availability and controllability.
On the contrary not all renewables are programmable and dispatchable. This is in fact the case of both wind and solar and also of geothermic which is programmable but not dispatchable, meaning that once the generation of electricity has begun, it is not possible to regulate it and to stop it depending on the needs of the moment.

Despite the greater flexibility of conventional sources, their use is progressively being reduced, especially in the most recent years, because of the growing concerns regarding environmental and climate issue and also due to the recent Russia-Ukrainian conflict that has drastically increased the prices of natural gas.

Following the generation activity, there is **trading** that takes place in the **wholesale market**, which is where large volumes of electricity are traded. Its main participants are generation companies that sell electricity and suppliers that purchase electricity at competitive prices to resell it to end-users in the retail market, in which smaller volumes of electricity are exchanged.
Electricity trading in the wholesale market can take place with respect to **multiple timeframes** from long-term to short-term negotiations; consequently, it is possible to identify respectively the Forward and the Spot electricity markets, which are going to be deeper analyzed afterwards.

After the electricity has been exchanged in the wholesale market, it is injected into the transmission network, also known as **national grid**, by generation companies to reach consumers. Consequently, **transmission**[25] is the third step of the value chain; and, as already affirmed, it is structured as a natural monopoly, therefore it is usually managed by just one company that has the duty to constantly ensure the equilibrium between demand and supply of electricity. This role is of primary relevance to guarantee the correct functioning of the system and it cannot be put in practice by multiple firms according to competition mechanisms.
The sector takes care of two fundamental activities: firstly, the **delivery of high-voltage electricity** throughout the entire country by using the national grid and second the **electricity dispatching**[26], which consists in the management of electricity flows throughout the national grid to constantly

[25] Source: National Grid (2022). https://www.nationalgrid.com/stories/energy-explained/electricity-transmission-vs-electricity-distribution
[26] Source: Terna Driving Energy (online). https://www.terna.it/en/electric-system/dispatching

ensure the balance between supply and demand. This is a crucial activity since it guarantees the continuity and safety of the service: it covers demand peaks and reduces the electricity transported in the grid when the consume is lower.
Moreover, the entities operating in this sector must be **completely independent** from companies belonging to the liberalized area of the value chain expressly to avoid cases of discriminatory behaviors towards small companies in terms of access to the grid.
In most European countries there are **TSOs** (transmission system operators) that regulate the access to the grid and that ensure the respect of transparent and egalitarian practices. In Italy the company that manages the transmission system is **Terna S.p.A.**, which was founded in 1999 after the liberalization process. It was the first European TSO and it is the **sixth largest transmission operator** in the world thanks to the size of its electrical grid.

Once the electricity injected in the national grid reaches the different geographical areas, it is transformed in medium and then in low-voltage by specific conversion stations. This process allows to bring the electricity from the national grid to local ones that are charged of the **distribution** process[27]. Also this activity is structured as a natural monopoly and it is usually managed by a limited number of companies that receive **multi-year State concessions**. Therefore, the monopolistic regime is **locally structured** as each company menages the distribution activity with respect to a given and pre-established area. While the transmission is more connected to the upstream part of the value chain, that is the generators, the distribution segment establishes a connection with the downstream part, namely the end-users that can be either households or business activities.
Just as transmission, also distribution must function in respect of principles of **transparency and fair access to the grid** to reduce as much as possible predatory behaviors. Among the Italian DSOs (distribution system operators) there is **e-distribuzione S.p.A.**, which is a subsidiary of the Enel Group and that is the biggest distributor in the Country.

Lastly, the value chain ends with the **retail** of the commodity to final consumers. Electricity is purchased by the providers from Power Exchanges or OTC or directly from the generators and then it is sold to final consumers. Providers are charged of managing and regulating all the needed **commercial and administrative activities** and they also have the responsibility to comply with the terms of the purchasing agreements signed by the clients.
Similarly to production and trading, retail has progressively been liberalized, meaning that more and more end-users are becoming able to **freely choose their electricity provider** depending on their

[27] Source: Gharehpetian, G. B. and Agah, S. M. M. *Distributed Generation Systems : Design, Operation and Grid Integration.* Elsevier, 2017

price convenience. This situation was not previously possible due to the exclusive existence of the **protected market** (Maggior Tutela)[28] that did not allowed consumers to choose the wanted supplier that instead was already given.

Despite being less transparent and more exclusive towards smaller suppliers, the protected market presents some important benefits that are the reason why it is continuing existing in some countries, like Italy.

It provides a greater safety compared to the open market and an increased price stability, moreover, it is able to safeguard smaller consumers like small companies and households that otherwise would not be able to properly choose the right provider due to disinformation issues[29]. However, despite its potential advantages, Italy has decided for the abolishment of the protected market both to foster greater competition and freedom in the retail sector and to align with the other European countries. Anyway, the timing for its shutdown was object of a few modifications since initially it should have been closed on July 1st 2020, then, also due to Covid-19 reasons, it was postponed to January 1st 2022, and lastly to **January 10th 2024** which is the date of its official abolishment. In fact, all end-users must have chosen an electricity supplier by then, otherwise they will be provided with one.

The introduction of the retail market has contributed to the creation of innumerable firms operating as electricity suppliers, however there are still some **major players**: firstly Enel Energia but also Eni Gas e Luce and following Edison Energia, AceaEnergia and E.OnEnergia. The last two companies are more focused on the retail of electricity coming from renewable sources, while Eni Gas e Luce is for example more involved in the retail of electricity that is produced using fuels, particularly natural gas and oil.

1.2.1 The European wholesale market: structure and functioning

The European wholesale electricity market is the place where large volumes of electricity are exchanged among market operators. It is a highly integrated market that enables the establishment of commercial relationships at **global level**[30].

Three are the main participants of this market, namely: **generation companies**, **suppliers** and **market operators**[31], which are responsible for the fair and transparent management of the power exchange.

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[28] Source: ARERA. Autorità di Regolazione per Energia, Reti e Ambienti (2023). https://www.arera.it/it/consumatori/finetutela.htm

[29] Source: AGCM. Autorità Garante della Concorrenza e del Mercato (2018). https://www.agcm.it/pubblicazioni/2018-09_Mercato_Libero_Energia_Gas.pdf

[30] Source: European University Institute and Florence School of Regulation (2020). https://fsr.eui.eu/electricity-markets-in-the-eu/

[31] Source: European Union – Energy Community and EU4Energy Programme (2020). https://energy-community.org/dam/jcr:ce2c5ded-112c-4a6b-9ddc-45a5de7cf5fc/Elearning_EL_market_032020.pdf

As previously anticipated, generators are responsible for selling the electricity at a given price, while suppliers purchase blocks of electricity to resell them to end-users. However, it is also possible for some end-users, usually big companies with an extremely high electricity demand, to directly enter the market and to autonomously purchase the commodity without the need to rely on providers.

The electricity market operates throughout **numerous timeframes**, leading to the existence of multiple types of markets that can be initially differentiated into Forward and Spot Markets; they respectively enable **long and short-term trading** activities.

The **Forward Market** (MTE)[32] is where **long-term bilateral contracts** are traded, these contracts can present delivery and withdrawal obligations. The trading activity can begin **from years to months** before the actual delivery and it is conducted through **continuous sessions** that take place every month during weekdays. Market operators can trade in both regulated market and OTC by submitting their orders in which they must specify the price at which they are willing to either purchase or sell, the period of delivery and the number of contracts that they want to trade.
The Forward Market is principally used by generators and providers with **hedging purposes**, therefore with the objective to agree in advance upon a given price and a given quantity of electricity to increase the stability of the cash flows and to insure from price uncertainty and price volatility that are extremely common in the industry and, particularly, between long and short-term trading.
This Market is the principal hedging instrument for **new entrants** since they are not provided with significant liquidity yet and are also still paying for the investments made in the infrastructures and technologies required for the production process. Therefore, small and newborn generators need to **lock the electricity price** the most to protect themselves from fluctuations that may drastically increase their expenditures.
Then, for what concerns incumbents, the situation is slightly different since the forward market is only partially used for hedging purposes thanks to the greater liquidity of which these companies are already provided and to the ownership of physical options, such as generation units or long-term physical transmission rights, that can function as a protection instrument[33].
Moreover, besides the risk management objectives, the Forward Market is also used as a **speculation tool**, mainly by big companies and by financial intermediaries. The **contracts** that can be traded in this market can be of multiple nature depending on their structures and obligations, namely:

[32] Source: GME. Gestore Mercati Energetici (online).
https://www.mercatoelettrico.org/En/Mercati/MercatoElettrico/MTE.aspx
[33] Source: European Union - ACER. Agency for the Cooperation of Energy Regulators (2015).
https://www.acer.europa.eu/en/Electricity/Market%20monitoring/Documents_Public/ECA%20Report%20on%20European%20Electricity%20Forward%20Markets.pdf

- **Forwards**: are **tailored contracts** between generator and supplier, meaning that they vary from case to case depending on the specific requests. They set the price of the commodity, the quantity that will be sold/purchased and the time of the delivery. Forward contracts are usually traded **OTC**, therefore they are autonomously regulated, and they are often **cash settled**. These types of contracts present a **higher risk of default**, i.e. **counterparty risk**, so it is possible that one of the parties involved may not comply with the obligations when the maturity of the contract is reached.
- **Futures**: are **standard contracts** that regulate an exchange of a given quantity of electricity at an agreed price for a pre-established time. Differently from forwards, these contracts are regulated, so they are traded in **Power Exchanges**. This implies a **higher transparency** and a significantly **lower probability of default**[34].
- **Swaps**: are agreements through which the parties involved set a **strike price** for a given volume of the commodity to be exchanged in the future. The final price paid by the provider will be equal to the difference between the price agreed upon and the spot price. Just like forwards, also swaps are traded **OTC**[35].
- **Contract for Differences (CfD)**: are contracts through which two parties exchange payments with respect to the value of the **underlying asset**, namely electricity, without the need of physical delivery. It allows the parties to set a **price differential** between the estimation of the quoted prices, usually between a valuation used for physical pricing and one used for hedging purposes[36].
- **Options**: are agreements that enable the provider to purchase a given quantity of electricity at a given price within a determined period in the future, but they **do not set any obligation**. The supplier must pay a **premium** to have the right to use the option. These contracts can be traded both in the **regulated market** or **OTC**.

Despite the shared purpose of safeguarding market operators form price fluctuation, these contracts are still unprotected from **systemic risks** that can unexpectedly hit the market and drastically compromise and obstacle its correct functioning. An example may be droughts, that can lower the amount of hydroelectric energy and consequently drastically increase its price.

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[34] Source: CME Group (online). https://www.cmegroup.com/education/courses/introduction-to-futures/definition-of-a-futures-contract.html
[35] Source: Enel Energia (online). https://globaltrading.enel.com/financial-products/swap-power
[36] Source: European Union - ACER. Agency for the Cooperation of Energy Regulators (2015). https://www.acer.europa.eu/en/Electricity/Market%20monitoring/Documents_Public/ECA%20Report%20on%20European%20Electricity%20Forward%20Markets.pdf

The majority of electricity is usually exchanged in the Forward Market using long-term contracts; in this way the Spot Market is mainly used to implement **short-term adjustments** and to solve real-time issues and complications in order to guarantee the equilibrium between demand and supply and the reliability of the service.

However, the European Forward Market is affected by a high degree of **fragmentation** since each region/country has its own market; therefore, differently from the Day-Ahead and Intraday Markets, this one in **not integrated at EU level**[37]. The different markets are connected through transmission rights that are issued by TSOs. The immediate effect of these structure is the **unequal distribution of liquidity** among the different national markets.

Then, there is the **Spot Market**[38] that manages the exchange of electricity for the **short period**. This market is the **most liquid** one and its main function is to adjust the amount of electricity previously traded in the Forward Market to meet the most recent changes of the system. It is then articulated into: Day-Ahead Market, Intraday Market, Daily Products Market and Ancillary Services Market.

The **Day-Ahead Market** (MGP) is where most of the electricity transactions take place. This market opens the morning of the ninth day before delivery and closes the day before the delivery, during which its results, namely the electricity price and the quantity exchanged, are made public.
The Day-Ahead Market is an **auction market** and not a continuous-trading like the Forward one because it enables participants to **simultaneously enter competitive bids**. Auction market do not require communication and deals between the parties involved since the final price and quantity are set in compliance with **market rules**. Therefore, generation companies and suppliers respectively submit asks and bids in which they indicate the minimum selling price and the maximum purchasing price. Once the market closes, all the accepted bids and asks are shared and the price is the result of the intersection between demand and supply curves accordingly to the model approved by all the electricity markets belonging to the European Union.
The results produced by the Day-Ahead market are **the most efficient** ones from an economic perspective, however their technical feasibility must be subsequently ensured by market operators that have the responsibility to verify that the amount of electricity agreed upon can be actually and efficiently transported by the national grid without creating overloads. Consequently, it can happen that the amount of electricity resulting from the equilibrium between demand and supply, may

[37] Source: European Union - ACER. Agency for the Cooperation of Energy Regulators (2023). https://www.acer.europa.eu/news-and-events/news/acer-proposes-changes-improve-eu-electricity-forward-markets
[38] Source: GME. Gestore Mercati Energetici (online). https://www.mercatoelettrico.org/It/Mercati/MercatoElettrico/MPE.aspx

actually require further modifications to not overcome the **limitation of the system** and to guarantee its practicability[39].

Therefore, when changes in the volumes traded are required to enable the functioning of the grid, the process continues in the **Intraday Market** (MI) that enables both generators and suppliers to submit additional asks and bids with the purpose to adjusts the outcome of the MGP. The Intraday Market operates in **real-time**, meaning that the negotiations begin the day before delivery and they end the day of the delivery accordingly to pre-established sessions. The MI can be differentiated in auction market and in continuous market.

The **auction market** follows the same mechanisms and rules of the Day-Ahead Market for what concerns the selection criteria of asks and bids. However, differently from the MGP, the demand bids that are accepted by the system are **not equally valued**. There may be price differences among the different geographical areas of a given country depending on the pricing model adopted: in Italy, for instance, there are different zonal prices, while in UK, because of the adoption of national pricing, electricity is purchased at the same price throughout the entire country. The auction market foresees multiple sessions throughout the day, whose number can vary from country to country; in Italy there are three subsequent sessions, while in Portugal and Spain they are, for instance, six.

Then, there is the **continuous cross-border European Market**, also known as single intraday coupling, that enables European Member States to freely exchange electricity **outside national borders** and across all Europe[40].This practice is allowed by the establishment of a **cross-border transportation capacity** among the different zones. So, differently from the auction market, the continuous one enlarges the operational area of the trading activity and increases the amount of liquidity available in all the European markets. Moreover, it consents to adjust the volume of electricity traded until up to one hour before delivery. This market is divided into three phases that begin in the afternoon of the day before delivery and that end one hour before delivery.

The Intraday Market is structured to enable the **alternation** between auction and continuous sessions without the risk of overlaps. In this way it is possible for countries to progressively adjust the amount of electricity traded not only within the national boundaries but also with other EU Member States.

Also, the operation that take place in this market are regulated by market operators that, similarly to the Day-Ahead Market, have the duty to analyze the results of the trading and to verify if the volumes of electricity agreed are compliant with the physical requirements of the grid and with its transportation capacity.

[39] Source:OMIE (online). https://www.omie.es/en/mercado-de-electricidad

[40] Source: OMIE (online). https://www.omie.es/en/mercado-de-electricidad

Following, the Spot Market also includes the **Daily Products Market** (MPEG), which is where participants trade electricity with the **obligation of delivery**. This market enables trading of daily products on a continuous basis from Monday to Friday. The exchange of electricity is concentrated in two days: **D-2** and **D-1**, which are respectively two days and the day before delivery. This market contemplates two clearing conditions, namely:

- The "**unit price differential**", though which the price of the electricity traded is equal to the difference between the common exchange price (PUN) and the price of electricity resulting from trading;
- The "**full unit price**", for which the final price of electricity after the trading period is determined by the unit value of electricity exchanged.

The sessions available for the physical delivery of electricity take place over a **24-hour horizon** with a schedule period corresponding to a calendar hour[41]. In consideration of that, it is possible to distinguish the electricity traded in two profiles: **baseload** and **peak load**.
The first profile is listed for all the calendar days and, it enables the delivery of electricity in all the sessions available. On the other hand, the peak load profile can be listed only on weekdays and the delivery of electricity is constrained and restricted to pre-established sessions, specifically from the ninth to the twentieth[42]. This differentiation depends on the fact that, while baseload electricity is the **minimum amount** of electricity needed by consumers at any given time of the day[43], peak load is a larger amount of electricity that must be provided only in specific moments of the day, when the power demand is higher. Consequently, peak load electricity is only delivered **to meet the fluctuating needs**[44] of consumers when, during demand peaks, baseload electricity is not sufficient.

Lastly, there is the **Ancillary Services Market** (MSD) through which it is possible to further regulate the electricity injected in the transmission system and to implement **real-time adjustments**.
Therefore, this market enables operation and modifications of the volumes of electricity during the day of the delivery on an hourly basis. Differently from the previously analyzed markets, this one is controlled and managed by **TSOs** that carry on a multiplicity of **ancillary services** to ensure the continuous balance between demand and supply, the correct functioning of the transmission segment and the security of supply.

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[41] Source: OMIE (2015). https://www.omie.es/sites/default/files/2019-12/20151223_reglas_mercado_ingles.pdf
[42] Source: GME. Gestore Mercati Energetici (online). https://www.mercatoelettrico.org/En/Mercati/MercatoElettrico/MPE.aspx
[43] Source: Sayigh, A. (ed.) *Comprehensive Renewable Energy*. Elsevier, 2012
[44] Source: Collins Dictionary https://www.collinsdictionary.com/dictionary/english/peak-load

The two most important services provided are regulation and reserve; both have the common purpose to contribute to the balance of the system.
Regulation consists in managing mismatches between the electricity consumed and the one injected in the grid and in operating small corrections where required.
Then, **reserve** is used to reestablish the equilibrium in case of large electricity imbalances, particularly whenever there are deficiencies of large generation companies[45].
The Ancillary Services Market is articulated in the **ex-ante market** and in the **Balancing** one.
The first enables the submission of both asks and bids, which are referred to six possible scheduling periods, the **day before delivery**. Its results are progressively published during the same and the next day depending on the specific period of trading chosen by the participants.
While the Balancing Market enables trading the **same day of the delivery**. It is in fact possible for participants to submit offers up to one hour before the time scheduled for the actual exchange.

Therefore, the regulation of the trading activity, of the interactions among the actors and of the amount of electricity exchanged, is under the responsibility of two different entities: **market operators** and **TSOs**.
While the firsts manage the Forward Market and of all the markets belonging to the Spot one, TSOs regulate the Ancillary Services Market since it is strictly connected to the transmission area.
The principal requirement for both market operators and TSOs is to be **autonomous** and **independent** from any organization belonging to the electricity industry because their primary responsibility is to **operate in a fair and transparent way** without discrimination. As already said, the Italian TSO is Terna S.p.A., while the market operator is **Gestore Mercati Elettrici (GME)**[46].

1.3 How prices are set: System Marginal Price and Pay As Bid

As previously analyzed, the electricity market can be distinguished in Forward and Spot markets. In addition to the different timeframes during which they operate, these two markets also rely on **different price-setting mechanisms**.
Since the Forward Market is mainly centered on bilateral contracts, prices are usually set through autonomous negotiations that only take place between the parties involved.
On the other hand, the electricity prices of the Spot Market are set following the **supply-demand model**. Prices are in fact based on the intersection between demand and supply of numerous

[45] Source: PJM (online). https://learn.pjm.com/three-priorities/buying-and-selling-energy/ancillary-services-market.aspx
[46] GME. Gestore Mercati Elettrici is an Italian company founded in 2004, initially under the name of Gestore del mercatoelettrico. It manages the exchange of electricity and of natural gas in the Italian Power Exchange, i.e. IPEX.

generators and providers: the more participants there are, the more the electricity price will be fair and reliable.

Generation companies and electricity suppliers respectively submit offers and bids for the selling and the purchasing of a given quantity of electricity, then, depending on the pricing method applied, it is possible to consider two different scenarios: the setting of a **uniform price** or the setting of **different prices** depending on the specific bids and offers.

The first outcome is related to the implementation of the **System Marginal Price (SMP)**, while the second one is the result of the **Pay-As-Bid (PAB)** model.

1.3.1 System Marginal Priced (SMP)

The **System Marginal Price (SMP)** is also known as **Pay-As-Clear** and it sets a uniform price for electricity, meaning that all the providers must purchase electricity at the **same price regardless the generation company and the energy source** employed during the production process[47].

This method correlates the price of electricity to the production costs that power plants must face during the process; each generation company offers electricity at a price equal to its **marginal cost**, leading to the definition of the supply curve, also called "**merit order curve**".

The market clearing price is set where this curve meets with the demand (*Figure 2*) and it is consequently equal to the marginal cost faced by the **most expensive power plant** accepted by the system, that is the last plant under (on the left) the demand curve.

Electricity is usually sold starting from the cheapest power plants, therefore renewable ones. It follows that all the plants on the left of the one that sets the price sell electricity at a price that is progressively higher than the expenses faced during the production process.

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[47] Source: Hirth, L. (2022). https://neon.energy/marginal-pricing

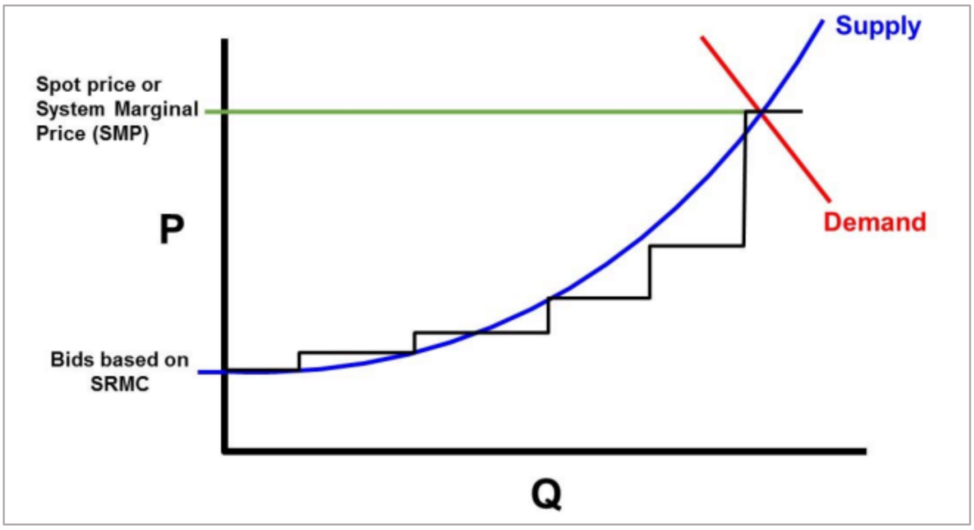

Figure 2 - System Marginal Price (SMP) model

Therefore, they obtain a "**contribution margin**", that corresponds to the difference between the uniform price and the one offered. However, the margin does not represent a profit since it must be invested to **cover the costs** of the plant and of the technologies purchased.
Hence, the higher the contribution margin, the more the fixed costs of the power plant, for this reason the margin is bigger at the beginning of the "merit order curve" where the variable costs are equal to zero.
The SMP is the most used pricing-system in the spot markets of many countries. Among the advantages there is the fact that it best complies with the competition regime since it strictly follows market mechanisms to set the price, hence it is the **fairest** possible system. Moreover, it guarantees a high level of **transparency** because companies are not incentivized to enlarge their marginal costs of production to sell electricity at a higher price. On the contrary, it is more convenient for companies to reveal their true costs since the lower they are, the higher are the possibilities to belong to the accepted offers and to gain margins to cover the investment costs. However, a drawback of the SMP is that it can lead the owners of the most expensive power plants to exert **market power** by setting higher prices with respect to marginal costs to make profits[48].

Different energy sources have different **cost functions**: either **fixed** or **variable**.
Renewable sources, particularly solar and wind, mainly face the first type of costs since they require large initial investments for the building of the plants and for the purchasing of the technologies, but their production costs remain stable over time. This is mainly correlated to the large availability of the sources and to the long lifetime of the machineries.

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[48] Source: European Union - European Commission (2023). https://energy.ec.europa.eu/topics/markets-and-consumers/action-and-measures-energy-prices_en

On the other hand, conventional sources, specifically fossil fuels, have variable cost functions that progressively increase over time following different speeds depending on the specific fuel. Their marginal costs are in fact related to different factors: the nature of the **source used**, the consequent type of **technology needed** and the price of **carbon allowances**[49]. The cost functions of the different conventional sources can consequently vary over time with respect to the mutation of these factors. Now, natural gas has the cost function with the highest slope, since it is the less available and most expensive source and so the related power plants are the ones that set the price in numerous countries, including many European ones.

This situation determines the strong **correlation between electricity and natural gas prices** that is representing a crucial issue and that fostered the need to decouple these two commodities. **Decoupling** is however not easy since gas and electricity are not connected by specific laws or regulations, their link is only the consequence of the functioning of the SMP.
The European Commission is investing time and resources to solve or at least to alleviate the problem; the only possible solutions may be the switch from SMP to another pricing system like the Pay-As-Bid model for instance, or the abandon of natural gas and the consequent shutdown of the related plants.
Anyhow, both settlements are unlike to be accomplished since the SMP, despite its issues, is the most efficient system to set the price and the shutdown of natural gas power plants cannot be achieved at least in the short term since gas is the most used electricity source in many countries, including Italy. A possible way to reduce the impact could be the introduction of a **cap on the price of the electricity** produced using natural gas[50]. Differently from the other solutions, this one directly impacts the retail prices, since it sets a maximum price that consumers can pay for electricity, the exceeding amount must be covered by European funds.
However, neither the price cap seems to be a solution due to the opposition of some Member State, Germany for example. The downside of this system may in fact be more deleterious than the problem itself since it does not incentivize end-users to reduce their electricity consumes, instead it may encourage them to use even more electricity since they are not paying it at a full price.

1.3.2 Pay-As-Bid (PAB)

Then, a second method to set the electricity price in the spot market consists in the **Pay-As-Bid (PAB)**. This system is less widespread, given the fact that it ensures **less efficiency and transparency**

[49] Source: De Boer, S. and Stet, C. (2022). https://www.rabobank.com/knowledge/d011318792-the-basics-of-electricity-price-formation
[50] Source: Hirth, L. (2022). https://neon.energy/marginal-pricing

to the market. In this case the price at which electricity is purchased is equal to the specific bids of each supplier. Therefore, this method does not set a uniform price, but, instead, **different clearing prices** depending on the intersections between specific offers and bids (*Figure 3*).

The immediate consequence of this mechanism, which is also the reason why the PAB is less preferred than the SMP, is that generators are incentivized to ask for a price that they expect to be the highest accepted by the system. Therefore, producers set a price that is usually greater compared to their production costs.

This is obviously not beneficial for suppliers but mostly for end-users that must pay more than needed to reach the market equilibrium.

However, an important advantage related to this system is that, differently from SMP, it **reduces price volatility** since it is based on **average price** rather than on the marginal one, which, for the reasons listed above, is more volatile[51].

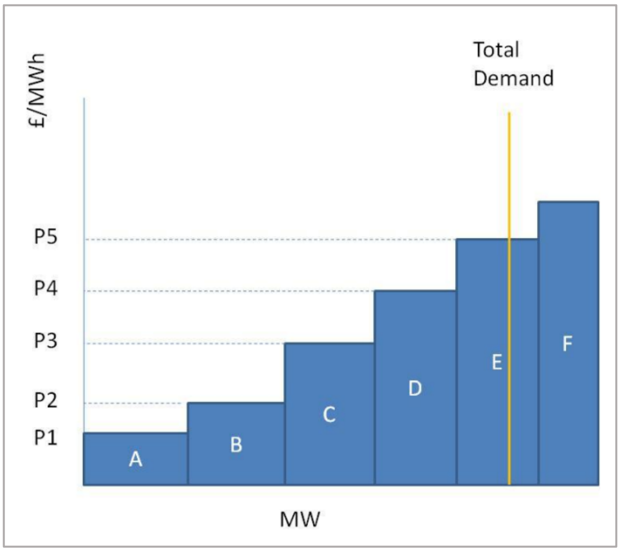

Figure 3 - Pay-As-Bid model

1.3.3 Pricing systems: national, zonal and nodal

Moreover, the electricity prices set in the wholesale markets may not always be uniform. In fact, depending on the system adopted, it is possible that the purchasing price of the commodity varies within the national territory.

It follows that there are three different pricing models[52] among which countries can choose, namely:

[51] Source: Haghighat, H. and Seifi, H. and Kian, A. R. (2012). https://www.sciencedirect.com/science/article/abs/pii/S0142061512000944#:~:text=Under%20the%20PABP%20mechanism%2C%20the,price%2Doffer%2C%20FRO

[52] Source: ESO (online). https://www.nationalgrideso.com/electricity-explained/how-electricity-priced

- The **national pricing**, through which all the geographical areas of a country can purchase electricity at the **same price** in any given moment; therefore, there are not differences across the national territory.
  This model is adopted by United Kingdom, Germany, France, Poland and Greece;
- The **zonal pricing**, also known as regional pricing, consists in the division of the territory of a country in a set of pre-established areas, each of which has a **different electricity price**. This pricing system, which can create controversies in terms of expensiveness and of inequalities, is often connected to the practice of **market coupling**, which enables the connection of previously isolated zones in order to exchange electricity and to create a new equilibrium price that is lower for the more expensive area and that becomes a bit higher for the cheaper one.
  This system is used in Italy, Sweden, Norway, Denmark and also in Australia.
- The **nodal pricing** or local marginal pricing (LNP) leads to the creation of an even more **fragmented system** compared to zonal pricing. It consists, in fact, in the division of the national territory into a countless number of nodes, each of them with a different wholesale electricity price. The number of nodes can depend on geographical characteristics or on the network structure.
  This method is adopted by New Zealand, Singapore and by numerous States of the US, such as California, whose electricity market is articulated in more than ten thousand nodes.

1.3.4 Carbon Allowances: functioning and impact on conventional and renewable power plants

As previously anticipated, the marginal cost of fuels is influenced by a multiplicity of factors, among which Carbon Allowances. They are government permits that enable fuel-based power plants to emit a **pre-established** amount of CO_2in the environment.
Carbon allowances are part of the "**EU Emission Trading Scheme"**[53] or "**cap and trade**"[54] program though which numerous countries in the world, including European Member States, aim to progressively reduce and to find a solution for the high levels of greenhouse gas emissions belonging to the energy sector.

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[53]*EU ETS*. Emission Trading Scheme is the main tool developed by the EU Commission to fight climate change and to lower the emissions produced by the power industry in a cost-effective manner. It has established the first and most relevant carbon market in the world.
[54] "Cap and Trade" is the principle that structures the EU ETS. It sets a threshold to the maximum level of emissions (cap) and it enables generation companies to exchange the permits by creating a specific market (trade).

Carbon allowances are sold at auctions throughout the year by governments and polluters bids for them.[55]

They set a maximum level of CO_2 emissions that each company can produce; however there may be two possible scenarios: a given company produces few emissions and therefore it owns exceeding allowances, or there could be the case of a company with a deficit of allowances that consequently pollutes more than what permitted.

These imbalances can be easily and efficiently solved though simple market operations.

Carbon allowances are in fact **tradable among generators** which can freely sell and purchase them depending on the needs, hence they have created a new market that benefits both polluters and non, since it enables the firsts to buy extra allowances to **avoid the payment of heavy fees** correlated to the extra pollution and it creates a **source of profits** for the seconds that, thanks to their low environmental impact, do not need all the allowances obtained.

Each year the number of allowances sold by governments is **progressively reduced** while prices increase.

The purpose is to push polluters to drastically decrease their emission level and to incentivize them to switch towards renewable sources.

This system provides a **temporarily solution** for fuel-based companies to continue emitting carbon (in the short-period) without having to pay heavy fees, but at the same time it encourages them to invest in cleaner technologies in order to become carbon free.

Moreover, it also provides a strong **competitive advantage** to those companies that already have smaller carbon footprint levels.

1.4 Evolution of energy sources over time and the progressive switch towards renewables

With the passing of the time, with the evolving of the technologies and with the growing concerns regarding climate and environmental issues, the **global electricity mix** has progressively experimented significant changes, particularly, the increasing share of renewable sources and the decrease of fossil fuels that led to a reduction of CO_2 emissions.

This result is the consequence of numerous **policies** and **regulations** introduced both at national and international level to fight climate change.

This issue is in fact largely caused by the power sector, of which the electricity industry represents one of the largest and, therefore, most relevant areas.

[55] Source: Tuckwell, D. (2022). https://www.globalxetfs.com.au/what-are-carbon-allowances-and-why-do-they-matter/

As shown in the graph below (*Figure 4*), the primary sources used, and their shares have changed with time.

From the very beginning the production process primary relied on **fossil fuels**, principally coal followed by oil and natural gas. Additionally, **hydro**, which initially was the only renewable source exploted, contributed to the mix for a significant amount. Then, there was also a small percentage of **nuclear** that progressively increased over time reaching a peak between 1990s and 2000s.

Then, starting from the beginning of the 21st Century the world began to invest in new and cleaner sources, among which solar and wind. Their shares in the electricity mix are growing at a fast speed throughout time and it is forecasted that renewable sources will constitute the **69% of electricity by 2050**, the 56% of which is produced with solar and wind. On the other hand, the use of fossil fuels for the generation of electricity will experiment a drastic decrease, which is already begun, leading to a share of **24% by 2050**[56].

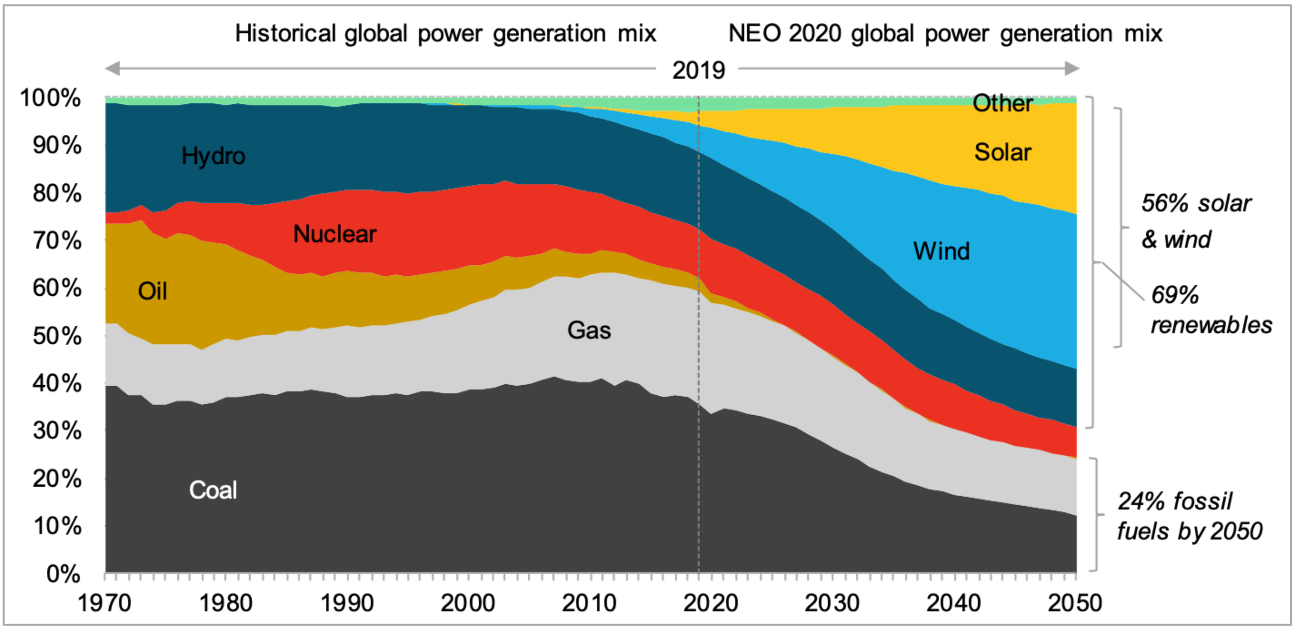

Figure 4 - Global electricity generation mix from 1970 to 2050

However, the global picture can be somehow misleading since it may seem that all the countries in the world are moving towards cleaner and renewable sources for the production of electricity and are progressively abandoning fossil fuels.

Anyhow this is not quite true because there are still numerous countries, whose electricity mix is strongly based on fossil fuels. This is, for instance the case of the majority of the East.

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[56] Source: BNEF. Bloomberg NEF (2020). https://www.statkraft.com/globalassets/0/.com/newsroom/2020/new-energy-outlook-2020.pdf

Middle East[57] produces electricity only using two sources, **natural gas** and secondly, oil. The share of the first source is even growing over time also thanks to the high availability in the region, particularly in **Qatar**.

Then, there is **Asia Pacific**[58] that includes large and important countries such as China, India, Japan, Korea and Australia in which the majority of electricity is produced using **coal**.
The courtiers belonging to this region are therefore among the most polluting ones and **China** is in the first position with the highest production and highest consume of coal in the world. Therefore, renewable sources only represent a minimum share of the electricity mix of both regions.
However, some countries have recently announced their **commitment towards climate issues** and their goal to reach carbon neutrality. This is, for instance the case of **India** and **China** that, despite the incredibly high emission levels, aim to meet the objective respectively by **2070** and by **2060**. China is, in fact, beginning to invest in both renewable sources and in the electrified transport, and it was ranked first for the global investments in energy transition in 2020. Moreover, China could deeply exploit its territory that is highly exposed to the sun for the building of solar farms. The country is also becoming a **key supplier of PV technologies** at a low and competitive price and for this reason it is starting to export them globally.

Then, **Africa**[59], similarly to Eastern courtiers mainly uses **natural gas**, of which the continent is highly provided, coal and, in a smaller amount, oil.
While, among the renewables, African countries produce electricity mainly from **hydro**, but the shares of wind and solar are progressively increasing.

Eurasia[60], in which **Russia** is the biggest Country and contributor to the electricity mix, mainly relies on **natural gas**, whose share is also growing over time. Oil was a minor source since the beginning and now its use is being even lowered. Other notable electricity sources are coal, nuclear and hydropower.

Additionally, **natural gas** and **coal** are widely employed also in **North America**[61], however while the share of the first is growing, coal is decreasing in the most recent years.

[57] Source: IEA. International Energy Agency (2022). https://www.iea.org/regions/middle-east
[58] Source: IEA. International Energy Agency (2022). https://www.iea.org/regions/asia-pacific
[59] Source: IEA. International Energy Agency (2022). https://www.iea.org/regions/africa
[60] Source: IEA. International Energy Agency (2022). https://www.iea.org/regions/eurasia
[61] Source: IEA. International Energy Agency (2022). https://www.iea.org/regions/north-america

On the other hand, **Central and South America**[62] little rely on fuels since their electricity production is principally and widely related to renewable sources, particularly **hydropower** that has the highest share.

1.4.1 The evolution of the European electricity mix

The **European** electricity mix, differently from the other Continents and regions of the world, is probably the **most differentiated** one as it widely uses both conventional and renewable sources without leading to a strong predominance of one over the others[63]. This can, in fact, be easily seen in *Figure 5* that represents the European electricity generation by source in a time period that starts from 1990, therefore at the begin of the liberalization process, and that ends in 2020.

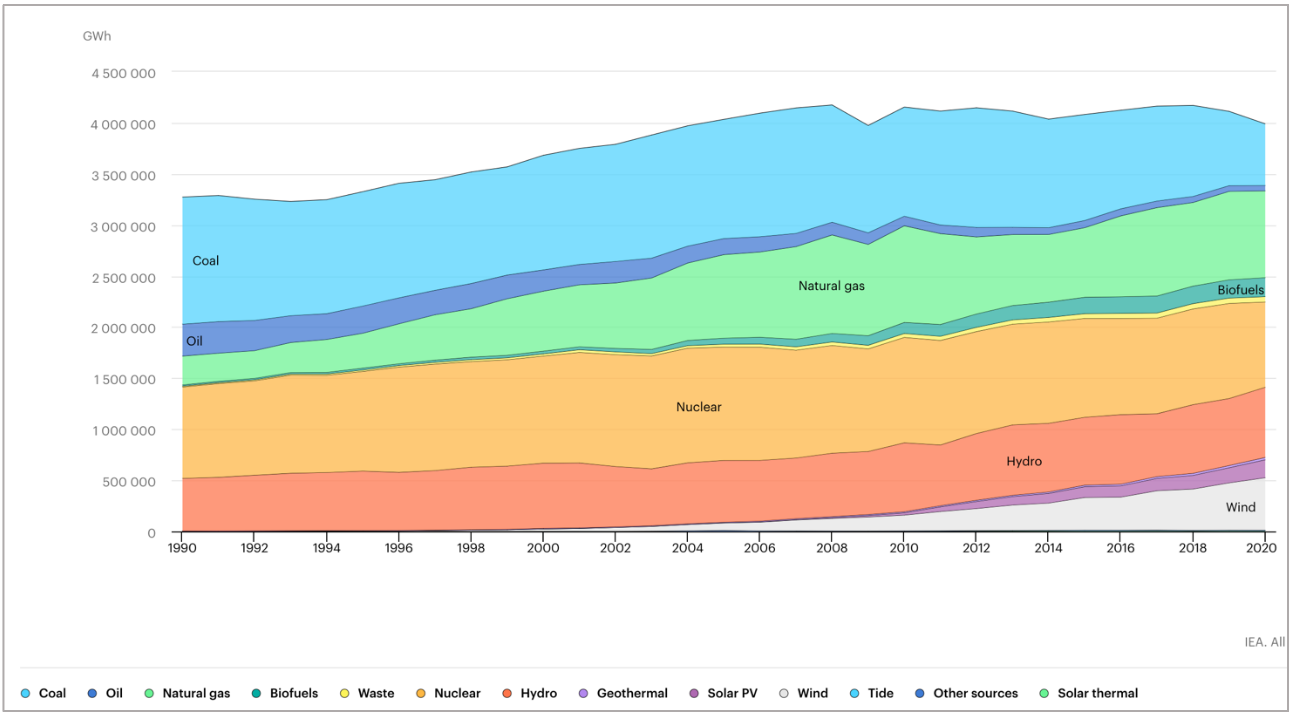

Figure 5 - European electricity generation mix 1990-2020

Fossil fuels are experimenting a progressive reduction over time, particularly oil and coal, that, due to the very high emissions, has been largely replaced by **natural gas**. The latter, despite the pollution factor, is still widely used, however the goal of Member States is to abandon it in favor of renewable sources, some of which, **hydropower** for instance, already play a key role in the electricity production.

[62] Source: IEA. International Energy Agency (2022). https://www.iea.org/regions/central-south-america
[63] Source: IEA. International Energy Agency (2022). https://www.iea.org/regions/europe

Solar and **wind** are growing at a fast speed also thanks to the favorable environmental conditions of most of the countries and the percentage of biofuels is increasing with time. Lastly, **nuclear** is among the most efficient electricity sources since its power plants have very high installed capacities, it is programmable and it is carbon-free, therefore it is not polluting. Its main drawbacks are the non-dispatchability, meaning that ones the generation process has begun it cannot be stopped and the issues of social acceptance. However, there are still numerous Member States that largely rely on nuclear for the electricity generation, **France** is for instance the most notable and it is also a key supplier for Italy. Additionally, there also are Belgium, Spain, Sweden and Germany[64].

1.4.2 The Italian electricity mix and consumes

As described by the graph below (*Figure 6*), the Italian electricity supply is still principally based on **fossil fuels**. **Natural gas** is, in fact, the main primary source, however considering the recent conflict between Ukraine and Russia and the cut of commercial relationships with the latter, the share of the fuel was drastically reduced leading to scarcity and to extremely high electricity prices. Although the numerous complications, this situation also gave the Country a push to increasingly invest in renewable sources and to truly initiate the energy transition.

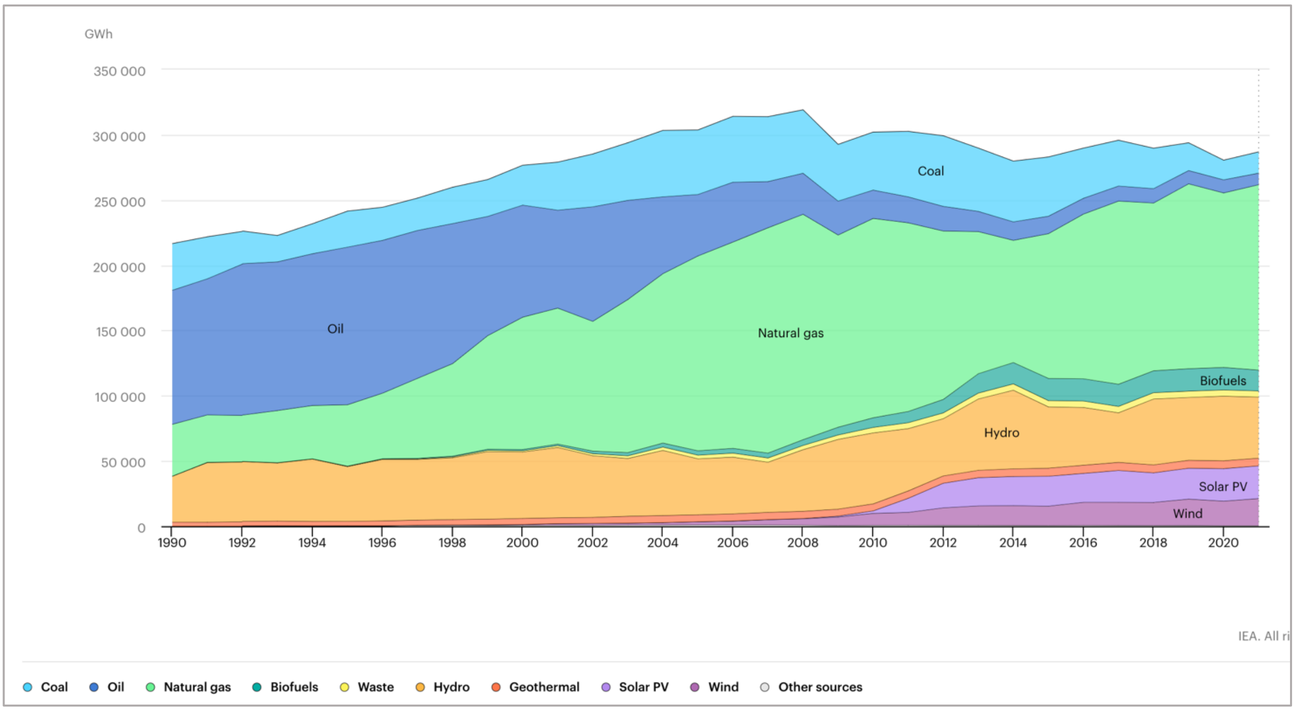

Figure 6 - Italian electricity supply by source 1990-2020

[64] Source: European Union - Eurostat (2021). https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Nuclear_energy_statistics

Besides **hydropower** that has always covered an important position in the electricity mix thanks to the numerous rivers available in the territory, Italy has increased the electricity supplied by **wind**, both inshore and offshore plants, and by **solar panels** starting from 2010.

The remaining fuels, namely coal and oil, are progressively being dismissed. Coal, differently from many other courtiers, never contributed in a very impactful way to the electricity supply but oil did, particularly concurrently with the liberalization process. However, at present, its share is significantly decreasing[65].

Italy is **almost completely autonomous** for what concerns the generation process, however, there is still a small portion of electricity that is purchased from foreign suppliers, a case may be the electricity coming from nuclear energy that is mainly bought from France.

In 2022 Italy has internally produced the **86.4% of electricity**, while only the remaining **13.6%** was bought from other countries to meet the demand[66].
Anyhow, as already anticipated, despite the progressive evolution and growth of renewable sources, in Italy there is still a prevailing consume of fuel-based electricity that accounts for about the **68.9%** of the total, while the remaining **31.1%** comes from renewable sources, mainly hydro, solar and wind. This percentage, however, significantly **increases every year**.

[65] Source: IEA. International Energy Agency (2022). https://www.iea.org/countries/italy
[66] Source: Terna Driving Energy (2023). https://www.terna.it/en/media/press-releases/detail/electrical-consumption-2022

Chapter 2: energy communities and analysis of how they contribute to cope with the energy crisis

2.1 The global energy crisis and its impact on the energy transition

After being hit by the Pandemic Covid-19 and after experiencing one of the most devastating economic recessions in the history, the world has been facing a global crisis that significantly impacted on the structure and functioning of the energy industry, particularly on the electricity market.

As already illustrated, the **energy crisis** has begun in February 2022 immediately after the invasion of Ukraine by Russia. The immediate consequence of the war was the mutation of the political and economic equilibriums worldwide, leading to the sudden interruption of most business relationships between Western countries and Russia.

United States and Europe have enforced numerous and severe **sanctions**[67] in support of Ukraine though which they obstructed and limited the movement of Russian people and their exchange of goods and services[68]. The main goal consisted in jeopardizing the operational area of Country, in hindering its economic growth and in proving the full Western support to Ukraine.
Among the actions undertaken against Russia, there also is the drastic cut of most of the commercial agreements related to the purchase of energy sources from the Country, which has always been a key global exporter of fossil fuels.
However, besides the unquestionable and immediate results achieved, the sanctions also present a significant downside. In fact, while the United States are mostly independent in the energy sector, the European Union, on the contrary, has been a major importer of Russian natural gas over the past decades. Therefore, with the strong initiatives undertaken, it has lost a fundamental supplier.

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[67]Source: Neate, R. (2022). https://www.theguardian.com/world/2022/nov/10/uk-sanctions-18bn-russian-owned-assets-ukraine

[68] Immediately after the begin of the war, the UK government has, for instance, applied severe sanctions over the assets owned by the seven oligarchs and by other Russian citizens for a total amount of 1.271 persons. The overall value of the frozen assets corresponded to £18.39bn.

Prior the war, 41% of the European natural gas was purchased from Russia (August 2021) and it was brought to Member States through the numerous pipelines[69] available[70]. While, after the implementation of the sanctions, the import of the source reached the **9%** just after one year (August 2022) and the percentage even lowered to **8%** in the following months.

The immediate implications of the scarcity of fossil fuels, mainly natural gas and oil, consist in the unmanageable **rise of electricity prices** and on the consequent **high inflation**, that lead to higher electricity bills and to a significant increase of the poverty index[71] of both developing and advanced economies[72].

Governments worldwide and particularly the ones of the most affected countries are trying to cope in the most rapid and effective way by enforcing measures to address the crisis in order to safeguard individuals and business activities.

Some of the most outstanding initiatives are the issue of the **REPowerEUPlan** by the EU Commission in May 2022 and of the **Inflation Reduction Act** by the United States in August 2022. Both programs establish a set of measures and goals to better face the emergency and to foster the switch towards renewable energy sources. In fact, despite the numerous complications and problems generated by the war and by the crisis, it is also possible to assess an important achievement, namely: the acceleration of the energy transition process by numerous countries that started to operate practically and actively to become self-sufficient in the energy generation.

Moreover, China, notwithstanding its declared support to Russia and its commitment to purchase fossil fuels from it, is quickly moving towards the production of clean energy and the reduction of GHG emissions.

For this reason, the country has issued the **14th Five-Year Plan** in March 2021 that basically states a set of goals to be achieved at economic, social and environmental level[73]. The program refers to the years 2021-2025 and it focuses on the support to innovation, on the investment in low-carbon projects

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[69] The most important pipeline that creates a connection between Russia, near St. Petersburg, and the European Union, specifically Germany, is the Nord Stream 1. It was launched in 2011 and, before the war, it used to transport 35% of the totality of gas purchased from the Country. Then, the Nord Stream 2 was built in 2021 with the project to enable the import of additional amounts of natural gas by EU Member States. Specifically, the pipeline should have annually carried 55bn cubic meters of natural gas. However, due to the start of the conflict, the Nord Stream 2 was never put into operation. As regards the Nord Stream 1, it is now not functioning, following leak problems that are supposed to be not accidental, rather the work of Russia in order to cut the connections with Europe.

[70]Source: BBC News (2022). https://www.bbc.com/news/world-europe-60131520

[71] The poverty index of numerous countries was already largely affected by the Pandemic Covid-19, the following energy crisis has further exacerbated and worsen the economic issues of households and business activities.

[72]Source: IEA. International Energy Agency (2022). https://www.iea.org/topics/global-energy-crisis

[73]Source: ADB. Asian Development Bank (2021). https://www.adb.org/publications/14th-five-year-plan-high-quality-development-prc

and on the achievement of a higher degree of social inclusion that begins with the reduction of the large gap between urban and rural areas[74]. The Plan is functional to the project of the Chinese government to become a global leader in the renewable energy and technologies sector, especially in the manufacturing and export of PV panels. The goals that have been set are extremely ambitious particularly if considering the current high dependency of the Country towards fossil fuels[75] and the related level of GHG emissions which is the greatest in the world.

2.1.1 REPowerEU Plan

The REPowerEU Plan is a set of measures and initiatives that was enforced by the EU Commission in May 2022, and which aims to safeguard Member States from the consequences of the energy crisis and to foster the energy transition.

Three are the main pillars of the plan, namely: the diversification of the suppliers and of the energy sources, the generation of clean energy and the related investments in the most advanced technologies, and the energy saving[76].

Numerous Member States have experienced severe scarcity of natural gas following the war in Ukraine that led to the impossibility to ensure the security of supply. However, the European Union still largely relies on the fuel for the generation of electricity; this is for instance the case of countries like Italy and Germany. Therefore, notwithstanding the plan to accelerate the transition towards clean sources and the targets set by the EU Commission for the lowering of energy consumes, Europe still must find an effective solution to cover the lack of natural gas in the short period.
The only possible option consists in the **diversification of the suppliers** and in the establishment of new commercial agreements and partnerships. In this way Member States can significantly reduce their dependency from Russia and they can also come to an agreement with a multiplicity of other providers throughout the world without establishing a semi-exclusive relationship as they previously did with Russia.
Therefore, besides the short-term purpose to cope with the scarcity issue, there is also the long-term objective to increase the resilience of the European Union in case of future crisis.

[74]Source: ADB. Asian Development Bank (2021). https://www.adb.org/publications/14th-five-year-plan-high-quality-development-prc
[75] China is the greatest producer of coal in the world with a share of 49.7% (2020) and it is also the largest consumer and the main importer.
[76]Source: European Union - European Commission (2022). https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_it

Norway, Azerbaijan, Qatar, Israel and Algeria are some of the new EU suppliers. However, these Countries mostly provide natural gas in its liquified form that is **LNG** (Liquified Natural Gas). The conversion of the fuel is necessary to enable the delivery process when there are no pipelines that directly connect suppliers and buyers. Therefore, natural gas is transformed into its liquid form through specific tank ships that are also used for the transportation. Consequently, the import of the fuel becomes more difficult to manage and more expensive due to the necessity to invest in the machineries needed for the conversion process.

Besides the establishment of new agreements, the plan has also enabled the creation of the **EU Energy Platform**[77] that basically allows Member States to jointly purchase natural gas. In this way the European Union can exert a higher and stronger bargaining power that single states would not be able to have if purchasing at national level.
Furthermore, the Platform has the purpose to unify Member States and to obstacle, particularly nowadays, during a situation of extreme difficulty, the rise of competitive behaviors among them and the consequent price increase. By operating collectively, the European Union is managing to purchase natural gas at a more competitive and affordable price, and it is also safeguarding the smaller and less economically influential countries from being put aside.

Following, there is the **clean energy objective** that foresees initiatives that, on one hand, operate on the reduction of fossil fuels and, on the other, directly on the development of renewable sources[78]. The goal is, in fact, to accelerate the 2030 target for renewables from 40%, as stated by the Fit for 55 Package, to **45%**[79].
Considering this framework, the EU Commission has approved some actions in the field of solar energy such as the introduction of stronger economic incentives to encourage private investments in solar panels and in the self-production of electricity as part of the **Solar Rooftop Initiative**.
The plan has also enforced the **EU Solar Strategy** aimed at doubling the solar capacity of Member States by 2025. Moreover, the EU Commission has largely committed in accelerating and simplifying the bureaucratic and legal actions behind the approval of renewable projects and investments.
The plan also sets the **35bcm** increase of biomethane by 2030 as part of the **Biomethane Action Plan** and the goal of reaching **10 million tons** of green hydrogen by 2030 for the import of which the European Union has already set up new partnerships with Namibia, Egypt and Kazakhstan.

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[77]Source: European Union - European Commission (2022).
https://ec.europa.eu/commission/presscorner/detail/en/IP_22_2387
[78]Source: European Union - European Commission (2022).
https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131
[79] In the end, the percentage of renewable energy sources to reach by 2030 that was agreed upon is currently equal to 42,5%

Lastly there is the project to consistently focus on **smart investments** to increase the innovation level and to drastically reduce GHG emissions. These investments are mostly addressed to transportation and heating, which are two of the most polluting sectors worldwide. They involve the purchase and development of the newest and most advanced technologies such as batteries to foster electric mobility and heating pumps to provide buildings and households with a more sustainable and efficient heating system.

Lastly, the REPowerEU aims to induce a general **decrease of energy consumption** to cope with the current shortage of natural gas and to avoid the high consumption of other, alternative, fossil fuels such as coal, whose usage, despite its high emission level, has increased since the begin of the crisis because of its lower price.
By setting the target of the 15% natural gas consumption decrease with respect to 2021 levels, the EU Commission has managed to significantly lower the dependency of Member States to the fuel and to encourage them to really start to invest in renewable sources. Moreover, the target was successfully reached and surpassed: energy consumes were in fact reduced by **20%**.
Another initiative of crucial relevance in terms of energy saving consists in the implementation of **new and stricter gas storage rules** aimed at ensuring the right collection of natural gas for the winter period.
The EU Commission has in fact set the obligation to fill the gas storage to **at least 90% of its capacity** every year by November 1st[80]. In this way it is possible for Member States to provide higher security and less price fluctuations and increases.

Additionally, the EU Commission has also proposed further measures to address the growing bill expenses that both households and businesses must suddenly face. These initiatives are however more controversial and still under discussion.
Firstly, there is the enforcement of a **cap on gas price**, meaning the setting of a maximum price threshold that consumers must pay, while the exceeding value is covered using national funds.
This measure was not adopted due to the opposition of some Member States among which Germany. Their main objection consisted in the lack of awareness that consumers would have had towards the real impact of the crisis and of their consequent indifference towards energy savings.
Then, the EU Commission has also discussed about the possibility to require **solidarity contributions** from those that have and still are benefiting from the crisis, specifically: fossil fuels generators and clean energy producers.

[80]Source: European Union - European Commission (2022). https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/eu-action-address-energy-crisis_en

The first cluster has been making enormous profits thanks to the high prices of natural gas and oil and to the rising demand for coal. While the producers of renewable energy have benefited from the extremely high contribution margins deriving from the large difference between the electricity market price set by the most expensive power plant and the price of the inframarginal generators.
The measure basically sets the duty for those that have benefited from the crisis to regularly pay the extra profits to the national governments with respect to a preestablished threshold. This action is extremely interesting since it aims to foster a greater equality and to hinder the possibility of some generators to enrich by exploiting a situation of deep social and economic discomfort.

2.2 Energy communities in the world: purpose and legal framework

The growing commitment of numerous countries worldwide and international organizations has led to the issue of many significant and impactful regulations and laws and to the increased awareness and sensibilization of individuals, entities and of the energy industry towards climate issues, sustainability and clean energy topics.

The shared goal consists in enabling the structuring of a more **interconnected and inclusive energy industry** that allows the participation of anyone, that is centered on a greater collaboration and that permits and fosters the self-generation of electricity and the reach of the decarbonization goals.
The European Union is extremely involved and proactive in this field, especially considering the present scarcity issues. In fact, similarly to other powerful countries such as United States and China, also the EU aspires to fill a leading role in the generation of renewable energy and in the reduction of GHG emissions.

Therefore, in order to effectively comply with its ambition and with the objectives set by Paris Agreement, the EU Commission has issued some fundamental Directives and Plans, which have introduced the concept of **energy communities** and have defined their purpose and structure for the first time.

Prior going forward with an in-depth analysis of the functioning and scope of energy communities, it is fundamental to clarify the differences between these types of organization and the practice of **collective self-consumption** (CSC)[81].

The latter basically consists in the establishment of a cooperative behavior, based on the joint self-generation of renewable electricity, among two or more individuals who necessarily live in the same

[81]Source: Frieden, D. et al. (2020). https://www.rescoop.eu/uploads/rescoop/downloads/Collective-self-consumption-and-energy-communities.-Trends-and-challenges-in-the-transposition-of-the-EU-framework.pdf

building or in the same apartment district. The participants to CSC usually produce the commodity by relying on a **commonly owned power plant**, which must be located in the building, for this reason the most adopted technologies are photovoltaics. Self-consumers then share and utilize a portion of the energy generated, while the surplus is injected in the national grid and sold to it[82].

Energy communities, on the other hand, can be described as legal entities based on the cooperation and collaboration among individuals, commercial activities and local authorities. They are centered on the self-production and self-consumption of electricity with the declared purpose to make the commodity **more affordable** and **available** within a given and limited geographical area.

Therefore, the main characteristics of these entities are the **decentralization** of the electricity production and the progressively **lower dependency** from the traditional energy market and the national grid for the purchase of electricity.

Energy communities are open to take a **multiplicity of forms**, for instance: non-profit organizations, small or medium size firms, associations and partnerships[83].

They are the outcome of the aggregation of people, firms and public entities, whose income must not be primarily related to the participation to the community and whose principal objective is, therefore, **not profit-oriented**. For this reason, it is not allowed the direct participation of enterprises operating in the electricity sector as members of the community. They can only join the organization by setting agreements to enable and to regulate the access to the greed of energy communities and their possibility to inject in them the electricity produced, therefore for what concerns the provision of the needed infrastructures.

The participation to energy communities takes place on a **voluntary basis** and it is **open to everyone**, except to those that have direct interests in the energy industry. Moreover, the decision to abandon the organization is usually completely free and without any obligation.

Therefore, differently from CSC, energy communities have a **precise legal structure**, they involve a greater group of actors, which are not exclusively individuals, and their operational area is broader. Moreover, the power plants employed within a given energy community must not be exclusively commonly owned, instead they can also be private. The only important factor is that the energy produced inside the community must be **shared** with all its members.

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[82] Source: Regione Emilia-Romagna (2023). https://energia.regione.emilia-romagna.it/comunita-energetiche/autoconsumo-collettivo-e-comunita-energetiche-rinnovabili-cosa-sono-e-quali-sono-i-benefici

[83] Source: European Union - European Commission (2023). https://energy.ec.europa.eu/topics/markets-and-consumers/energy-communities_en

2.2.1 Renewable and Citizen Energy Communities

The EU Commission has recently issued two Directives, that will be analyzed afterwards, that have provided a clear differentiation between two forms that energy communities can assume: Renewable Energy Communities and Citizen Energy Communities.

Renewable Energy Communities[84] present more limitations and qualifications for the access. They are strongly based on the principle of autonomy, meaning that the functioning of the entity must not be influenced by the actions undertaken by single members or by external market actors. Moreover, these communities require the **proximity of the members** to the project and to the generation plants. As it can be deducted by their name, the production of electricity must exclusively come from the use of **renewable sources**, which usually are solar, wind and hydropower.
Differently form the second type, the access to RECs is restricted to a narrow group of members whose participation to the project is not their principal economic activity. To safeguard the autonomy of the entity, such members must not be highly powerful or economically influential; therefore, they can only be natural persons, local authorities and small and medium firms.

On the other hand, **Citizen Energy Communities** present fewer binding requirements and less limitations for what concerns both the subjects that are allowed to participate and for the nature of the energy sources used.
In fact, anyone can be involved to the project regardless the size and the proximity. However medium and large companies are not permitted to exercise effective control in order to avoid a possible abuse of power for profit objectives. Furthermore, these communities are **technology-neutral**, meaning that they do not necessarily rely on the generation of clean energy, for instance they can also use fossil fuels.

Besides the undeniable differences, both forms share the same purposes, namely the generation of **social**, **economic** and **environmental benefits**. These may consist in the greater involvement of citizens in the energy industry, in the lowering of the electricity prices and in the possibility to earn from selling the excess to others or to the national grid, and, particularly in the case of RECs, in the contribution to the decarbonization process and to the emission reduction.
Additionally, both communities conduct quite the same activities such as the generation, distribution, storage and consumption of the electricity jointly produced[85].

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[84]Source: Enel Green Power (online). https://www.enelgreenpower.com/countries/europe/Italy/renewable-energy-communities
[85]Source: European Union - European Commission (online). https://rural-energy-community-hub.ec.europa.eu/energy-communities/what-energy-community_en

However, considering the growing focus on energy transition and the significant scarcity of fossil fuels, countries are trying to foster the establishment of Renewable Energy Communities more, since they better comply with the global future evolutions and objectives.

2.2.2 Energy Communities legal framework in Europe

The European Commission has firstly added to its legislation the topic of energy communities in 2019 with the issue of the **Clean Energy for all Europeans Package** (CEP)[86] that has enforced a set of measures finalized at the effective achievement of the energy transition and at the reduction of greenhouse gas emissions throughout all Member States.

The CEP has enforced two main Directives that play a fundamental role in the definition of the structure and scope of both Renewable and Citizen Energy Communities, namely the Renewable Energy Directive (REDII) and the Internal Electricity Market Directive (IEMD).

The **Renewable Energy Directive 2018/2001/EU** was enforced in December 2018, and it has set a new target for the consume of renewable energy of at least **32%** of the total share by 2030[87]. Moreover, the Directive particularly focuses on those sectors such as transportation and heating that are officially recognized as the principal responsible for the leakage of CO_2 emissions. The REDII has, in fact, fixed a minimum consumption of renewable energy in the transportation industry of at least **14%**.
Therefore, because of the particular focus on clean energy sources, this Directive is addressed to the management and regulation of Renewable Energy Communities.

Then, there is the **Internal Electricity Market Directive 2019/944/EU** that was issued in June 2019. The Directive establishes common rules for all Member States regarding the management of the different activities of the energy industry such as generation, transmission and distribution and for the effective and efficient regulation of the electricity market[88]. In fact, the Directive has set some important norms and measures to accomplish a better functioning of the retail market.
The goal of the IEMD consists in encouraging the creation of a common and fully integrated market for the fair and affordable exchange of electricity[89]. Moreover, through the Directive, the European Commission has managed to structure a more inclusive environment by fostering the active

[86]Source: European Union - European Commission (2019). https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en
[87]Source: European Union - European Commission (2023). https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en
[88]Source: IEA. International Energy Agency (2022). https://www.iea.org/policies/13710-common-rules-for-the-internal-market-for-electricity-updated-eu-directive-2019944
[89]Source: European Union (online). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019L0944

participation of citizens to the industry and by largely focusing on the practice of self-production of electricity. Differently from the REDII, this Directive regulates and sets the roots for the establishment of Citizen Energy Communities.

These two European Directives have been transposed into the Italian legislation initially through the legislative decree 162/2019, also known as **Milleproroghe Decree** and then with the **legislative decrees 199/2021** and **210/2021**.

With the **art. 42-bis**[90], the Milleproroghe Decree has firstly introduced in the Italian legislation the concept of Renewable Energy Communities and it has enforced an initial and highly restricted regulation for their establishment.
For instance, it has set a limit to the power capacity of renewable plants of a maximum of **200kWe** and it has stated that it was only possible to create a community among physical and legal persons connected to the same **secondary processing cabin**. So, the area and the dimension of RECs were initially extremely limited.
Afterward, the two legislative decrees issued in 2021 loosened the regulation and enabled the enlargement of the operational area of the Renewable Energy Communities. Additionally, they also contributed to the reduction of the legal and bureaucratic obstacles and delays. Among the new measures introduced it is possible to identify the increase of the power capacity threshold of the production plants from 200kWe to **1MWe**, the necessity to belong to the same **primary substation** of the REC, and the possibility for pre-existing renewable plants to actively contribute to the communities[91].

However, besides the significant changes and improvements introduced, the new regulations have also preserved some of the previous directions: for instance, the possibility for end-users that participate to the community to **freely choose their electricity suppliers**[92].

2.2.3. Energy Communities initiatives: the Repository, the Rural Advisory Hub and the Citizen-Led Renovation

In order to further support the diffusion of numerous energy communities throughout all Member States, the EU Commission has developed three initiatives that pursue the common goal of facilitating

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[90]Source: Enel Green Power https://www.enelgreenpower.com/it/paesi/europa/italia/comunita-energetiche-rinnovabili/direttive-europee-decreto-milleproroghe

[91] Prior the deliberation issued by ARERA it was not possible for the owners of power plants purchased before the legislative decree 199/2021 to participate to the energy community. In fact, just the technologies purchased and installed after the new regulation were admitted.

[92]Source: De Luca, A. (2023). https://senec.com/it/comunita-energetiche-normativa-aggiornata

their establishment; namely: the Energy Communities Repository, the Rural Energy Communities Advisory Hub and the support service for Citizen-Led Renovation[93].

The **Energy Communities Repository** was launched in April 2022 with the resolution to support individuals, business activities and public entities in the establishment of both renewable and citizen energy communities in **urban areas**.
The Repository is designated to provide technical and administrative knowledge and directions, impact and sustainability assessments of the energy communities that are about to be established and policy analysis[94]. It is currently appointed to assist the foundation of **urban energy communities** particularly in **East-European countries,** in order to enable the dissemination of the project throughout the entire territory.

Then, the European Commission has created, in June 2022, the **Rural Energy Communities Advisory Hub**, which basically oversees the same activities as the Repository, but, with the difference that it helps individuals and entities for the establishment of both forms of communities in **rural areas**.
The Hub is also employed as a platform for the collection of all the data and information related to RECs and CECs, that can be consulted and analyzed by governments, by local authorities and by the stakeholders involved in the project.

Lastly, the EU Commission has also established the **Citizen-Led Renovation**, which is a support service exclusively addressed to citizens who aim to create an energy community.
The initiative pursues the objective of allowing and fostering a **greater empowerment** and **engagement** of individuals with respect to the accomplishment of these projects. Therefore, it selects a few pilot projects that are launched by citizens and it assists them in order to solve technical, legal and organizational issues in the most effective way possible. Differently from the other initiatives, the development of this service is even more recent, precisely it was launched in April 2023.

Anyhow, besides the latest initiatives and measures, the establishment of energy communities throughout the world has also been strongly fostered by the will and the necessity to meet the clean energy and decarbonization goals set by the **2030 Agenda of the United Nations**[95] that aims at

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[93]Source: European Union - European Commission (2023). https://energy.ec.europa.eu/topics/markets-and-consumers/energy-communities_en
[94]Source: Castanié, M. (online). https://www.enelgreenpower.com/learning-hub/contributors/energy-communities-myriam-castanie
[95] The 2030 Agenda was signed by 193 countries throughout the world and it was approved by the United Nations in September 2015. The Agenda has set seventeen Sustainable Development Goals (SDGs) addressed to the improvement and evolution of social, economic and environmental issues. They aim consists in encouraging growth, welfare and innovation. They are also highly committed to protect the planet. The relevance of SDGs has significantly expanded

progressively solving the environmental issues of the planet, at improving social welfare and health and at enlarging the global innovation level. These goals should be achieved by all the countries that have joined the initiative within 2030[96].

2.3 Energy communities: structure and functioning, main actors, enabling technologies and energy sources

The process of creating an energy community can be summarized into three principal steps, namely: the establishment of a legal entity, the identification of a suitable area, and the installation of smart meters by all the members of the community[97].

As anticipated in the previous paragraph, energy communities can be organized according to a multiplicity of legal forms and they can follow many and alternative business models that differs depending on a variety of factors: mainly, the actors involved, and the rules agreed upon.

These drivers determine and influence a set of consequent aspects, such as the degree of involvement of stakeholders, the availability of resources and the electricity demand of the community[98].

2.3.1. Legal forms and establishment processes of Energy Communities

Among the legal forms it is possible to identify the **co-operative** which is one the most widespread organizational structure. This form primarily aims at providing the benefits of the generated electricity to its members, which have the right to vote for governance and profit allocation decisions. Co-operatives are also likely to generate many other advantages for both the community and its members; for instance, greater expertise and knowledge deriving from the arrangement of training programs and from practice sharing.

Otherwise, energy communities can be structured as **trusts and foundations**, therefore as charitable organizations. Also this legal form allows to provide numerous benefits to the members of the community and to the surrounding society, particularly to the individuals or households that cannot afford to actively contribute to the project.

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from Covid-19 and nowadays during the energy crisis, since they have become a key guideline to foster global recovery. Goal 7 is based on the provision of clean and affordable energy, therefore the contribution of energy communities to this objective can be significant and decisive.

[96]Source: Regalgrid Europe (online). https://www.regalgrid.com/en/magazine/community-energy-around-the-world/

[97]Source: BibLus-net (2022). https://biblus.acca.it/comunita-energetiche-cosa-sono-e-come-funzionano/.

[98]Source**:** European Union - Interreg Europe (2018). https://www.interregeurope.eu/sites/default/files/inline/2018-08-30_Policy_brief_Renewable_Energy_Communities_PB_TO4_final.pdf

Then, there is also the **public utility company**. In this case energy communities are established and administrated by municipalities that operate on behalf of citizens. This legal form is optimal in case of rural or isolated areas, which, due to the potential lower access to electricity through national grids, require a managerial approach that is stronger and more effective.

These three structures are mainly centered on the achievement of **social benefits**, therefore a greater security of electricity supply at lower prices and the increased engagement of individuals.

Anyhow, energy communities can also take two different legal forms that are more **profit-oriented**, but always within the limits allowed and in respect of the primary purpose of RECs. These forms are the **partnership** and the **public-private partnership**.
In the first case the initiative involves privates, namely individuals and business activities that jointly decide to cooperate for the self-generation of electricity within a given area. Differently form the co-operative model, in this case the voting power is not equal among all the participants, instead, it depends on the amount invested, therefore those that have placed more funds are the ones that can exert greater decisional and bargaining power.
Then, the public-private partnership is established through an agreement between local authorities, business activities and individuals; it follows the same functioning and rules as the partnership.

Energy communities can be established according to two alternative modalities[99]. The first one consists in the **"top down" approach**, meaning that the initiative is launched and managed directly at local level by public authorities or by related organizations.
The main drivers in this case are the necessity to solve issues of energy poverty and to produce social, economic and environmental value in the area. The project is mainly funded using **public resources**, and the revenues generated by the community are split among its members and then are partially reinvested within the organization with the purpose to enforce it and to enlarge its operational area.

Then, another possible method to establish energy communities is centered on the **"bottom up" approach**. This is the case in which the initiative can either start from individuals, from small and medium local activities, which are willing to invest in the purchase of renewable technologies for the generation of electricity or from organizations such as cooperatives.
In this case the community focuses more on the minimization of the cost of energy and on taking advantage from the financial income related to the generation and selling of the commodity.

[99]Source: Vansintjan, D. and Franzò, S. (online). https://www.enelgreenpower.com/learning-hub/debates/energy-communities-development-models

Lastly, energy communities can be created using a more **business-oriented approach**. In this case the initiative is launched by a company operating in the energy industry, which captures the potential of a given area for the self-generation of electricity. The company is the one that provides both funds and technologies, which are usually more advanced and efficient compared to the ones purchased at local level. Moreover, once the energy community has been created, it is possible for local public and private entities to contribute to the project and to invest in it.
This approach is beneficial for both the energy company that earns from the revenues of the community and for locals who can take advantage of the technologies and of the influence and expertise of the electric utility to expand the size and the impact of the project.

Then, it is fundamental to **select a location** that can be suitable for the establishment of the community and, particularly, for the installation of the needed power plants and enabling technologies. All the members of RECs must live and/or work in proximity to the power plants. Moreover, the plants used by the community must be connected to the **same primary electrical substation**; therefore, the permitted extension of the area is limited to a given perimeter that corresponds to about three or four municipalities or to two or three neighborhoods of big-cities[100].

Lastly, each member of RECs must install a **smart meter** that is a device which enables the collection, transmission and exchange of information and data between buildings, distribution operators and electricity retail companies.

2.3.2 Prosumers: the new main actors of RECs

As already affirmed, one of the main objectives of energy communities consists in the empowerment of individuals and in the stimulation of cooperative behaviors, of a more responsible consume of electricity and of a greater awareness towards the energy crisis and climate issues.

In this framework, characterized by the growing role and responsibility of individuals, a new figure has emerged, namely: the **prosumer**.
The word corresponds to the merge between producer and consumer, and it used to indicate all the individuals or entities that intend to perform a **proactive role** within the community, therefore as both consumers and producers of the commodity. So, anyone who is willing and economically able to invest in the purchase of a small size power plant, can automatically become a prosumer and a self-generator of electricity without the need to fully rely on the national grid and on the traditional suppliers.

[100]Source: Enel Green Power (online). https://www.enelgreenpower.com/it/paesi/europa/italia/comunita-energetiche-rinnovabili

When prosumers operate inside an energy community, they have the responsibility to sell a portion of the electricity produced to other members who take part to the project as simple consumers.

The distribution process of the commodity is allowed by using **micro-grids** which are structured similarly to the distribution ones, with the difference that they operate at a smaller scale and with lower voltages.

However, prosumers are **not entirely self-sufficient**, in fact, it may occur that their power plants are not able to generate enough electricity to meet the necessities. Consequently, they are still obliged to purchase the commodity from the national grid.

The number of prosumers is quickly expanding throughout the world; especially in the European Union thanks to the numerous regulations and directives aimed at promoting and at incentivizing the active role of consumers in the electricity sector. For instance, it is forecasted that Member States will count around **250 million prosumers by 2050** and that they will contribute to the generation of the **45%** of the total renewable electricity provided[101].

2.3.3 Clean energy sources used by RECs

As stated by the REDII, Renewable Energy Communities must exclusively exploit clean energy sources for the generation of electricity. These sources can be of multiple nature, namely: solar, wind and hydropower[102].

Solar energy probably is the most exploited source because of the greater ease of installation and lower investment costs of **solar panels**, compared to the technologies required by the other sources. Photovoltaics represent, in fact, the most flexible solution, since they can be located in numerous places depending on the space availability, for instance on rooftops, gardens or country lands that belong to the area allowed for the establishment of the community[103].
Therefore, solar energy can be considered the main renewable source that enables anyone who is willing to actively join a REC to become a prosumer.
Moreover, the generation of electricity from solar is being increasingly incentivized by the **lower expenditures** required for the purchase of PV panels. This price reduction can be principally attributed to the greater commitment of many countries in the energy transition and in the related investment in the adequate technologies and plants.

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[101] Source: Enel Green Power (2023). https://www.enelgreenpower.com/it/learning-hub/gigawhat/cerca-articoli/articles/2023/03/prosumer-energia
[102] Source: Eagleproject (2022). https://www.comunitaenergetichepnrr.it/
[103] Source: A2A Energia (2022). https://magazine.a2aenergia.eu/mobilita-elettrica/i-vantaggi-delle-comunita-energetiche

Many countries have in fact begun to produce the needed technologies; this is for instance the case of Italy that has opened a large **PVs factory in Catania**[104] under the ownership of Enel Green Power[105].

However, the current global leader in the manufacturing of PVs is **China**, that has recently invested significant resources and funds in the perspective of becoming the leading Country of the energy transition. The main feature of the Chinese photovoltaics production consists in the achievement of **economies of scale**, meaning the production of the maximum feasible amount of panels at the lowest possible cost. The result is a mass production of the technology that is of medium quality and that has low and, therefore, extremely competitive prices. Consequently, China is becoming the major exporter of photovoltaics in the world.

This situation can be extremely detrimental and risky since many countries, that are attempting to detach from fossil fuels and from their exporters, are progressively establishing a dependency relationship with China, but in the field of renewable energy.

It follows that, Italy and generally the entire European Union are employing funds, knowledge and all the resources available to strengthen and to enlarge the local manufacturing of solar panels, with the explicit purpose to become fully autonomous and detached from non-European countries.

Alternatively, RECs can also exploit **wind** for the generation of electricity. In this case it is fundamental for individuals or groups within a community to own a **micro-wind turbine**, which is basically the small-scale version of traditional wind turbine. This technology can either be exploited in urban and rural areas: in the first case it principally enables the electricity decentralization by allowing individuals, activities or other organizations to become more self-sufficient, while in the second situation it enables the provision of electricity to those areas that are not efficiently connected to national grids.

An important benefit related to the purchase of micro-wind turbines consists in the fact that, if strategically located, they can offer significant power generation performances. The power produced

[104] The 3SunGigafactory, located in the Etna Valley, was initially founded in 2010 as a joint venture between Enel Green Power, Sharp, a Japanese enterprise, and STMicroelectrinics, an Italian French company. However, already from 2015, Enel has become the only owner. 3SunGigafactory is the largest factory in both Italy and Europe for the manufacturing of photovoltaics; for instance, it has fabricated millions of extremely sophisticated PVs. In fact, the company boasts a high degree of automation and the employment of the most advanced technologies throughout the production process that permit the construction of extremely high-quality solar panels. Moreover, this high innovation level has enabled the factory to operate on a continuous basis, namely 24 hours a day, every day of the year, without interruptions or pauses.

[105]Source: Enel Green Power (online). https://www.enelgreenpower.com/it/chi-siamo/innovazione/3SUN-factory

from wind corresponds to the cube of its speed, therefore, the more micro turbines are positioned in a highly exposed area, the more they can contribute to the local electricity generation mix.
However, differently from traditional ones, micro turbines can only be located **onshore**, and their production capacity can amount to a **maximum of 100kWe**[106].
Nowadays, the principal markets for micro wind turbines are in the United States, in China, in the United Kingdom and in Germany. There is, however, potential for further developments, particularly in compliance with the progressive electrification of developing countries and with the global energy transition.

The principal issues related to the adoption of these technologies are of dual nature, namely: economic and social.
Firstly, the initial investment required for the purchase and installation of the turbines is still very high, these technologies are in fact even more expensive than the traditional turbines and their cost further increases if their owners want them to be connected to the national grid.
Then, for what concerns the second challenge, **issues of social acceptance** may arise; for instance, resistance towards the installation of micro turbines due to the possible noise, visual impact and risk of animal strikes.
All these factors constitute the reasons why these technologies are not widely exploited yet. However, the potential of wind energy is unquestionable and, with the adequate regulations, strategies and social acceptance campaigns, they will be largely and efficiently exploited in the future years.

Lastly, **hydropower** is another important clean source suitable for the generation of electricity in RECs. In this case the technologies required by these power plants are **hydroelectric turbines**, which are devises that enable the conversion of more than 90% of the kinetic energy of water into mechanical energy, specifically into electricity[107].
The entire process of establishing a hydroelectric power station is extremely complex, it therefore requires a long planning process, the collaboration of a strong and deeply committed group of persons and organizations, and numerous funds.
A fundamental step that must be conducted during the planning process consists in the **identification of an appropriate area** for the installation of the turbines. Differently from solar and wind power plants, the establishment of a hydroelectric plant is obviously strictly related to the presence of a river or watercourse that possesses an adequate magnitude for the placement of the technologies. This

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[106]Source: Project Drawdown (online). https://drawdown.org/solutions/micro-wind-turbines
[107]Source: Enel Green Power (online). https://www.enelgreenpower.com/learning-hub/renewable-energies/hydroelectric-energy/hydroelectric-turbines

requirement represents an important limitation that forbids many communities, that do not present a suitable location, to rely on the source.
Due to the considerable financing required for the achievement of the project, members that have invested in the initiative become **full-fledged investors**. They in fact own a proportional amount of shares with respect to what invested. Consequently, they actively participate, control the process and exert proportional voting powers.
Similarly to the other clean plants previously discussed, also hydropower stations present high initial costs but very low marginal ones, meaning that the technologies employed for the production of electricity need very **few maintenance expenditures**.
Therefore, it can be assessed that the return on investment (ROI) in these cases is quite convenient since hydropower plants allow to make profits in a very short period: starting from around five years after the investment[108].

Anyhow, despite the expensiveness and the limitation related to the availability of the site, RECs that rely on hydropower can provide a **greater and more stable security of supply** compared to wind and solar plants since the availability of water, except for extraordinary situations, is stable and continuous. On the other hand, wind and sun are not dispatchable and not always available.
However, unlike solar energy, both wind and hydropower technologies are more expensive and they also present more restricted requirements for what concerns the installation, such as the availability of open land with a high exposure to winds or the presence of rivers and streams with an appropriate size and speed.
Therefore, these sources can be considered more **collective** since individuals, singularly, usually do not possess the economic prerequisites nor the adequate spaces to privately own such plants.

Moreover, these technologies can also be used together; hydropower stations, specifically **hydropower water batteries**, can be employed by energy communities as **storage solutions** to collect and save the electricity generated by solar and wind power plants[109]. In this way it is possible to preserve the exceeding electricity produced in favorable conditions and to utilize it in case of shortages without the need to inject it in the national grid and without the risk of disperse it.
The electricity gathered by these batteries can then be released when needed and when the plants are not able to produce enough to meet the needs of the members. Therefore, the combined use of these

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[108]Source: The Renewable Energy Hub UK (2023). https://www.renewableenergyhub.co.uk/main/hydroelectricity-information/community-hydroelectricity-stations
[109]Source: IHA. International Hydropower Association (2022). https://www.hydropower.org/blog/with-hydropower-we-can-create-a-renewable-and-resilient-energy-system

technologies enables waste reduction, a more efficient management of the commodity and a more stable security of supply.

Anyhow, energy communities are also beginning to invest in **more advanced and powerful sources**, such as hydrogen, geothermal and district heating. However, since their management is still extremely complex and expensive, their adoption will increase concurrently with the improvement and strengthen of the knowledge and practices of energy communities.

2.3.4. Enabling technologies

In addition to the clean energy sources and to the related power plants, RECs must also invest in a multiplicity of **enabling technologies** whose principal scope consist in allowing communities to become efficient and fully interconnected among all their members.
These technologies are directed at permitting an uninterrupted sharing of real-time data concerning the consumes and the behaviors of the participants with the objective to guarantee the most efficient distribution of the commodity among all the members.
Two are the mandatory technologies required for the creation of RECs, namely: micro grids and smart meters.

Micro grids, also known as smart grids, constitute a primary necessity for the correct functioning of energy communities, since they permit the distribution of electricity from the prosumers to all the participants to the project. They can be described as the small-scale version of traditional transmission and distribution grids since, regardless the size, they similarly operate, and they pursue the same function: delivering electricity to every household and building and ensuring the security of supply.
They can either be entirely **independent from national grids** or they can be **connected to them**[110].
The first case usually occurs when the area in which the REC has been created is isolated and not supplied with the traditional grids.
While, in the second case, which is also the most frequent, micro grids still remain attached to the national ones so that they can have the opportunity to purchase electricity from them whenever it is needed and to inject and sell the surplus produced within the community.
Smart grids represent a new and innovative instrument to increase the independency of local actors from electricity suppliers and from traditional grids. They allow a greater sustainability, they are cost-effective options and they enable citizens to become more resilient and aware for what concerns the electricity production and consumption.

[110]Source: Nokia (online). https://www.nokia.com/thought-leadership/video-series/green-local-energy/

Then, the other fundamental enabling technology of RECs is the **smart meter**, which is a devise for the collection and transmission of all the data and information concerning the electricity consumes and behaviors of households, business activities and other organizations that parteciapte to the project. This technology is in fact capable of quantifying the amount of electricity injected in and purchased from the micro grids: it, therefore, permits to compute with a higher degree of certainty and exactitude, the electricity bills of the members of energy communities, without the need to rely on estimates.
Smart meters must be purchased and installed by every member of the community and they must be connected to the smart grid in order to enable the monitoring, the correct and efficient management of the distribution of the commodity and the injection of the exceeding part into the national grid[111].

These devices create a **bi-directional connection**[112] that actively involves and enables end-users to constantly monitor their consumes and expenses and, consequently, to switch towards more responsible behaviors oriented at reducing wastes and increasing energy savings.

However, the purpose of smart meters goes beyond the application to energy communities; in fact, they can also be purchased by end-users that exclusively purchase electricity from the traditional market.
Similarly to RECs, they permit to collect timely data about the electricity consume of individuals or entities that own the device. The information gathered is then analyzed by the companies operating in the retail sector to increase the level of precision and correctness of the bills, so that they can be based on the effective usage of the commodity.
Therefore, in both energy communities and traditional market, smart meters foster the concept of **"digital energy"**, meaning the creation of a more integrated, monitored, fair and innovative energy network.

Both devices, in order to properly function and to be able to store and analyze information, require some of the newest and more sophisticated technologies; for instance: Artificial Intelligence, Internet of Things, 5G and Blockchain.
These enabling instruments provide a high degree of efficiency, flexibility and interoperability among all the devices of the community.

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[111] Source: Regalgrid Europe (online). https://www.regalgrid.com/magazine/smart-meter-scopri-come-funzionano-i-contatori-intelligenti/
[112] Source: Eichberger, S. (2020). https://www.energy-community.org/dam/jcr:a00932e4-140d-4940-9aca-96c600f40900/E-Control_Smart%20Meter_Eichberger.pdf

For instance, **IoT** and **AI** guarantee advanced sensing and computing capacities that enable to quickly and effectively analyze the information collected with a margin of error close to zero.
Then, **5G** consents a fast communication with no delays, obstructions and interferences.
Lastly, **Blockchain**, thanks to its interconnected and extremely protected block structure provides a high degree of privacy and security from possible cyber-attacks[113], which are likely to occur in energy communities due to the significant interconnection among the members and because of data-sharing practices.

2.4. Potential benefits and challenges of RECs

As already anticipated, Renewable Energy Communities can provide numerous advantages to the economy, to individuals and to the society as a whole; however, since they are extremely recent projects they are not fully organized nor regulated yet. Therefore, besides the many benefits, they also pose important challenges that must be progressively overcame to enable the proper and efficient functioning of these organizations of individuals, activities and local public authorities.

As previously mentioned, the benefits generated by energy communities principally impact on the environmental, economic and social spheres.

By enabling the generation of electricity exclusively using clean energy sources, RECs can largely contribute to the transition towards renewable electricity and to the drastic reduction of GHG emissions.
Moreover, by increasing social awareness[114] regarding energy topics, they also incentivize greater electricity savings and a more controlled behavior and less waste of the commodity.
All these factors positively impact on the **environment** and on the **air quality** since they contribute to drastically lower the consumes and the related emissions. Energy communities are, therefore, increasingly helping many European and global countries to meet the goals of the Paris Agreement and to reach carbon neutrality in the upcoming years.

The establishment of RECs is also fundamental for the **decrease of the electricity prices**, which is particularly needed, especially nowadays in the middle of the energy crisis. Energy communities in fact enable their members to jointly generate electricity without the need to entirely depend on national grids.
Since the first and foremost purpose of these organizations is to expand the availability of the commodity by relying on a fair and competitive approach, electricity is usually sold at a **price equal**

[113] Source: Tera (2022). https://www.terasrl.it/en/2022/04/20/energy-community-en/
[114] Source: Sorgenia (2023). https://www.sorgenia.it/guida-energia/comunita-energetiche

to the production costs[115]. This strategy highly differs from the one adopted by the traditional market in which, on the other hand, electricity is sold using the System Marginal Price model, through which all the electricity produced, even the one generated by renewable sources, is sold at a price equal to the cost of the most expensive power plant accepted by the system, namely the natural gas power plant. It follows that even if clean energy should be sold at a lower and more affordable price, as a result of the lower marginal and maintenance costs, it is purchased at the market price, which is significantly higher. Besides the fact that the revenues obtained are only partially profits since a significant portion of them is reinvested within the power plants, it still remains that the electricity that could be more affordable is purchased by end-users at forbidding prices.
Consequently, energy communities enable members to buy the commodity at lower prices and to reduce the cost of electricity, while positively contributing to the improvement of the air quality.

Lastly, the creation and participation to RECs is extremely beneficial to the society. Firstly, since these communities are **open to everyone**, **democratic** and **highly transparent**, they greatly contribute to the rise of awareness of individuals towards climate and energy issues and towards the necessity to accelerate the transition.
They encourage persons and business activities to cooperate with each other and to become more independent from the traditional market.
Moreover, they constitute a more **inclusive environment** by providing stable and secure electricity to those areas that are not efficiently connected to the grid or not linked at all, for instance some isolated rural areas.
Then, another fundamental advantage consists in the reduction and **fight of energy poverty**[116] in order to enable those individuals that are economically marginalized in the traditional market to purchase electricity at a more favorable price[117].
Lastly, energy communities create numerous **job opportunities** both directly and indirectly associated to the project, for instance works related to the management of the community itself and of the needed technologies or jobs related to the local supply chain. These new employment opportunities lead to a greater social well-being and to the development and strengthening of more advanced knowledge, skills and practices.

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[115] Vansintjan, D. and Franzò, S. (online). https://www.enelgreenpower.com/learning-hub/debates/energy-communities-development-models
[116] Energy poverty occurs when individuals have low incomes, the thermal efficiency of households is significantly low while the costs of energy and the energy bills are extremely high. This is for instance the condition of many developing countries, Africa for instance.
[117]Source: European Union - European Commission (2022). https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty-eu_en

It is also important to point out that many benefits provided by RECs do not exclusively remain within its boundaries and its members. They in fact contribute to the generation of **positive externalities** that favorably impact on the outside society, economy and environment. For instance by creating further employment opportunities, by contributing to the innovation of the local territory and by improving the quality of the surrounding environment.

However, besides the numerous advantages, RECs are still far from being perfect and efficient, since they are extremely recent and not appropriately regulated yet.

Firstly, issues related to the **economic acceptance** of the project can still occur, meaning that individuals, business activities and local entities may not be willing to invest large amount of their own resources in a project whose outcome is still uncertain and not sufficiently regulated nor safeguarded.
In these circumstances, the only possible alternative is to request external financing principally to banks or other financial intermediaries; however, also in this case, the challenge is likely to endure due to the general lack of commitment and awareness towards the initiative.

Additionally, the REDII is a quite recent regulation, therefore many Member States have not appropriately adapted their national legislation to it. As a consequence, the legal and bureaucratic practices required for the establishment of an energy community may still be highly confusing and they probably require long time to be fulfilled[118]. These **potential delays** and **obstructions** are additional elements that can discourage individuals from funding a REC.
Moreover, the **lack of a stable and well-defined regulatory framework** contributes to the rise of multiple complications and doubts related to the management of the plot of land in which the plant and the technologies are located[119]. This one can, in fact, be either a public or a private property; in this second eventuality it may still be difficult to set boundaries and to establish to which extent and under which rules it is possible to install commonly owned technologies in the area.

Additionally, the creation of energy communities requires a **strong driving force**[120] able to manage all the steps of the creation process and to encourage cooperation and participation to the project. This force can be of multiple nature, for instance a company interested in investing in a given area, local authorities or simply a group of highly committed individuals.

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[118]Source: Sorgenia (2023). https://www.sorgenia.it/guida-energia/comunita-energetiche
[119]Source: Barbiroglio, E. (2022). https://ec.europa.eu/research-and-innovation/en/horizon-magazine/energy-communities-bring-renewable-power-people
[120]Source: European Union - Interreg Europe (2018). https://www.interregeurope.eu/sites/default/files/inline/2018-08-30_Policy_brief_Renewable_Energy_Communities_PB_TO4_final.pdf

The challenge occurs when there is a **lack of leadership** and the group that has launched the initiative is not able to gather and to engage others nor to appropriately guide them towards the establishment of the community.

Lastly, besides the economic, regulatory and organizational problematics, energy communities must also face **issues of social acceptance**, that basically consist in the resistance of numerous individuals and groups towards the installation of renewable power plants.
This opposition is caused by the inaccurate belief that these technologies can be responsible of problems of noise and turbulence and, therefore, by the idea that they negatively impact the land and the quality of life. This behavior is the consequence of the aforementioned controversies of RECs but also of the lack of national and local sensibilization campaigns that should be aimed at educating individuals to the benefits that these new forms of self-generation of electricity could bring to the society as a whole.
However, not all renewable technologies are equally subjected to this issue, for instance solar panels, especially the ones placed on rooftops, are considered less intrusive and are therefore more accepted. Wind and hydropower, on the other hand, are more controversial principally due to the greater size, to the fact that they are not static and to the greater initial investment required.

2.5. RECs in the world, in Europe and in Italy

Fostered by the growing environmental commitment and by the issue of proper regulations, energy communities are beginning to spread across the world widely and quickly. Some interesting examples of the successful implementation of RECs are briefly listed and analyzed below.

RECs established in the **United States** are mainly centered on the self-generation of solar energy, for which the Country owns extremely powerful and advanced technologies. US energy communities were, in fact, capable to generate **51.45 GW** of electricity using PV panels in 2018[121]. The regulatory system in the matter is **highly decentralized**, meaning that each State is free to autonomously set rules and measures that are tailored to the specific situations and necessities.

Then, **Australia** is also significantly investing in the diffusion and expansion of Renewable Energy Communities. They are located both along the cost and in the most inland and disconnected areas of the country where the national grid is not able to provide an efficient and secure supply of energy. The electricity produced by energy communities has been progressively growing and, even if the generation capacity is still far from the US outcomes, Australia has managed to achieve a production of **10.3GW** in 2018.

[121]Source: Regalgrid Europe (online). https://www.regalgrid.com/en/magazine/community-energy-around-the-world/

Additionally, national government and other legal entities are highly committed to the achievement of energy transition and to the establishment of numerous RECs throughout the national territory. Therefore, they are increasingly incentivizing the Country, its citizens and activities to invest in smart technologies and in the generation of clean electricity. In this framework, the role played by **ARENA**[122] is key: the Agency has, in fact, allocated **$330,000** to encourage the joint production of electricity[123] in the Country.

Lastly, it is possible to discuss about some interesting **European Union** cases of electricity self-production. The most advanced and enduring RECs are mostly located in the Northern area, where the use of clean sources was already highly widespread prior the energy crisis.

The Member State with the largest number of operating energy communities, precisely 1.750, in 2020 was **Germany**. The commitment of the Country towards the establishment of these organizations has begun during the ‘90s and it has rapidly grown over time.
German self-generation of electricity mainly relies on solar energy, though which the Country has produced **45.9GW** of electricity already in 2018. Since then, besides becoming a European leader, the State was also able to position itself among the global top five, with a very small deviation with respect to the United States.

Then, the second position for the number of RECs founded on the territory is covered by **Denmark**, with 700 communities[124]. The dedication of the Country to the autonomous generation of electricity using renewable sources dates back to the ‘70s, when it has begun to invest in numerous enabling technologies.
Because of the long history and, consequently, experience in the field, the renewable generation capacity of Denmark is among the highest in the world. The Member State mainly produces electricity using the numerous **wind turbines** that were installed throughout the national territory, 80% of which were already under the ownership of communities in 2013. Moreover, the Country is also progressively increasing its investments in solar panels since 2012.

Italy is also expanding the number of RECs established in the national territory. In fact, the latest Legambiente report (2022) has identified 35 fully operative communities, 41, which are currently in

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[122] ARENA. Australian Renewable Energy Agency, it was funded by the Australian Government on 1 July 2012. The purpose of the Agency is to support the Country in the energy transition process; therefore, in the investment in smart and enabling technologies and in the increase of the electricity generation capacity related to renewable energy sources.
[123]Source: ARENA. Australian Renewable Energy Agency (2022). https://arena.gov.au/what-is-renewable-energy/
[124] Source: Enel Green Power https://www.enelgreenpower.com/countries/europe/Italy/renewable-energy-communities/renewable-energy-communities-italy-europe

the design stage, and 24 that are about to be founded, for a total of **100 Renewable Energy Communities**[125].

The power plants employed by Italian RECs tend to have a capacity that ranges **between 20kWe to 60kWe**[126]; however, according to the studies and analysis provided by Legambiente, renewable plants are not, for now, widespread nor powerful enough to enable Italy to meet the 2030 objectives.

Then, for what regards the clean energy sources used, the principal one is **solar**, mainly thanks to the high exposure of the Country to sunlight.

Anyhow, there are also many examples of communities that exploit wind and hydropower, for instance the energy **community of Foiano di Val Fortore**[127] that has managed to utilize all the three sources and technologies together to enable the production of electricity and then, its storage though the use of hydroelectric turbines. With this system, the community is now able to ensure a 100% energy coverage to the entire municipality.

[125] Source: Legambiente (2022). https://www.legambiente.it/comunicati-stampa/legambiente-presenta-comunita-rinnovabili-2022/

[126] Source: Enel Green Power (online). https://www.enelgreenpower.com/countries/europe/Italy/renewable-energy-communities/renewable-energy-communities-italy-europe

[127] Source: Legambiente (2022). https://www.legambiente.it/wp-content/uploads/2022/05/Comunita-Rinnovabili-2022_Report.pdf.

Chapter 3: analysis of the possible configurations of REC and of the economic benefits that they may generate on the members

3.1 Research question

Renewable energy communities, as already stated in the previous chapter represent a quite recent phenomenon, particularly if considering the Italian case.
In fact, most of them have been designed and established after the issue of specific legislations, for instance, the Milleproroghe Decree that was promulgated in 2019 and that was the first instrument through which the Italian government has introduced and defined the concept, structure, functioning and purposes of RECs.

Anyhow, despite the numerous progresses that Italy has been making in the sector, and the growing involvement and commitment of households, companies, organizations and institutions with respect to the initiatives and to the topic of energy transition in general, there are still numerous improvements and clarifications that must be accomplished.

The objective of this chapter consists in providing an analysis of the **economic feasibility** related to the establishment of a renewable energy community and of the **economic benefits** that it may grant to its participants, both in terms of electricity savings and earnings. Therefore, the goal is to ascertain whether the RECs, as they are currently structured and regulated, can be truly beneficial to individuals and organizations from an economic perspective.

3.2 Incentive schemes and financing methods currently implemented in Italy

Prior proceeding with the analysis of the different case studies, it is necessary to focus on the incentive schemes and financing methods that have been introduced and that are currently granted by the Italian government.

Since the issue of the REDII by the European Commission and the consequent national implementation of it through the **Milleproroghe Decree**[128], the Italian government has begun to provide several economic incentives aimed at encouraging individuals, SME and public authorities to establish Renewable Energy Communities and collective self-consumptions initiatives[129]. The incentives are primarily directed at facilitating the purchase of the needed technologies by making them more affordable and by ensuring a shorter payback time for the initial investment.

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[128]The Milleproroghe Decree, technically named Decree Law n.162, was issued on December 30th, 2019. Then, from the following year, it has been coordinated with the conversion law n.8, which was promulgated on February 28th, 2020.
[129]Source: Italia. Decreto-Legge 30 dicembre 2019, n. 162, https://www.gazzettaufficiale.it/eli/id/2020/02/29/20A01353/sg

3.1.1 Current regulations

Presently, the topic of REC and CSC is still regulated by the Milleproroghe Decree, specifically accordingly to what stated in **art. 42-bis**, and by the related enforcement resolutions of ARERA[130] and MiSE[131].

Respectively, the former has validated the virtual regulatory model for the remuneration and concession of the economic benefits resulting from the amount of electricity consumed within the Community[132]. Then, the latter has identified and introduced two different incentive tariffs to be applied on any renewable power plant employed in collective self-consumption initiatives and on RECs.

The value of the tariff corresponds to **100€/MWh** in the case of collective self-consumption (CSC) and **110€/MWh** for Energy Communities[133].

Anyhow, the **Legislative Decree 199/2021** issued on November 8th, 2021, has introduced some adjustments, and it has partially loosened some of the parameters that were set by the Milleproroghe Decree[134].

Two are the most meaningful and impactful modification namely: the rising of the total admitted power capacity of the renewable plants from 200kWe to **1MWe**, and the enlargement of the perimeter of energy communities from the secondary to the **primary substation**[135].

Additionally, it has introduced the possibility for already existing plants to be part of RECs, but with the obligation to contribute up to a given threshold; namely the **30% of the total capacity of the Community**[136].

Moreover, another significant legislative instrument introduced with the purpose of strengthening the regulation of both REC and CSC and of fostering their establishment is the Decree-Law 34/2020,

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[130] ARERA. Autorità di Regolazione per Energia, Reti e Ambienti. Delibera 04 agosto 2020 318/2020/R/eel, https://www.arera.it/it/docs/20/318-20.htm

[131] Italia. Ministero dello Sviluppo Economico. Decreto 16 settembre 2020, https://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2020-11-16&atto.codiceRedazionale=20A06224&elenco30giorni=false

[132] Source: ARERA. Autorità di Regolazione per Energia, Reti e Ambienti (202). https://www.arera.it/allegati/schede/318-20st.pdf

[133] Italia. Ministero dello Sviluppo Economico. Decreto 16 settembre 2020, https://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2020-11-16&atto.codiceRedazionale=20A06224&elenco30giorni=false

[134] Source: Italia. Decreto legislativo 8 novembre 2021, n. 199, https://www.gazzettaufficiale.it/eli/id/2021/11/30/21G00214/sg.

[135] The initial threshold was considered excessively tight and limiting since it significantly reduced the overall possible participation to the community and it also hindered the scalability of the initiatives, which should be a fundamental objective.

[136] Enel X (2023). https://www.enelx.com/it/it/storie/2020/05/comunita-energetiche-cosa-sono

also known as **Rilancio Decree**[137]. It was issued by the Italian government on July 1st, 2020, precisely during the Pandemic Covid-19, with the objective to provide an incentive to foster new investments in the field of energy efficiency and for the recovery of the construction industry with a particular focus on the seismic risk mitigation.

The leading fiscal measure introduced by the decree to achieve these two goals consists in the so called **Superbonus**, which basically corresponds to a **tax deduction of 110%**; the rate is, however, planned to progressively decrease throughout the years, until reaching 65%. With respect to the two areas of application, it is therefore possible to distinguish between two subsidies, namely the **Super Ecobonus** and the **Super Sismabonus**.

This initiative is not directly aimed at favoring the establishment of Renewable Energy Communities; instead, it primarily refers to apartment buildings and to individuals, which, due to the issues generated by the Pandemic, experienced significant monetary losses and were not able to autonomously invest in projects of these extents anymore. So, the general objective consisted in enabling and supporting the economic recovery of the entire Country; moreover, the Decree has also strongly committed in encouraging the establishment and expansion of energy efficiency solutions.

The Superbonus has, in fact, proven to be an effective initiative to incentivize investments, particularly for what concerns the energy sector. Many households have, in fact, adopted **thermal insulation systems**[138] to reduce the leakage of heat form buildings and to decrease the waste of electricity and the CO_2 emissions generated[139].

Additionally, the Ecobonus has fostered the installation of numerous solar panels on many rooftops, therefore, it has drastically encouraged individuals to partially switch towards self-generation practices.

Moreover, the Rilancio Decree has also positively contributed to the development of Italian energy communities by providing a regulation in **art. 119**. Specifically, the Decree has taken in consideration two options: the case of energy communities that **manage power plants**, or rather, the situation in which they **install the needed power plants**. In the first case the decree has stated that it is possible to use the tax incentive for the renewable power plants that are managed by RECs and by their

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[137] Source: Ediltecnico: quotidiano online per professionisti tecnici (2023). https://www.ediltecnico.it/112102/superbonus-fotovoltaico-e-comunita-energetiche-rapporto-tra-detrazioni-edilizie-e-cer/

[138] Thermal insulation systems are a solution for individuals and organizations to partially decrease the energy demand for both cooling and heating and, consequently, to contribute to the GHG emissions reduction. These systems, through the employment of specific insulation material, create a building envelope that prevents both heat losses and gains.

[139] Source: Regalgrid Europe (online). https://www.regalgrid.com/en/magazine/thermal-insulation-things-and-what-materials-to-use/

members up to a maximum power capacity of **200kWe**. The maximum amount of spending to which the Super Ecobonus can be applied corresponds to 96.000€.

While, if RECs directly invest in the construction of the required plants, the incentive is applicable to a maximum power capacity of **20kWe**, while the exceeding portion is subjected to the **ordinary tax deduction of 50%**[140] for a maximum capacity of **200kW**. Also, in this case the incentive can cover up to a half of a maximum expenditure of 96.000€.

Moreover, the **Rilancio Decree** has introduced an additional incentive mechanism that enables the participants of energy communities to sell the surplus of electricity directly to Gestore dei Servizi Energetici (GSE) without the need to rely on the free market[141]. This method is denominated **Ritiro Dedicato**[142] and it consists in the purchase, at a pre-established price per kWh, of the electricity self-generated and not consumed in the REC by the GSE. Therefore, differently from the free market[143], it is characterized by a greater practicability and efficiency, and it safeguards prosumers from the volatility of electricity prices.

3.1.2 MASE Decree and TIAD

At present, the Italian government is waiting for the approval of the draft of the MASE[144] implementing Decree, which is still under the analysis of the European Commission.

This new legislative instrument focuses on the identification and introduction of a new and improved incentive system that can simplify the process of implementation of RECs and that can accelerate the general energy transition of the Country.
Therefore, compared to the current legislation, it may represent a significant step forward towards the accomplishment of 2030 and 2050 goals.
Additionally, another purpose behind this resolution consists in determining the criteria to properly and efficiently manage the distribution of the funds provided by the **Recovery and Resilience Plan**[145] (RRP).

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[140] Source: Salamita, D. (2022). https://www.lavoripubblici.it/news/comunita-energetiche-rinnovabili-condominio-superbonus-110-bonus-ordinario-50-28576
[141] The possibility to obtain the incentive is conditional to the sale of the electricity that has been produced within the community and that was notself-consumed.
[142] Source: Ediltecnico: quotidiano online per professionisti tecnici (2023). https://www.ediltecnico.it/112553/comunita-energetiche-rinnovabili-e-compatibilita-tra-bonus-ristrutturazione-e-ritiro-dedicato/
[143] The average price of electricity in the free market amounts to 50€/MWh
[144] MASE. Ministero dell'Ambiente e della Sicurezza Energetica, established in 1986, https://www.mase.gov.it/
[145] The Recovery and Resilience Plan is the plan structured and approved by the Italian government in 2021 with the aim of fostering the economic recovery of the Country in a post-Pandemic framework.

Two are the main innovations in the incentive and financing area that will be introduced by the Decree, namely: the **premium tariff** and the **non-refundable aid**[146].

The former is an incentive that is applied on the percentage of self-generated electricity that is shared and self-consumed within the REC. The tariff is structured into two parts, specifically a **fixed** and a **variable amount**, whose values vary according to the power capacity of the renewable plants employed.

Therefore, for practical and clarity reasons, the tariff has been divided into the following three ranges:

<table>
<tr><th colspan="4">Premium Tariff</th></tr>
<tr><th>Power capacity (kWe)</th><th>Fixed part (€/MWh)</th><th>Variable part (€/MWh)</th><th>Maximum total amount (€/MWh)</th></tr>
<tr><td>< 200</td><td>80</td><td rowspan="3">Maximum between 0 and the difference between 180 and zonal price. Threshold of 40.</td><td>120</td></tr>
<tr><td>from 200 to 600</td><td>70</td><td>110</td></tr>
<tr><td>>600</td><td>60</td><td>100</td></tr>
</table>

Table 1 - Premium tariff amounts considering the power capacity

As shown above, the fixed part of the tariff progressively decreases with the rise of the power capacity, while, for what concerns the variable one, it may correspond to a value of up to **40€/MWh**. Consequently, the Decree has set the maximum amount of the incentive that each cluster may be entitled to obtain.

146 Arcudi, C. et al. (2023). https://agici.it/wp-content/uploads/2023/04/AGICI-Accenture_Report-Comunita-Energetiche_-Maggio2023.pdf

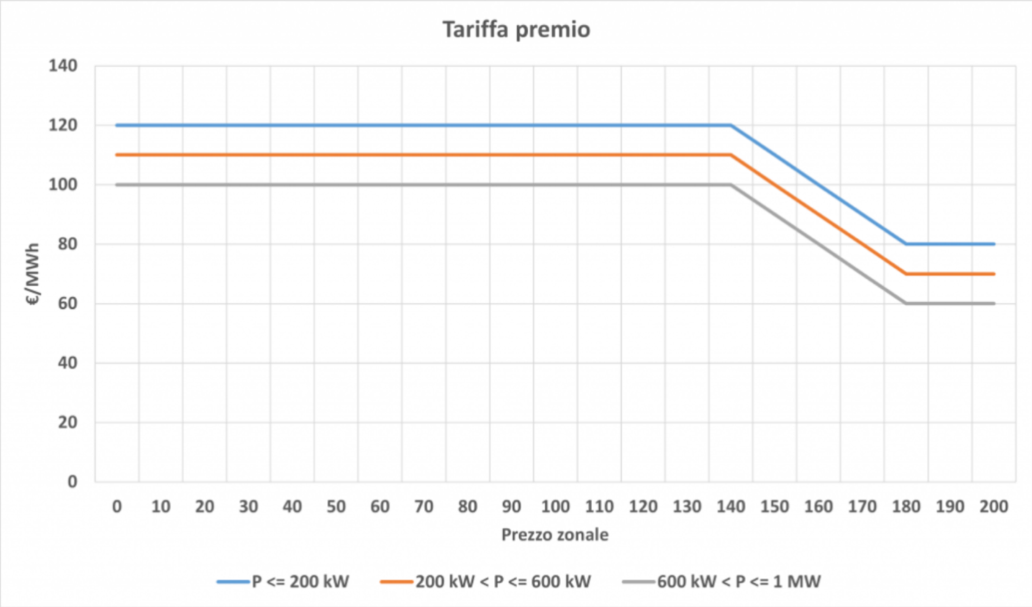

Figure 7 - Variation of the premium tariff with respect to different zonal prices

The main requisites needed to receive the incentive are two, namely:

- The maximum nominal power capacity[147] of the single plant cannot exceed 1MWe;
- The power plant must be located in the area underneath the same primary substation of the REC.

Once the incentive has been granted, it is provided for a duration of **20 years**[148] starting from the entry in operation of the renewable plant.

Additionally, for what concerns the RECs that employ solar panels for the electricity generation, the Decree has also planned some price corrections to be applied to the tariff in consideration of the different exposure to sunlight and, therefore, availability of the resource throughout the Country.

So, the central regions of Italy (Lazio, Marche, Toscana, Abruzzo and Umbria) are entitled to receive an extra of **4€/MWh**, while the northern ones (Emilia-Romagna, Friuli-Venezia Giulia, Liguria, Lombardia, Piemonte, Trentino-Alto Adige, Veneto and Valle d'Aosta) will obtain an extra of **10€/MWh**[149].

[147] The nominal power capacity of a renewable plant corresponds to the sum (in MW) of the nominal power capacities of the single generators that belong to the plant itself.

[148] The Decree has, however, identified a set of grounds of revocation, which, if they may occur, they will determine the full recovery of the subsidies. This resolution can be taken if the REC suddenly lacks one or more eligibility requirements or in case of the employment of false statements and information in order to have access to the support system.

[149] Dominelli, C. (2023). https://www.ilsole24ore.com/art/comunita-energetiche-impianti-ammessi-spese-finanziabili-e-requisiti-ecco-come-si-accede-incentivi-e-aiuti-AE749XtC

Lastly, the premium tariff will not be applied to the share of self-produced and self-consumed electricity generated by the renewable power plants that were financed using the Superbonus[150].

Then, the Decree also aims to introduce some subsidies that consist in the non-refundable aid that is provided using the resources of the RRP, which amount to **2,2€ bln** and through which the Italian government aspires to install a total power capacity of at least 2GW and to reach a yearly electricity production of 2.500GWh[151].

It is crucial to specify that the primary requisite to become eligible for the subsidy is that the REC must be established in a municipality that counts a **maximum of 5.000 inhabitants**.

The total value of the aid cannot surpass the **40%** of the initial investment costs and it is distributed in two different moments[152]; precisely, the first amount is provided immediately after the accomplishment of the 30% of the work[153]. Then, the energy community can be supplied of the remaining 10% by making a request for final reimbursement to the GSE and by attesting the completion of the construction activities.

The maximum investment cost allowed to be able to obtain the subsidy is classified into three categories based on the power capacity of the pants that RECs plan to install:

Maximum investment cost	
Power capacity (kWe)	Maximum investment cost (€/kW)
< 20	1.500
from 20 to 200	1.200
from 200 to 600	1.110
from 800 to 1.000	1.050

Table 2 - Maximum investment cost that can be financed with RRP non-refundable aid

[150] Premium tariff and Superbonus 110% cannot be cumulated.
[151] Dominelli, C. (2023). https://www.ilsole24ore.com/art/comunita-energetiche-ecco-come-si-accede-incentivi-e-contributi-fondo-perduto-pichetto-nuova-energia-all-italia-AEsREDsC
[152] Similarly to the premium tariff, also for this support system the Decree has identified some grounds of revocation that will predispose to the cancellation and to the repayment of the received aid by the Community.
[153] Arcudi, C. et al. (2023). https://agici.it/wp-content/uploads/2023/04/AGICI-Accenture_Report-Comunita-Energetiche_-Maggio2023.pdf

Some of the main expenditures that can be partially financed by the funds of the RRP are the ones concerning the building of the power plants, the purchase of technological equipment (hardware and software), the practicability analysis and the cost estimations required for the accomplishment of the project, and the connection of the REC to the national transmission and distribution systems.

Lastly, the RRP non-refundable aid can be cumulated with the premium tariff, however the latter must be granted for a **maximum of 40%**.

Additionally, correlated to the MASE Decree, there is **Testo Integrato dell'Autoconsumo Diffuso**[154] (TIAD)[155], which is a resolution issued by ARERA in substitution of the previous one (318/2020/R/eel) that aims at providing a **more precise regulation** and a **procedural simplification** of the practices and steps needed for the establishment and management of both RECs and CSC projects.

Among the numerous deliberations, it is important to focus on the introduction of the obligation for distribution companies to publish on their websites the map of all the areas that belong to each primary substation present in the territory under their jurisdiction. The purpose of this requirement consists in reducing issues of information asymmetry and in enabling individuals and organizations that want to fund or to become part of an energy community to effectively verify the area to which their PODs[156] belong[157].

Moreover, the TIAD has also provided a quantification of the network costs that REC and CSC participants avoid considering the consume of self-produced and shared electricity. Specifically, for what regards RECs, the avoided costs amount to **8,48€/MWh**[158].

Lastly, it is fundamental to mention that notwithstanding the fact that the text of the resolution has been approved and it is, therefore, ready to be implemented; it will be applied exclusively after the enactment of the MASE Decree.

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[154] ARERA. Autorità di Regolazione per Energia, Reti e Ambienti. Delibera 27 dicembre 2022, 727/2022/R/eel, https://www.arera.it/it/docs/22/727-22.htm

[155] Source: ARERA. Autorità di Regolazione per Energia, Reti e Ambienti (2023). https://www.arera.it/it/com_stampa/23/230104.htm

[156] Point Of Delivery (POD) is a 14 characters code that can be found on both electricity bills and meters, and it refers to the point where the commodity is delivered. Each user owns its specific code.

[157] Enel energia (online). https://www.enel.it/it/supporto/faq/dove-trovare-codice-pod-e-pdr

[158] RSE. Ricerca sul Sistema Energetico (online). https://dossierse.it/19-2023-cer-e-autoconsumo-collettivo-alcune-simulazioni-numeriche-alla-luce-della-nuova-regolazione/

3.3 Identification of the RECs configurations object of analysis

With respect to the research question structured at the begin of the chapter, it is now essential to identify a set of possible situations that may arise within an energy community to conduct a proper and effective analysis of the economic benefits that it may provide to its members.

In order to properly do that, it may be suitable to refer to the recent research «**Community Energy Map**»[159], which provides a classification of renewable energy communities.

The study has, in fact, structured a mapping of all the RECs currently operating in the Italian territory and, also, of the ones that are still undergoing a planning and design process[160]. Moreover, the research has also distinguished the communities in two time periods, namely: the ones that were established prior the Law 8/2020 and the ones that were funded afterwards, therefore the ones that comply with the requirements introduced and that are shown in *Figure 8*.

Figure 8 - RECs developed after the enforcement of Law 8/2020

Lastly, the research has also elaborated a classification of RECs into three different models according to the nature of the promoters of the project. Specifically, the clusters identified are the pluralist model, the public lead model and the community energy builders model[161].

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[159] *Community Energy Map* is research published on December 13th, 2021, oriented at providing a general framework and an analysis of the As-Is situation, arrangement and diffusion of RECs in Italy. The study was jointly conducted by RSE (Ricerca Sistema Energetico), Luiss Business School and by the University of Trieste.

[160] De Vidovich, L. and Tricarico, L. and Zulianello, M. *Community Energy Map : una ricognizione delle prime esperienze di comunità energetiche rinnovabili.* F. Angeli, 2021

[161] De Vidovich, L. and Tricarico, L. and Zulianello, M. *Community Energy Map : una ricognizione delle prime esperienze di comunità energetiche rinnovabili.* F. Angeli, 2021

3.3.1 The pluralist model

The first case occurs when the REC is established directly by its **members**; usually the initiative begins from groups of people and associations such as cooperatives or local non-profit organizations, while it rarely starts from individuals. This phenomenon can principally be attributed to a lack of knowledge, of initial commitment to the cause or to the inability to produce the needed social engagement.

This model is, therefore, centered on a **bottom-up** approach and it is primarily oriented at reaching a greater energy efficiency through the employment of RES and at reducing the electricity expenditures thanks to the autonomous generation of the commodity. Then, other additional goals pursued by the model consist in strengthening social cohesion and in educating residents to key environmental topics and issues[162].

Then, for what regards the financing methods, the communities structured according to this model can either rely on **self-financing**, that is the case in which all the participants invest a portion of their own economic resources (equally or not), or on **external financing**, therefore by asking for bank loans to cover the initial expenditures[163].

3.3.2 The public lead model

Then, there is the public lead model in which the promoters of the project are **municipalities** or other **local public authorities**. So, differently from the previous method, this case follows by a **top-down** approach.

Similarly to the pluralist model, also in this case some of the main objectives concern the achievement of energy efficiency and of electricity expenditure reductions[164]. Anyhow, the public lead model is also considerably committed to the fight against **energy poverty**, which, unfortunately, constitutes a significant issue especially for what concerns small and rural areas.

The RECs created using this approach are usually financed with **public funds** and resources.

For the sake of the study, it is convenient to take into account the case of a REC that is established in a municipality that counts less that 5.000 inhabitants and that is, consequently, eligible for receiving the non-refundable aid supplied by the RRP that can cover up to 40% of the initial investment cost.

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[162] Armanasco, F. (2022). https://www.enea.it/it/seguici/events/come-res-1/Armanasco_ComeRES.pdf
[163] De Vidovich, L. and Tricarico, L. and Zulianello, M. (2023). https://www.rivistaimpresasociale.it/rivista/articolo/modelli-organizzativi-per-le-comunita-energetiche
[164] Bovio, S. (2022). https://www.ge.camcom.gov.it/it/promuovi/enterprise-europe-network-een-alps/camcom-12-07-2022-bovio.pdf

Moreover, since the public lead model is strongly focused on the issue of energy poverty, the analysis will only take into account a sample of households selected according to the possible economic difficulties for accessing to electricity[165].

3.3.3 The community energy builders (CEB) model

Lastly, the final cluster is the community energy builders (CEB) model which presents a slightly different structure and organization compared to the other two systems and it is also the most controversial and difficult to regulate, to structure and to manage.

The promoters of this model are of multiple nature and the RECs are established through a "partnership" and a collaborative method between local groups of people or local organizations such as cooperatives, and **Energy Service Companies (ESCos)**, therefore, firms actively operating in the electricity industry.

Consequently, this model is based on **heterogeneity** and on a mixture between two approaches, respectively: bottom-up and top-down[166].

The CEB system, if effectively handled and regulated, may be the most performing one since, thanks to the knowledge, expertise and machineries provided by energy utilities, it can enable the establishment of more technological and efficient communities, which may be able to drastically decrease the dependence of locals from the electricity market and to significantly contribute to the lowering of energy poverty[167].

Additionally, since the **financing is mostly or entirely provided by ESCos**, the members will be relieved from the need to invest their own resources or from the obligation to repay the loan granted by the bank.

Besides, the model ensures some interesting benefits also to the electricity companies, which, in light of the present energy transition and crucial market developments, have the opportunity to find **new business opportunities** and to profit from an activity that otherwise may compromise the stability of their industry.

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[165] RSE. Ricerca sul Sistema Energetico (online). https://dossierse.it/19-2023-cer-e-autoconsumo-collettivo-alcune-simulazioni-numeriche-alla-luce-della-nuova-regolazione/

[166] De Vidovich, L. and Tricarico, L. and Zulianello, M. (2023). https://www.rivistaimpresasociale.it/rivista/articolo/modelli-organizzativi-per-le-comunita-energetiche

[167] De Vidovich, L. (2022). https://moodle2.units.it/pluginfile.php/497754/mod_resource/content/3/13_STTRE_societ%C3%A0%2C%20territori%20e%20transizioni%20III%20le%20CER.pdf

So, in this case the main focus of the analysis will be centered on the possibility or not to identify a "**meeting point**" between the interests of the investors and the ones of the members[168]. Therefore, in finding an equilibrium between two needs, respectively: the objective to make profits out of the investment and the goal to lower the electricity expenses and bills of the members of the community.

3.4 RECs economic impact analysis

As already mentioned, the three RECs models that were introduced and described in the previous paragraph will now be analyzed in order to provide an estimation of the possible economic benefits that individuals or other organizations may gain by participating to the project.

3.4.1 Assumptions

Prior singularly analyzing the three cases, it is necessary to provide and to briefly illustrate the leading assumptions and considerations that are valid and common for all the models described.

First and foremost, the analysis considers a time span of **20 years** starting from the purchase of the plant and the establishment of the community. This time is equal to the period during which the incentive is granted.

Additionally, it is imagined that the energy communities are all located in a **central region of Italy**, so that they are entitled to receive an extra revenue from the premium tariff (4€/MWh).

Following, it is supposed that all the three cases exclusively employ PV panels as a technology and, therefore, **solar power plants**. The principal driver of this choice is the awareness that most of the existing and developing RECs mostly rely on solar energy for the reasons already analyzed in the previous chapters, which mainly consists in the grater practicality and ease of management of the plants, and on the significant exposure of the national territory to sunlight.

Then, for what concerns the installed capacity of the power plant, it will correspond to **200kWe**. Notwithstanding the current possibility to install greater plants for up to a maximum of 1MWe, the choice has been, however, addressed to a smaller one considering the significant improbability of both residents and other organizations of being able to invest and to effectively manage high performing plants.
Moreover, the 200kWe power plant has also been selected considering the possibility to exploit the **economies of scale**, while still remaining in the **lowest power capacity range** identified by ARERA

[168] RSE. Ricerca sul Sistema Energetico (online). https://dossierse.it/19-2023-cer-e-autoconsumo-collettivo-alcune-simulazioni-numeriche-alla-luce-della-nuova-regolazione/

in the TIAD for what concerns the grant of the **premium tariff**, which, in this circumstance coincides with the highest value.

Additionally, the average yearly productivity of the power plant has been estimated equal as **1.300** hours, which corresponds to an average of about 4 hours per day; and it has also been assumed an annual producibility loss of the solar panels of **0,4%**.

Lastly, there is no specific requirement nor assumption regarding the location of the power plant. In fact, it can be installed either on a rooftop, on a dismissed area or on an unfertile plot of land[169]. However, the analysis of the pluralist and of the CEB models are based on the hypothesis that the plant does not possess any direct connection to any user. This condition impedes to exploit the physical self-consumption[170], while it exclusively permits to rely on the virtual[171] one[172].
For the public lead model, instead, it is assumed a limited percentage of physical self-consumption. Both systems are represented in *Figure 10*.

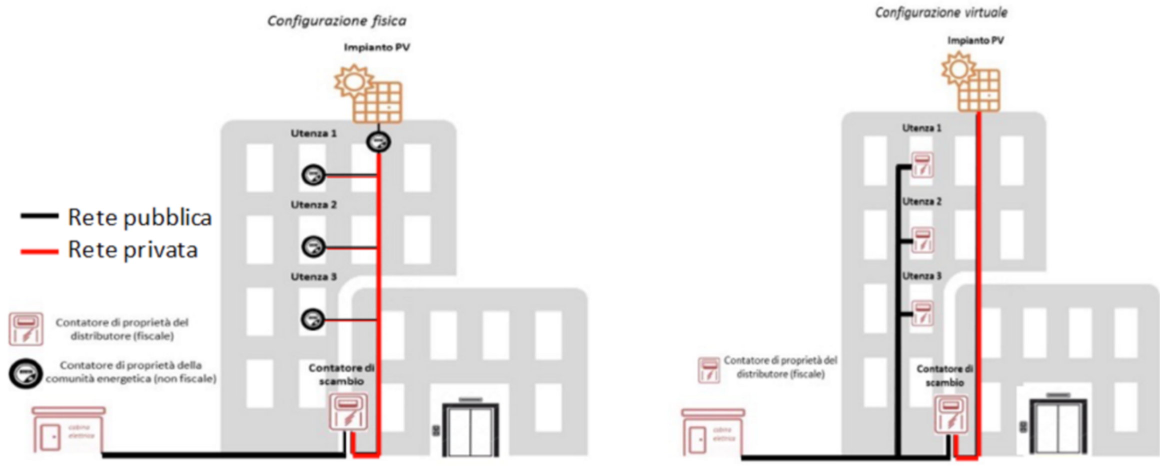

Figure 9 - Physical and Virtual self-consumption systems

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[169] It is, however, fundamental to respect the obligation to locate the power plant in the area that belong to the same primary substation of the energy community and its members.

[170] Physical self-consumption occurs whenever the renewable power plant and the electric meter of the user possess the same Point of Delivery (POD), meaning it is only necessary to utilize the private grid in order to transfer the electricity produced.

[171] Virtual self-consumption is the process of sharing the electricity self-produced by the community when the POD of the power plant does not correspond to the ones of the participants. In this case, it is, consequently, required the employment of the public grid in order to transmit the commodity. Moreover, unlike the physical system, in this case there is the obligation to measure the electricity that has been actually shared and self-consumed within the REC for every given moment.

[172] RSE. Ricerca sul Sistema Energetico (online). https://dossierse.it/17-2020-gli-schemi-di-autoconsumo-collettivo-e-le-comunita-dellenergia/

Then, the estimated cost of the initial investment is based on the amount per kW provided by the RRP with respect to the different power capacities.

Moreover, for both the pluralist and the community energy builders models it is hypothesized a total of **180 users**, which are mainly represented by the **households** located in the area that belongs to the primary cabin. Anyhow, it is also taken into account a limited number of **non-domestic organizations**, for instance: SME, local administration and tertiary sector services and activities, whose participation leads to an increase, particularly during day hours, of the amount of electricity shared and self-consumed within the energy community, which it has been estimated to correspond to **60%** of the total generation.

The public lead model, on the other hand, is based on two different assumptions considering the smaller size of the municipality and, consequently, of the community. The users involved in the project are, in fact, **100** and they are **exclusively households**. Moreover, the electricity shared through the virtual self-consumption is equal to around **33%** of the total production.

Finally, for what concerns the possibility to sell the exceeding electricity produced to the free market, it has been used the same Prezzo Unico Nazionale (PUN) equal to about **132€/MWh**.

3.4.2 Case study 1: the pluralist model

Based on the aforementioned assumptions and considerations, it is now possible to proceed with the study of the economic benefits that the pluralist model can generate.

Firstly, it is fundamental to estimate the **cost of the investment** that the community and its members, singularly, must face at the beginning of the project. In order to do that it is necessary to rely on the two previous assumptions concerning the power capacity of the plant (200kWe) and the cost for each kWe (1200€/kW).

The result is equal to **240.000€** and it is obtained by multiplying the two values. It follows that each member of the community must invest **1.333,33€** for the purchase and building of the plant.

Then, it is necessary to compute the electricity production throughout a time range of 20 years by taking into account, other than the already mentioned power capacity (200kWe), also the data regarding the annual operating hours of the power plant (1.300h) and the yearly productivity loss (0,4%).

Year	1	2	3	4	5
kW/h	260.000	258.960	257.924,16	256.892,46	255.864,89
Year	6	7	8	9	10
kW/h	254.841,43	253.822,07	252.806,78	251.795,55	250.788,37
Year	11	12	13	14	15
kW/h	249.785,21	248.786,07	247.790,93	246.799,76	245812,56
Year	16	17	18	19	20
kW/h	244.829,32	243.850	242.874,60	241.903,10	240.935,49

Table 3 - Annual electricity generation (kWh) in a time range of 20 years

Then, referring to the data collected in *Table 3*, it is now feasible to determine that the annual average generation of the commodity within the community amounts to about 250.353kWh that, if converted, are equivalent to **250MWh**.

Afterwards, it is necessary to discern between the electricity that is shared within the energy community and, therefore, self-consumed by its members (60%) and the one that, instead, is injected in the national grid to be sold to the electricity market (40%):

Annual self-consumed electricity (60% of the total generation)	
150.211,884 kWh =	150,21 MWh
Annual electricity injected in the grid (40% of total generation)	
100.141,26 kWh =	100,14 MWh

Table 4 – Annual % of electricity self-consumed and of electricity sold to the market

For what regards the electricity injected in the grid, considering the current higher prices, it is assumed that the REC has chosen to sell the commodity to the **free market**, rather than relying on the system of Ritiro Dedicato[173] managed by GSE which, is more stable but still less profitable[174].

As already anticipated, one of the main purposes of the research consists in measuring and providing an estimation of the possible economic earnings that the participants of the community can obtain annually and in 20 years.

So, it is fundamental to specify the formula and the parameters needed for the computation, namely:

Net revenues (incentive + energy sales + avoided grid costs - operational costs[175]) - **Investment cost**

Table 5 - RECs earning computation formula

Given the already measured value of the investment costs, it is now necessary to measure the different components of the net revenues, beginning with the **premium tariff**.

The electricity shared among the participants of the community is eligible for the economic benefits related to the tariff. Therefore, since the power capacity is equal to 200kW, the plant belongs to the range that can obtain the highest possible tariff, namely **120€/kWh**.
Additionally, as already mentioned, it is assumed that the REC is located in a central region of Italy, therefore, it can also benefit from an extra of **4€/MWh**.
Consequently, the total incentive can reach a maximum amount of **124€/MWh**.

The annual and total (20 years) incentives that can be granted to the community supposing that it is entitled to receive the highest tariff, are:

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173 The electricity given to the GSE through the mechanism of the Ritiro Dedicato and in compliance with the PGM (Prezzi Minimi Garantiti) price regime, is currently sold at 44€/MWh (0,044 €/kWh) in the case of solar power plants.
174 Sorgenia (2023). https://www.sorgenia.it/guida-energia/ritiro-dedicato#:~:text=L'unico%20regime%20commerciale%20attivo,tutela%20degli%20investimenti%20gi%C3%A0%20avviati.
175 In the computation of the net revenues should also be included the tax deductions, however in the case of the REC, which are categorized as societies, they are not applicable to single individuals but exclusively to the community as a whole. This leads to the impossibility to correctly define and estimate the expenses, therefore they will not be included in the analysis.

Premium tariff	
Annual incentive	18.626,27 €
20 years incentive	372.525,47 €

Table 6 - Annual and total premium tariff incentives

Then, for what concerns the estimations of the earnings deriving from the **sale of electricity** (non-shared) to the free market, it is firstly necessary to compute an average of the PUN[176] for 2023[177], which will be used as a reference for the calculation of both annual and total revenues[178].

2023	Jenuary	February	March	April	May	June	July
€/MWh	174	161	136	134	105	105	112
Average (€/MWh)	132,43						

Table 7 - Monthly PUN (€/MWh) for 2023 and current average

Given the average PUN of 2023 it is now possible to estimate the annual and total revenues deriving from the injection of 40% of the commodity produced to the national grid and from its selling to the free market:

Electricity sales to the free market	
Annual sales	13.261,56 €
20 years sales	265.231,27 €

Table 8 - Annual and total revenues from the sale to the free market

176 Enel Energia (online). https://www.enel.it/it/supporto/faq/cos-e-il-pun
177 PUN values are currently available until July 2023.
178 A2A Energia (2023). https://www.a2aenergia.eu/assistenza/tutela-cliente/indici/indice-pun

Afterwards, another factor to consider for the profit computation consists in the **avoided grid costs**, meaning the expenditures that each user does not have to face when consuming the electricity self-generated within the community. These costs are, in fact, exclusively related to the purchase of electricity directly from the market.

For what concerns renewable energy communities, they are fixed and set by ARERA. They currently amount to **8,48€/MWh**[179]. (ARERA 2023)[180].

Avoided grid costs	
Annual savings	1.273,80 €
20 years savings	25.475,94 €

Table 9 - Annual and total avoided grid costs

Finally, the **operational costs** must be subtracted to the three revenues generated. Operational costs are all the expenses that must be annually borne by the community.

They can be distinguished between **ordinary** and **extraordinary** costs: the former must be paid every year and they consist in the cleaning, maintenance and insurance of the power plant, on the management of the system and on administrative expenses.
The latter, on the other hand, are costs that occur less frequently and that, consequently, are usually more expensive; for instance: the cost related to the changing of the **inverters** (this practice usually occurs about every 10 years), and the expenses required in case of **malfunctioning** of the system or of some of its components.

Therefore, given an average value of **35-50€/kW**[181] for ordinary expenses depending on the size of the power plant, and assuming a cost of around **40€/kW** for the plant considered in the study, these expenses may correspond to around **8.000€**.

[179] 8,48€/MWh corresponds to the current highest value of the $TRAS_E$ tariff component.
[180] Source: ARERA. Autorità di Regolazione per Energia, Reti e Ambienti (2023). https://www.arera.it/allegati/eventi/230222Autoconsumo.pdf
[181] Isoterma (online). https://www.isoterma.it/blog/fotovoltaico/manutenzione-impianti-fotovoltaici

Instead, the extraordinary expenses and in particular those related to the substitutions of the inverters approximately total **1.330€** every year[182].

Therefore, the annual and total operational costs amount to:

Operational costs	
Annual expenses	9.330 €
20 years expenses	186.600 €

Table 10 - Annual and total operational costs

Finally, given the difference between the net revenues (475.232,68€) and the investment cost, it results that the annual and 20 years earnings for both the entire REC and single users amount to:

	Earnings	
	1 year	20 years
Energy Community	11.831,63 €	236.632,68 €
Single user	65,73 €	1.314,63 €

Table 11 - Annual and total earnings of both the REC and the single user

It is therefore possible to state that each member of the community gains around **1.315€ in 20 years**.

Then, another factor to consider in order to assess the economic feasibility and convenience in establishing and participating to a REC is the **payback period** of the initial investment.

[182] RS Components (online). https://it.rs-online.com/web/p/inverter/2157656

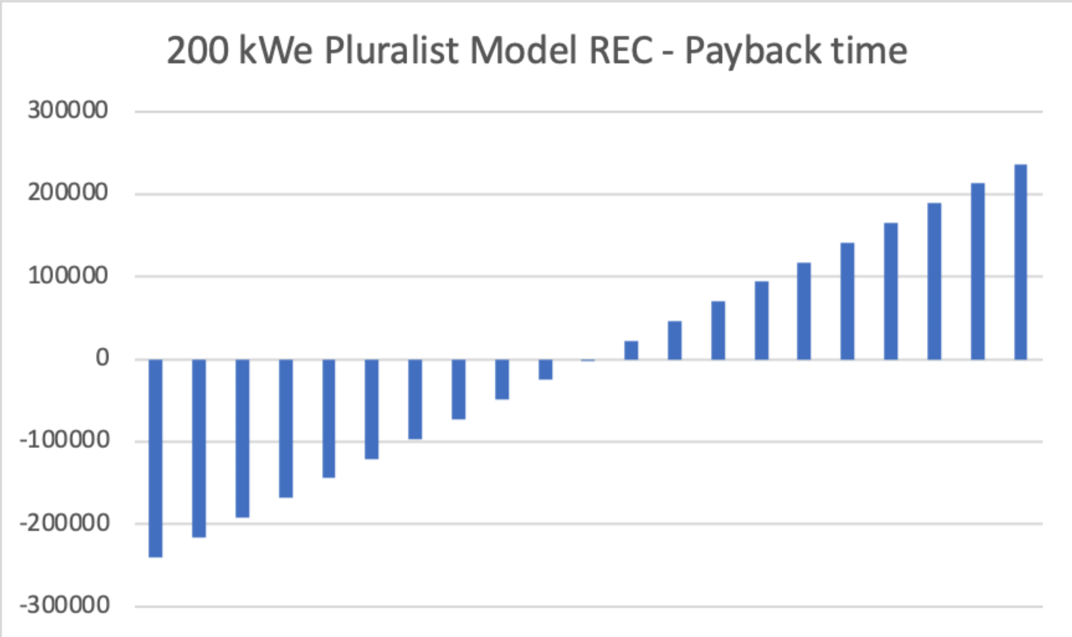

Figure 10 - Estimated payback period of the initial investment in the pluralist model

As represented in the graph above, given annual net revenues equal to 23.761,63€, it is possible to estimate that the initial investment will be fully repaid **between the 10th and the 11th year**.

Lastly, for what regards the potential **energy savings** that each member of the community can obtain, they approximately amount to the **40-45%** of the entire electricity bill, and to about the **80-85%**[183] of the sole energy component of the bill. (DossieRSE, 2023).

3.4.3 Case study 2: the Community Energy Builders (CEB) model

The community energy builders model, as already affirmed, foresees the contribution of companies or operators that belong to the electricity industry in the establishment of the REC.

Electric utilities are involved in the project as **third parties**, whose main role consists in investing in the needed machineries and technologies, therefore in providing the **capital** required for the purchase of the solar power plant (200kWe) and the **technical knowledge and experience** for the proper and efficient management of the community.

Similarly to the previous model, also this one is based on the same assumptions concerning the electricity generation and the percentages of both self-consumption (60%) and energy injected in the grid (40%). Moreover, the estimations regarding the other parameters, namely the incentive, the sale

[183] RSE. Ricerca sul Sistema Energetico (online). https://dossierse.it/19-2023-cer-e-autoconsumo-collettivo-alcune-simulazioni-numeriche-alla-luce-della-nuova-regolazione/

of electricity to the market, the avoided grid expenses and the operational costs are remaining unchanged.

Anyhow, the main distinctive and signature factor of the CEB model with respect to the previous one concerns the necessity to **split the earnings equitably and fairly** between the investing company and the members of the community.

It is, therefore, crucial to fulfil the needs of both parts while trying to find and to reach an **equilibrium point** in which it is possible to accomplish the requests of the energy utility without compromising the necessities of the participants.

More specifically, the primary goal of the investor consists in **recovering the entirety of the capital** provided for the purchase of the power plant in a reasonable and feasible timing. Then, the company also aims to **make extra profits** from its contribution to the project.

On the other hand, users and members of the energy community want to **lower their electricity expenses** by partially relying on the electricity self-generated. Moreover, just like the investor, they also aspire to make some **earnings** from the REC.

Consequently, a reasonable division of the revenues, which might balance the different requirements and necessities could consists in the grant of all the revenues related to the sale of electricity to the free market and of the ones deriving from the avoided grid costs to the electric utility. While the earnings generated by the 60% of the electricity self-consumed, therefore, the ones object of incentive, are equally divided into two parts between the investor and the members.

Then, for what concerns the operational costs, it can be assumed that, similarly to the tariff, they are borne by both parties at **50%**.

This distribution of the earnings can be considered approximately close to the equilibrium point.

For obvious reasons, a significant portion of the revenues is given to the electric utility since it is fundamental to ensure the payback of the investment made in the shortest possible time. Moreover, it is also important to grant to the company a certain degree of profitability consequent to its fundamental contribution in the achievement of the project and to its leading role.

So, as represented in the graph below, the payback period required to cover the investment, considering annual net revenues of **19.183,50€**, can be accomplished **between the 12th and the 13th year**.

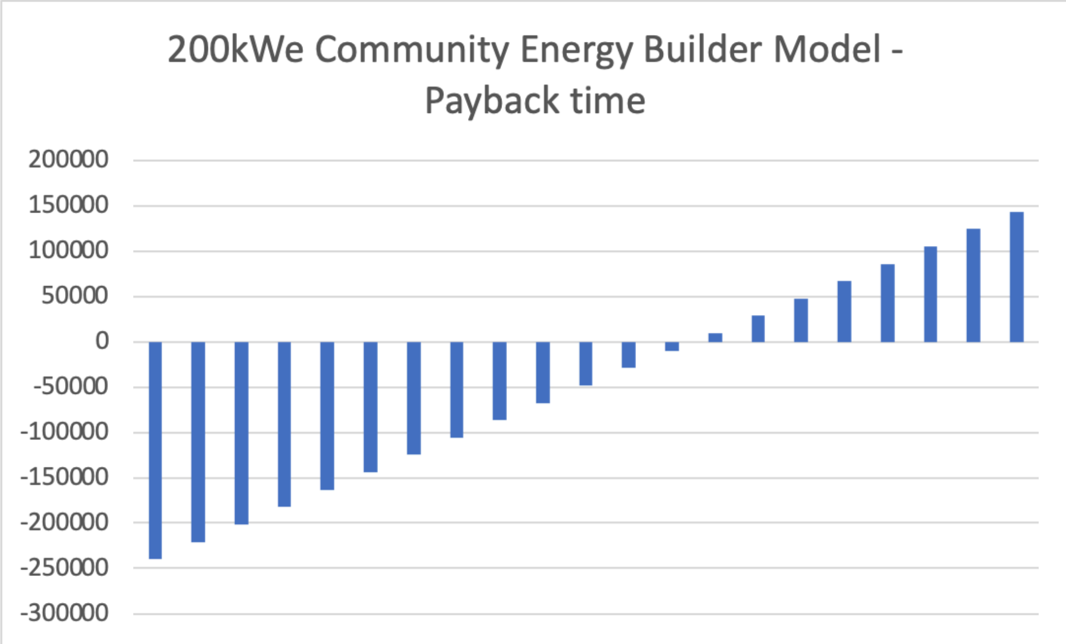

Figure 11 - Estimated payback period of the initial investment in the CEB model

Then, the earnings that the electric utility, the REC and its members can obtain, are approximately close to:

	Earnings	
	1 year	20 years
Electric utility	7.183,50 €	143.669,94 €
Energy Community	4.648,14 €	92.962,74 €
Single user	25,82 €	516,46 €

Table 12 - Annual and total earnings of the electric utility, of the REC and of the single user

Since, in this case there are more subjects involved, the gains are lower compared to the pluralist model; anyhow, the loss is offset by the fact that the members of the REC do not have to invest their own resources for the purchase of the power plant, which, even if shared among 180 people, still constitutes a burden and a responsibility.

Moreover, the CEB model can also significantly benefit the users in the long run, since closer interactions and a continuous cooperation with an energy company may empower them and extend their technical expertise and know-how in the management of both machineries and the community in its entirety.

Then, for what regards the company, by observing the results of both the payback period and the profits that the utility can make, it is possible to infer that there is not a significantly high convenience in investing in energy communities if the main objective is to significantly earn out of them.
Anyhow, if the choice is analyzed considering a wider perspective, it could be extremely strategic. The members of the community, if fact, rely to the electricity self-generated only for a given amount, while they continue purchasing the remaining part from the market and, precisely, from electric utilities.
So, investing in an energy community may be a fundamental **business opportunity** for creating connections and for attracting new client by exploiting the proximity with them and the establishment of a relationship based on greater trust, communication and transparency.

Lastly, the estimated savings related to the energy bills may account to about **10-15%** of the variable part of the bill, and to around **25-31%**[184] of the sole energy component of the bill. (DossieRSE, 2023).

3.4.4 Case study 3: the public lead model

The last model considered in the study is the public lead one, and, because of the different purpose and structure, it is based on slightly different hypothesis compared to what assumed for the pluralist and the community energy builders models.

Therefore, as already anticipated, this model foresees a participation to the community of **100 users**, which are **exclusively households**. So, unlike the other two cases, it is not considered the involvement in the project of SME and of tertiary sector services.

This model is based on a **top-down approach**[185] since the initiative is launched by the municipality with the aim to produce widespread economic and social benefits in order to hinder and downsize energy poverty.

It is supposed that the REC is established in a town that counts **less than 5.000 inhabitants**, so that it is possible to provide some numeric estimations of the impact of the funds provided by the RRP for the initial investment and of the benefits that they may generate on the members.

[184] RSE. Ricerca sul Sistema Energetico (online). https://dossierse.it/19-2023-cer-e-autoconsumo-collettivo-alcune-simulazioni-numeriche-alla-luce-della-nuova-regolazione/

[185] De Vidovich, L. and Tricarico, L. and Zulianello, M. (2023). https://www.mdpi.com/2071-1050/15/3/1997

Although, the hypothesis regarding the power capacity of the plant employed (200kWe), the operating hours (1.300h) and the annual productivity loss (0,4%) are still valid, leading to a yearly average electricity generation equal to **250MWh**, the model envisages a different allocation of what is produced.

Specifically, it is assumed that the power plant is installed over or near a municipal building, therefore, unlike the previous model, it is connected to the same POD.
As a consequence, a limited percentage of **physical self-consumption** must be considered (about **5%**), leading to the injection to the grid of around **238MWh**.

Then, the electricity self-consumed within the community is forecasted to significantly decrease because of the smaller number of participants and, particularly, due to the non-involvement of SME whose high electricity demand contributed to rise the amount of self-consumption in the previous two models. Consequently, in this case, it is assumed the self-consumption, and so, the portion of electricity subject to the incentive, to be equal to **33%**.

So, the amounts of the electricity self-consumed and of the one sold to the free market respectively amount to:

Annual self-consumed electricity (33% of the total generation)		
78485,71 kWh	=	78,49 MWh
Annual electricity injected in the grid (67% of total generation)		
159349,77 kWh	=	159,35 MWh

Table 13 - Annual % of electricity self-consumed and of electricity sold to the market

Then, the cost to finance the purchase and the installation of the power plant, similarly to the other models, is equal to **240.000€**, given the power capacity (200kWe) and the unitary cost per kWe (1.200€/kW).

However, since it is hypothesized that the community is entitled to receive the **non-refundable aid** provided by the RRP for a maximum rate of **40%**[186], the municipality must only cover the remaining portion of the expenses[187].

However, given the use of **public resources** for the financing of the power plant, it is likely that the municipality also decides to apply for a **bank loan** in order to avoid investing all the available funds. Consequently, it is assumed that the portion of the investment autonomously covered by the town is equal to 30%, while the remaining amount (30%) is financed using the loan, which has an annual **interest rate of 5%**.

Therefore, the **costs allocation** for the purchase of the solar plant among the three different sources of funding corresponds to:

Initial investment financing	
RRP (40%)	96.000 €
Public funds (30%)	72.000 €
Bank loan (30%)	144.000 €

Table 14 - Allocation of the financing of the initial investment in the public lead model

Afterwards, in order to provide an estimation of the earnings, it is necessary to recompute the incentive, the electricity sold to the market and the avoided grid expenses.

The operational costs, instead, are assumed to remain unchanged (**186.600€** in 20 years).

For what regards the **premium tariff**, it is, firstly, fundamental to remember that it can be cumulated with the non-refundable aid of the RRP, but it can be granted up to a **maximum of 40%**[188], so that it can be equivalent to the percentage of the subsidy.

In this case, the annual and overall incentive amounts to:

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[186] This analysis is based on the assumption that the municipality is eligible for the obtainment of the highest RRP contribution, meaning the 40%, in order to cover the cost of the initial investment. It is, however, more frequent that the contribution is equivalent to a smaller percentage.

[187] Elettricità Futura. Imprese Elettriche Italiane (2023). https://www.elettricitafutura.it/Policy/Mercato-e-Reti/Incentivi-Comunit-Energetiche-e-Autoconsumo--Schema-DM-MASE_5114.html

[188] Dominelli, C. (2023). https://www.ilsole24ore.com/art/comunita-energetiche-impianti-ammessi-spese-finanziabili-e-requisiti-ecco-come-si-accede-incentivi-e-aiuti-AE749XtC

Premium tariff (5.000 inhabitants municipality)	
Annual incentive	3.892,89 €
20 years incentive	77.857,82 €

Table 15 - annual and total premium tariff incentives

Then, considering the same PUN estimated for the other models, it is possible to obtain the revenues deriving from the portion of **electricity** self-generated that can be **sold to the free market**, which in this case is significantly higher than the previous ones. More precisely, it is equal to:

Electricity sales to the free market	
Annual sales	21.102,46 €
20 years sales	422.049,26 €

Table 16 - Annual and total revenues from the sale to the free market

Lastly, with respect to the changes made, it is possible to apprise the **avoided grid costs** to about:

Avoided grid costs	
Annual savings	665,56 €
20 years savings	13.311,18 €

Table 17 - Annual and total avoided grid costs

So, on the basis of the available data, it can be estimated that a REC established using this model can provide an average overall (20 years) saving of about **34%** on the variable components of the electricity bill, and of approximately **73%** if exclusively considering the energy portion. (DossieRSE, 2023).

While, the earnings that the community obtains and employs to support the energy expenditures of the participants, can be derived from the difference between the net revenues (**326.622,81€** in 20 years for the entire community) and the cost of the investment (**216.000€**), which does not include the amount covered by the non-refundable aid (96.000€).

Earnings of the REC	
Annual	5.530,91 €
20 years	110.618,26 €

Table 18 - Annual and total earnings of the REC

Finally, it is fundamental to compute the **payback time** necessary to regain what invested. However, given the multiple sources of financing, it is appropriate to exclusively focus on the funds provided by the **bank**, which are the ones that must be repaid within 20 years from the granting of the loan (**144.000€**).

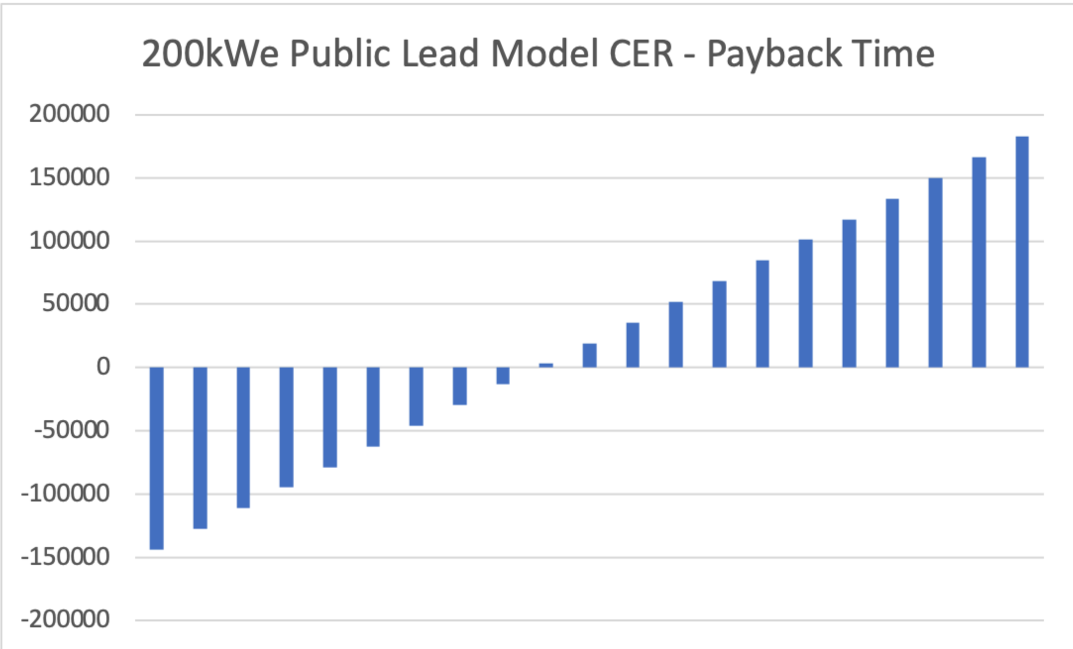

Figure 12 - Estimated payback time for initial investment in the public lead model

As represented above the payback time for this specific case and with the public lead model ranges **between the 8th and 9th year** after the obtainment of the loan.

3.5 Final conclusions and hypothesis on future evolutions

The analysis of the three different energy community models has enabled to tangibly identify the principal benefits, both economic and social, that may be granted to the members.

For instance, self-generation and self-consumption of electricity lead to two key achievements, which are: energy **savings on the electricity bills** and the introduction of a **protection mechanism** with respect **to the price fluctuations** that occur in the market.
In fact, the partial substitution of the purchase of electricity from the national grid with the practices of physical and virtual self-consumptions, has permitted individuals to rely on a more stable and more unexpensive source.

Moreover, the participation to RECs, besides being a source of savings, is also **profitable** thanks to the opportunity to sell the exceeding and not self-consumed electricity to the free market (as assumed in the three case studies) or directly to the GSE through the "Ritiro Dedicato".

Then, it is also important to focus on the social advantages, which are particularly relevant if considering the public lead model, which is fully oriented towards the improvement of the living and economic conditions of individuals and families.
It has, in fact, been observed how RECs can contribute to the **reduction of the degree of energy poverty**.
Moreover, the social achievements also include the **growing awareness** of citizens and private and public organizations with respect to the energy topic and to the related issues, the **increasing commitment** in the project and the **progressive acceptance** of the machineries required, for instance, solar power plants.

Additionally, these models, particularly the community energy builders one, thanks to the active participation of companies from the electric industry, foster and enable a significantly high **knowledge and practice sharing**, leading to an overall improvement for what concerns the technical and managerial skills of the members.

Then, as already pointed out, the participation to energy communities can also be quite beneficial for third parties, such as electric utilities, that contribute to the project as investors and with their expertise.
In their case, the real profit does not derive from the possible earnings that the incentives and the other activities can produce, since they appear to be quite limited if considering the ones that electric companies operating in the market are used to make. Instead, the true gain comes from the possibility to exploit the participation to the community and the tighter and closer connections with users to

spread new proposals, such as energy efficiency options. Therefore, it can be affirmed that the joining to RECs projects may represent an intelligent **business strategy**, especially if considering the progressive decrease of consumers in the electricity market that energy communities may encourage in the long run.

Anyhow, besides the promising benefits and results, there are still numerous visible obstacles to the correct and efficient establishment and management of RECs.

The **current regulation** can be considered the main responsible for the existence of these barriers, which are mainly related to the present incentive and financing schemes.

Some of the most relevant critical aspects concerning the topic are the extremely **limited application period** for the tender and the **dearth of clear information** regarding the nature of the incentives, particularly for what concerns the regional ones, and the subjects that are entitled to receive them[189].

Moreover, it is extremely frequent that the incentives and financing methods are **not specifically addressed to renewable energy communities**, instead, they tend to refer to the area of the energy transition in general which may or may not include them.

Then, specifically for the regional funds, the ERDF[190] tenders, regarding the resources planned for the period 2021-2027, are not open to application yet[191]. This obviously leads to significant delays, unclearness, and to a participation loss.

Therefore, all these difficulties hinder and discourage the access to the tenders and the foundation of RECs.

Additionally, it is widely believed that the regulation behind the concession of the non-refundable aid of the RRP is not effective nor strategic for the accomplishment of the general goal, namely: the achievement of the energy transition in the briefest possible time.
In fact, the 5.000 threshold requisite is considered **counter-productive** since the establishment of energy communities in extremely small municipalities cannot significantly exploit economies of scale and, therefore, are likely to **lack of efficiency** in the self-generation of electricity. Additionally, most of the eligible municipalities are in the **northern regions** of Italy, which are consequently the ones with the minor exposition to sunlight.

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[189] Arcudi, C. et al. (2023). https://agici.it/wp-content/uploads/2023/04/AGICI-Accenture_Report-Comunita-Energetiche_-Maggio2023.pdf

[190]The European Regional Development Fund (ERDF) is part of the European Structural and Investment Funds provided by the European Union. It main purpose consists in providing economic resources to both public and private entities in order to reduce regional gaps and disparities in every Member State.

[191] European Union - European Commission (online). https://ec.europa.eu/regional_policy/funding/erdf_en.

Therefore, it may be more efficient to allow also larger towns to obtain the subsidy so that they can invest in bigger and more powerful plants, they can reach economies of scale and increase their efficiency level while positively impacting on the overall energy transition of the Country.

Lastly, it is worth to mention some aspects of RECs that should be improved, for instance the **management of the bottom-up approach**, which, due to the lack of expertise and know-how is usually extremely complex and controversial.

Then, given the unclear regulations and the long and complex bureaucratic procedures, the current REC initiatives present very small sizes, therefore, their **scalability is significantly limited**. So, considering the present situation, tens of thousands of configurations would be needed to impact on the electricity industry.

Other barriers are represented by the **insufficient commitment** of individuals and organizations in terms of participation to the project and, particularly, of **willingness to invest**.

Finally, up to now, the contribution provided by electric utilities is quite limited due to the **restricting regulations** that impede companies from the energy industry to participate to RECs in a more impactful way compared to the current situation in which they are exclusively allowed to provide the technologies and the related support[192].

Anyhow, with the right regulation and incentives, the establishment of energy communities may be quite economically feasible and also beneficial for all the participants.

[192] De Vidovich, L. and Tricarico, L. and Zulianello, M. (2023). https://www.rivistaimpresasociale.it/rivista/articolo/modelli-organizzativi-per-le-comunita-energetiche

Chapter 4: Study of the role that electric utilities can play within RECs and analysis of a related real-life case study

4.1 Current involvement of electric utilities in REC projects

Besides the local economic, social and environmental scopes of renewable energy communities, they also and mostly pursue a more general objective, which is the accomplishment of the **energy transition** and the achievement of **climate-neutrality** by 2050.
RECs are, in fact, one of the many instruments employed by Member States in order to meet the Renewable Energy Directive goal set by the EU Commission that consists in reaching a consume of electricity produced using RES of at least **42,5%[193] by 2030[194]**.
Therefore, the quantity of electricity production coming from energy communities required to accomplish the plan in Italy is equal to about **6TWh**[195], which require an installed power capacity of approximately **5GWe**[196].
However, the current Italian situation is quite far from this case, since only **30** renewable energy communities are effectively operative, and their total installed capacity amounts to around **60MW**. This leads to a significant delay of Italy compared to other European countries such as Denmark and Germany, which cover a leading role in the field.

The reason behind this **underdevelopment** can be principally attributed to the **limits to the participation of large companies**, particularly of the ones operating in the energy industry, to the establishment and management of energy communities. In fact, as already affirmed in chapter 3, the current Italian legislation does not allow electric utilities nor other companies that belong to the sector to effectively participate to energy communities as members.
This decision is driven by the necessity to strictly guarantee and safeguard the centrality and respect of the three pillars of RECs, namely the economic, social and environmental objectives, and, consequently, to avoid the prioritization of private and profit-driven goals.
In fact, the RECs currently existing in the Italian territory are mostly established primarily according to the Public Lead model and secondly, through the Pluralist one. Since the promoters of the two

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[193] The EU renewable energy sources target has recently changed. In fact, it has been increased from the previous 32% to 42,5%, which is a lower percentage compared to the one initially proposed by the EU Commission (45%) but which is also greater with respect to what established by the "Fit For 55%" Package (40%).
[194] Source: Il Messaggero (2023). https://www.ilmessaggero.it/economia/news/energie_rinnovabili_green_accordo_europa_elettricita_verde_green-7319227.html
[195] With an electricity generation of around 6TWh from renewable energy sources, it will be possible for Italy to reach a CO_2 emissions reduction of about 1,35mln tons and an economic benefit that ranges between €1,3 and 1,5bln.
[196] Source: Deganello, S. (2023). https://ntpluscondominio.ilsole24ore.com/art/comunita-energetiche-svolta-arrivo-famiglie-e-pmi-AEhd9zYD

models, respectively municipalities or other public authorities, and cooperatives or individuals, do not possess the competences nor the abilities that are unquestionably necessary in order to effectively build and manage energy communities, the immediate result consists in the **lack of scalability** of the initiative, which significantly hinders and slows down the accomplishment of the aforementioned goal.

On the other hand, the previously examined community energy builders model is the most promising and performing one mainly thanks to the involvement of electric utilities in the establishment process and for what concerns the technical and administrative management of the community.
Moreover, this model also simplifies the financial operations, since it allows to **relieve members from the expenses** correlated to the purchase of the equipment. It is, in fact, the electricity company that provides all the needed funding to cover the initial investment.
This contribution is fundamental since it drastically eases and accelerates the creation process and prevents issues related to the unwillingness to provide private capital that frequently occur whenever individuals are asked to financially contribute to the project.
Moreover, as already widely examined, electric utilities are also the ones that generally determine the efficient and successful functioning of energy communities by providing all the needed technical support and knowledge, which are crucial to ensure the growth and the expansion of the project.
However, due to the strict legislation that obstacles a greater participation of utilities in REC initiatives and to the difficulties related to finding a suitable balance between the interests of the parties involved, the CEB model is the most controversial and, so, the less widespread.

Therefore, if Italy wants to achieve the energy transition and to comply to the timing that have been set by the European Union, the diffusion of this system and the growing establishment of **public-private partnerships (PPP)**[197] between locals and electric utilities are the principal steps to follow.
Additionally, the latest ARERA Regulation, namely the already mentioned TIAD[198], has introduced the possibility for energy communities of delegating the representative role to a **third party** that can be a company that belongs to the energy sector.
The main driver behind this choice is precisely the need to allow experts to largely contribute to energy communities in order to accelerate their diffusion throughout the national ground.

[197] Source: Bresciani, I. (2023). https://www.fastzero.it/notizie-e-bandi/459/come-le-utility-possono-accelerare-le-cer
[198] ARERA. Autorità di Regolazione per Energia, Reti e Ambienti. Delibera n. 727/2022/R/eel, https://www.arera.it/it/docs/22/727-22.htm

In this way, although the companies continue not to be part of the energy communities as members, they will still have the opportunity to be **involved in the design and implementation stages** of the project and they will be able to exert **decision-making powers** regarding its management.

Moreover, electric utilities will benefit from the contribution to the initiatives because they will be able to **expand and to strengthen their network of customers**, to easily sell their products and services and to **enlarge their business model** by introducing new activities[199]. Lastly, energy companies can also increase their commitment towards more sustainable energy sources and, therefore, energy generation practices.

Then, on the other hand, the members of the communities will be relieved from significant expenditures and will be **continuously supported** by the utilities, which will play the role of **facilitators**[200], therefore, they will solve any technical issue, malfunctioning of the power plant and administrative problem.

Additionally, utilities will ensure the growth and scalability of the initiatives, leading to greater economic, social and environmental benefits both inside the community, by reducing **energy poverty** and bills expenditures of the participants and outside, by generating **positive externalities** such as the reduction of CO_2 emissions.

4.2 Solisca: case study of a REC established and managed with the contribution of an electric utility

Given the hypothetical analysis of the economic benefits that the contribution of electric utilities is capable of ensuring to REC members, it is now appropriate to discuss about a **real-life energy community** that has been established through a PPP.

The case study that has been selected is represented by the renewable energy community of **Solisca**, which is located in Lombardy, precisely in the 1.500 inhabitants municipality of Turano Lodigiano in the province of Lodi.

It is important to mention that the analysis was conducted with the contribution of Dr Fabrizio Prestinoni Head of PA Green Sales of Sorgenia, who has provided some recent insights and data related to the latest results of the Community.

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[199] Source: Giuliano, F. (2022). https://www.rivistaenergia.it/2022/12/comunita-energetiche-rinnovabili-quale-ruolo-per-le-utility/

[200] Source: Re, L. (2023). https://www.qualenergia.it/articoli/comunita-energetiche-rinnovabili-perche-utility-ruolo-chiave/

The name that has been given to the project derives from Sanskrit and it means light, brightness, heat, life, vitality and energy, which all constitute the main pillars of the project[201].

As already mentioned, the community was funded through the establishment of a PPP between the town hall represented and guided by Mayor Emiliano Lottaroli, who is the person that has launched the initiative and also the current President of the REC, and **Sorgenia S.p.A**.[202], which is a company that operates in the free market of both electricity and natural gas. It is, therefore, possible to assess that this specific energy community is based on a sort of mixture between the public lead and the community energy builder models, since it has been funded through a top-down approach and its main goal consists in fighting energy poverty, and, then, it involves a company from the electric industry that has provided the needed capital and expertise.

The planning and design of the project has begun in 2020, prior the entry into force of the RECs legislation, then, the power plants started to operate from June 2021 and Solisca was created in November of the same year. However, at that time it was not officially recognized as a REC yet. The CER was finally inaugurated and became officially operative and productive since **April 1st, 2022**, when it was finally recognized as a legal entity by the GSE[203].

For the electricity generation, the community employs two solar power plants that count an overall capacity of **46,5kWe** and that are installed on the rooftops of two public buildings, namely the gym and the sports field of the town, which are located next to the town hall.
The power plants share the **same PODs** of the public buildings, therefore, additionally to the virtual self-consumption, they also enable a limited percentage of the physical one.
Sorgenia has provided the **capital** needed to cover the initial investment, meaning the purchase of the enabling technologies and machineries required for the building of the plant, and to face the expenses related to the bureaucratic procedures required for the establishment and the authorization of the community, for an overall amount of about **70.000€**[204].

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[201] Source: Higeco Energy (2022). https://www.higecoenergy.com/comunita-energetiche-rinnovabili/comunita-energetica-turano-lodigiano

[202] Sorgenia S.p.A. is a green-tech Italian energy company that was formed in Milan in July 1999 concurrently with the liberalization of the electricity market, which occurred after the issue of the Bersani Decree (Legislative Decree 79/99). Since October 2020 the company is part of F2i SGR S.p.A. (Fondi Italiani per le Infrastrutture), which is the largest independent Italian infrastructure funds manager.

[203] Source: Sorgenia (2022). https://www.sorgenia.it/comunicati-stampa/sorgenia-inaugurata-la-comunita-energetica-rinnovabile-turano-lodigiano?campaign_code

[204] Source: Patrucco, D. (2022). https://www.qualenergia.it/pro/articoli/caso-comunita-energetica-rinnovabile-turano-lodigiano/

The members of Solisca have grown over time, specifically the households involved in the project. In fact, the community was initially constituted by 9 public buildings, by 1 parish and by 9 families. But at present, the initiative counts a participation of a total of **23 households**[205].
However, the number of households is forecasted to further increase, since other 25 families should join the Community in the upcoming years.

Additionally, it is important to specify that, due to the **top-down approach** of the initiative and to the location of the power plants, the Municipality is the **sole prosumer** existing within Solisca, while the remaining users only participate to the community as consumers.

The Community has been organized as a **free association** so that it is possible for its members to freely abandon the project, whenever and without any obligations.

The principal purpose of Solisca consists in providing economic and social benefits to all the participants, especially for what regards the **fight against energy poverty**.
As a matter of fact, the households that are part of the project are all **low-income families**, so that the Municipality can actively and concretely support them and lower their electricity expenses. Additionally, in line with the legislation, the Community also pursues environmental goals, particularly in terms of emissions reductions, in order to improve the air quality and the health conditions.

Solisca can boast two important national records, namely: it is the first renewable energy company that has been established in the region of Lombardy, and it is the first REC that has undergone a process of **full digitalization**.
Additionally, Solisca can be also considered the first Italian energy community strongly committed to **solidarity purposes**, and it is also the second REC established in the Country.

Among these records, it is important to briefly focus on the digitalization aspect. In fact, the Community, besides purchasing the traditional enabling technologies needed for enabling the virtual self-consumption of electricity and for the measurement and collection of the data related to the consumes of end-users, respectively smart grids and smart meters, is also provided with a **digital platform** and a related **App** in order to register and monitor the outcomes of the project.
The platform was created with the contribution of Sorgenia and it is part of **MyCER**, a project designed and fulfilled by **Higeco Energy**[206].

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[205] Source: Sorgenia (2022).
https://www.sorgenia.it/shared/files/attachments/2023/reportdisostenibilita2022sorgenia.pdf
[206] Higeco Energy is an innovative startup that belongs to Higeco Srl, a group, funded in 2008, operating in the field of remote control and monitoring systems for the industrial sector. Higeco Energy is the branch of the Group that is

Through MyCER it is possible to constantly keep track of all the data and information concerning the generation, consume and sale of electricity in the Community. The platform provides **real-time insights** which are both collective and individual, so that it is possible to evaluate and analyze the behaviors towards electricity consumption of the different members of Solisca[207].

This is possible thanks to the employment of an enabling technology that was already described in chapter 2: the smart meter. At present, Solisca is provided with 12 of these devises, they permit a more efficient, fast and precise collection of data and information.

However, there are still members who do not own the meters, so, in their case the Community resorts to estimate curves.

MyCER also ensures a higher degree of **transparency** and, therefore, a decrease of information asymmetry, since all the participants of the community have access to the platform and have the possibility to constantly check the functioning of the Community and the levels of their own consumes. Consequently, the platform also represents an effective instrument for **rising the awareness** of individuals with respect to energy saving practices.

Moreover, the platform also **regulates the allocation of the incentives** provided by the current legislation, so that everyone is aware of what has earned[208].

Then, besides the economic parameters, the platform also provides some indicators related to the **environmental sustainability** of the initiative, for instance the amount of CO_2 emissions that have been avoided thanks to self-generation and self-consumption of electricity from RES, and the equivalent number of trees that should have been planted in order to absorb the emissions produced without the Community[209].

Lastly, all data and insights provided by the platform are safeguarded using a **blockchain technology** that prevents from losing information and from divulging them.

Then, it is important to focus on the fact that the electricity self-generated within Solisca is not exclusively provided to the users that participate to the project, a portion of it is, in fact, employed to power a **charging point**, located in the same primary substation of the power plant, for electric vehicles and to which is also connected a service of car-sharing.

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involved in the offering and provision of products and services specifically addressed to the energy management and monitoring.

[207] Solisca was the first Italian renewable energy community to which the platform was provided and, currently, it is also the most developed one; however there are also two other RECs that have started to utilize MyCER namely the Comunità Solare Locale located near Bologna, and a collective self-consumption group in Bergamo.

[208] Source: Higeco Energy (online). https://www.mycer.it/mycer/

[209] Source: Ciaralli, I. (2022). https://www.greenplanner.it/2022/02/11/solisca-comunita-energetica-digitale/

One of the most important factors that must be analyzed consists in the reasons behind the participation of Sorgenia to the initiative and on the role played.
The involvement of the electric utility in the establishment of Solisca is way far from being fortuitus, since the company was already active in the territory.
Sorgenia had, in fact, built a **natural gas power plant**[210] in the area of Bertonico, near Turano Lodigiano[211].
Consequently, the contribution to the initiative and the provision of the needed capital and technologies constituted a way through which Sorgenia was able to **compensate** for the negative externalities caused by the construction and operations of the plant in the area.
Moreover, the involvement in Solisca also represented a tool for Sorgenia to **foster the emissions reduction in the area** and to improve air quality, particularly considering the CO_2 pollution caused by the plant.

4.2.1. Feasibility analysis

During the planning stage of Solisca, Sorgenia has conducted the **feasibility analysis** of the project in order to provide an initial estimation of the expected performances and related benefits that the Community would be able to provide once becoming fully operative.

Before going forward, it is important to specify that the estimations that are about to be analyzed were based on the forecasted overall number of participants, namely 33 members, and not on the initial one.

The estimated power capacity of the solar plants corresponded to about **46,5kWe** and the annual operating hours were hypothesized to amount to about **1.150h**, therefore, the average daily activity of plants should be of around three hours, also considering the minor exposition of the territory to sunlight[212].
These assumptions lead to an overall electricity generation of almost **54MWh** per year.

Then, for what concerns the evaluation of the percentage of electricity self-consumed and of the one injected in the national grid, Sorgenia, by collecting and analyzing the electricity bills of the potential

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[210] The power plant became fully operative by 2011 and it was officially inaugurated in May 2012 and it is located in the territory in between the two municipalities of Turano Lodigiano and Bertonico, both in the province of Lodi. It was built on the area of an ex-refinery, it presents a surface of 150.000 square meters and it has a power capacity of 800MW. The plant employs the most innovative and advanced technologies for the thermoelectric generation. Sorgenia has also made several improvements overtime in order to reduce the negative environmental impact of the project.
[211] Source: Sorgenia (online). https://www.sorgenia.it/la-centrale-di-bertonico
[212] Source: Sorgenia (2022). https://www.sorgenia.it/comunicati-stampa/sorgenia-inaugurata-la-comunita-energetica-rinnovabile-turano-lodigiano?campaign_code

users initially involved in the community, has conducted a research about their consumption trends and behaviors in order to ensure them the highest possible benefits.
Therefore, it has been firstly computed the percentage of electricity needed to fulfill the physical self-consumption needs, since, as previously mentioned, the two power plants share the same PODs with some users of the community, specifically some municipal/public buildings.
The amount estimated corresponds to about **23%** of the total generation, which is approximately equal to **12MWh** each year.

Then, out of the remaining annual electricity, so **42MWh**, Sorgenia has supposed that the **45%** of it is virtually self-consumed within Solisca, therefore, it is entitled to receive the GSE remuneration, the GSE incentive and the ARERA payment for the avoided grid expenses.

The first corresponds to about **120€/MWh**[213] and it is the remuneration that the GSE grants to the communities for the electricity self-consumed.
Then, Solisca is also provided with some incentives that have been introduced by the Decree 16/09/20[214] and that, in the case of renewable energy communities, amount to **110€/MWh**[215]. These incentives are **feed-in premium**[216], meaning that they can be cumulated to the electricity market value.
Lastly, the electricity that is consumed by the members of the Community is also entitled to receive a remuneration by ARERA for what concerns the avoided expenses related to the purchase of the commodity from the national grid. As already specified in the previous chapter they currently amount to **8,48€/MWh**.

Then, the remaining **55%** of electricity self-generated is injected into the national grid and it is sold to GSE through **Ritiro Dedicato**. Notwithstanding the fact that, differently from the free market, Ritiro Dedicato is not fully dependent on the PUN and, consequently, it is less volatile, its retribution can still moderately vary over time. Anyhow, the system always ensures a minimum price (**Prezzo**

[213] Source: Gualtieri, A. (2023). https://www.pmi.it/economia/green-economy/383262/comunita-energetiche-rinnovabili-nuovi-incentivi-e-risparmi.html
[214] The Decree was issued by the MiSE (Ministero dello Sviluppo Economico) on September 16th 2020, with the primary purposes of introducing an incentive scheme able to adequately support the development and growth of renewable energy communities, and of making some corrections to the limits identified in the Rilancio Decree (34/2020).
[215] Source: Italia. Ministero dello Sviluppo Economico. Decreto 16 settembre 2020, https://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2020-11-16&atto.codiceRedazionale=20A06224&elenco30giorni=false.

[216] Source: RSE. Ricerca sul Sistema Energetico (online). https://dossierse.it/17-2020-gli-schemi-di-autoconsumo-collettivo-e-le-comunita-dellenergia/

Minimo Garantito), which, in the case of the electricity produced using solar power plants[217], corresponds to **44€/MWh**[218].

Finally, Sorgenia, in order to provide an estimation of the annual savings of the members of the community and of Solisca in general, has also provided an approximate value of the average electricity consume of the households involved in the project, which approximately amounts to **2.500kWh** every year.

SOLISCA - Feasibility Analysis	
Total installed power capacity	46,5 kWe
Annual operating hours	1.150h (3h per day)
Annaual electricity generation	53.475kWh (53MWh)
Annual physical self-consumtion (23%)	12.299,25kWh (12MWh)
Annual electricity injected to the grid	41.175,75kWh (41MWh)
Annual virtual self-consumption (45%)	18.529,09kWh (19MWh)
Annual electricity sold to GSE (55%)	22.646,66kWh (23MWh)
Annual average electricity consumes per members (only households)	2.500kWh (3MWh)

Table 19 - Feasibility analysis of Solisca conducted by Sorgenia

With respect to the aforementioned information and computations, Sorgenia has, then, forecasted both the annual earnings generated by the Community and the annual savings on the electricity bills that derive from the consumption of the electricity self-generated.

For what concerns the former, Solisca is expected to earn about **5.500€** from the incentive system and the remunerations related to both the electricity consumed within the Community and the one sold to GSE.

[217] Source: GSE. Gestore Servizi Energetici (online). https://www.gse.it/documenti_site/Documenti%20GSE/Servizi%20per%20te/RITIRO%20DEDICATO/Altri%20contenuti/Prezzi%20medi%20RID%20aggiornato%2007-2023.pdf

[218] 44€/MWh is the Prezzo Minimo Garantito established for year 2023.

SOLISCA - Estimated annual earnings	
GSE remuneration for self-consumption	2.280,00 €
GSE incentive for self-consumption	2.090,00 €
ARERA avoided grid expenses	161,12 €
GSE remuneration through Ritiro Dedicato	1.012,00 €
Annual earnings of the REC	5.543,12 €

Table 20 - Annual earnings of Solisca estimated during the feasibility analysis

Anyway, it is important to point out that these revenues are **not net of the costs** that the Community must pay to Sorgenia for the management and maintenance of all the technologies and of Solisca itself.

While, for what regards the energy savings of the Community, considering the average annual consumption of 2.500kWh for the households, Sorgenia has estimated that they will approximately amount to **2.500€** every year for the entire REC.

However, during the planning stage, the electric utility was not able to provide more in-depth information concerning the effective allocation of the economic benefits and, so, the effective gains that the Community would have been able to obtain.

Moreover, during this initial phase, Sorgenia did not specified the costs related to the technical management and support that the electric utility provides to the Community and that, consequently, the latter must bear[219].
However, it is still possible to attempt to provide an approximative estimation of them, as already did for the three models analyzed in chapter 3.
The most significant expenses that Solisca must pay to the electric utility are the ones related to maintenance, and they can be distinguished between ordinary and extraordinary.
As already explained in the previous chapter, the former occur every year, while the latter, which consist in the changing of the inverters or of some components in case of malfunctioning, are spread over a longer time span.

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[219] Source: Patrucco, D. (2022). https://www.qualenergia.it/pro/articoli/caso-comunita-energetica-rinnovabile-turano-lodigiano/

So, for the estimation of ordinary costs, based on the parameters[220] used for the analysis of the three RECs models, it can be assumed that they amount to approximately 35€/kWe[221], so to an overall annual cost of about **1.600€**.

On the other hand, for what concerns the extraordinary costs, they are principally related to the purchase and substitution of the inverters, which usually occurs every 10 years, therefore two times considering a 20-years range. They are estimated to totally amount around **14.000€**[222].

Lastly, another topic that resulted unclear from the feasibility analysis is related to the **incentive repartition mechanism** between the Community and the electric utility.

Anyhow, these doubts and complications did not represent a real threat to the realization of the project, since both Sorgenia and the Municipality were satisfied by the potentiality of the initiative and by the economic and social benefits that it would be able to ensure.

4.2.2. Analysis of the current economic benefits generated

At present, the renewable energy community of Turano Lodigiano has been fully operating for **over one year**, therefore, it is now possible to briefly observe and analyze the current outcomes that the project has generated.

Firstly, the effective power capacity of the two solar plants that were installed in the Municipality correspond to what was initially forecasted, so, it is equal to **46,5kWe**[223].
More precisely, the power plant positioned on the rooftop of the public gym is composed by a total amount of 54 panels and it has an exact capacity of **33,48kWe**.
The second plant, namely the one located over the sports field, is constituted by 28 PVs, for a total capacity of **13,02kWe**, therefore, it has about half the capacity of the former.

However, during the feasibility analysis there was an underestimation for what concerns the annual operating hours, in fact, unlike the **1.150h** that were forecasted, the two power plants have operated for about **1.875h**, meaning for a daily average of 5h, instead of the expected 3h. Consequently, Solisca

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[220] The average value of ordinary maintenance expenditures varies from 35 to 50€/kWe depending on the size of the power plant.
[221] Source: Isoterma (online). https://www.isoterma.it/blog/fotovoltaico/manutenzione-impianti-fotovoltaici.
[222] The cost of the inverter for a 15kWe PV plant is about 2.000€, while, in the case of a 30kWe power plant, it approximately amounts 5.000€.
[223] Source: Sorgenia (2022). https://www.sorgenia.it/comunicati-stampa/sorgenia-inaugurata-la-comunita-energetica-rinnovabile-turano-lodigiano?campaign_code

has managed to self-generate a significantly greater amount of electricity corresponding to **87MWh**[224].

Moreover, as predicted during the initial planning stage, out of the total production, the Community has partially taken advantage of physical self-consumption for a percentage close to the one that was initially expected, namely about **23%**.
So, the total electricity that was not injected in the grids during this first year is almost equivalent to **17MWh**.

On the other hand, with regard to the electricity injected in the grid and shared, Solisca has experienced some variations for what regards the shares of virtual self-consumption and of the electricity sold to the market.

Specifically, the former has been subjected to a 5% decrease, therefore it approximately amounts to **40%**, that corresponds to an annual usage of **27MWh** within the community.

While, the remaining electricity, so the portion that is sold to the free market, or rather, considering the case of Solisca, to the GSE through Ritiro Dedicato, has consequently increased compared to the initial estimation. In fact, given its percentage of **60%**, the total amount is equal to about **40MWh**.

Then, as already said, the electricity that is consumed by the members of the Community and that is used to power the charging point for electric vehicles is object of the incentives provided by the GSE, specifically the 110€/MWh[225] remuneration, of the GSE payment for the shared electricity of 120€/MWh and of the 8,48€/MWh for the avoided grid expenses.
While, for what concerns the electricity that is sold to GSE, it is currently paid at least 44€/MWh.

SOLISCA – First year outcomes	
Total installed power capacity	46,5 kWe
Annual operating hours	1.875h (5h per day)

[224] Source: Scacchi, C. (2023). https://www.thegoodintown.it/solisca-la-comunita-energetica-di-turano-lodigiano/
[225] After the approval and enforcement of the MASE Decree and of the related ARERA Regulation, the TIAD, the renewable energy community will be subjected to a new incentive regime, specifically to the Premium Tariff already applied in the case studies analyzed in chapter 3. Considering the specific case of Solisca and given the small size of the power plants employed, the community will be included in the cluster eligible for the highest tariff, namely 120€/MWh. Moreover, considering the geographical location, that is in the north of Italy, Solisca will be also entitled to receive an extra of 10€/MWh due to the lower availability of sunlight.

Annaual electricity generation	87.179kWh (87MWh)
Annual physical self-consumtion (23%)	17.435,80kWh (17MWh)
Annual electricity injected to the grid	67.127,83kWh (67MWh)
Annual virtual self-consumption (40%)	26.851,13kWh (27MWh)
Annual electricity sold to GSE (60%)	40.276,70kWh (40MWh)
Annual average electricity consumes per members (only households)	2.500kWh (3MWh)

Table 21 - Outcomes of the first year of activity of Solisca

Consequently, the renewable energy community of Turano Lodigiano has been able to earn approximately **8.200€** in one year.

SOLISCA – First year earnings	
GSE remuneration for self-consumption	3.240,00 €
GSE incentive for self-consumption	2.970,00 €
ARERA avoided grid expenses	228,96 €
GSE remuneration through Ritiro Dedicato	1.760,00 €
Annual earnings of the REC	8.198,96 €

Table 22 - Revenues of the first year of activity of Solisca

However, no information concerning the allocation of the earnings has been disclosed yet, since, at present, the Community is still regulating the matter and trying to find the most equitable balance. It is in fact necessary to understand the financial statements of the first year of activity of the CER and its main economic implications to identify the best distribution of what was gained within Solisca.

Moreover, considering the energy self- consumed, the annual savings of the community with respect to the electricity bills are also greater that what expected, it in fact approximately amount to about twice what was estimated.

It has been computed that the electricity generated within the REC has been able to avoid the emission of almost **50 tons** of CO_2, precisely, 46.205kg.
This result could, otherwise, be obtained by planting approximately **3.000 trees**; activity that requires way longer time to be fulfilled and to lead to significant results.

Also in this case, no information regarding the maintenance costs that Solisca must bear were disclosed, neither by Sorgenia nor by the Community itself.
Anyhow, considering that this is the first year of activity of the community, it is likely that Sorgenia did not have to incur into extraordinary expenses.
So, it can be assumed that the Community had to cover only an amount of around **1.600€** related to the ordinary costs.

It can be easily noticed that the forecasts on which the feasibility analysis was based are not fully reflected during the effective functioning of Solisca.
The most impactful difference can be spotted in the greater number of operating hours of the two power plants, that have led to a significantly higher electricity generation throughout the year, and, consequently, to greater earnings and savings.

Additionally, also the estimated percentages of virtual self-consumption and of electricity sold to GSE have experienced some variations, precisely the slight decrease of the former and the consequent growth of the latter. This change has led to the decrease of the potential earnings that Solisca would have been able to obtain if it had operated according to the percentages initially estimated.
In fact, the electricity consumed within the community through the practice of virtual self-consumption is the most profitable one, thanks to the high revenues that are provided by the incentive tariff, by the avoided grid costs and by GSE remuneration.

On the other hand, the electricity that the Community sells to the market is paid considerably less; this is partially the consequence of the choice of Solisca to rely on Ritiro Dedicato rather than selling the commodity produced directly to the free market.
In fact, as already specified, the latter purchases the commodity at the electricity market price of the specific moment, therefore it strictly depends on the PUN. As a consequence, despite the high volatility risk, the prices are generally much higher, also as a result of the current energy crisis.

The choice between the two systems mainly depends on the **objectives perused** by the different renewable energy communities.
In the case of Solisca, for instance, the main goals are of social nature. The Community is in fact principally committed in **improving the welfare and living conditions of the members**, who are

low-income households for the most part. Consequently, rather than earning from the project, the leading objective consists in enabling all the participants to lower their electricity bills, therefore, to save some money.

So, the extra earnings that the Community generates are also important since they benefit the members as well, but they do not represent the priority of the project.

Consequently, Solisca has probably opted for Ritiro Dedicato because of the stability that the system provides and for the higher degree of certainty. If the leading purpose of the communities had been to earn as much as possible out of the project, the best choice would have probably been the sale of the commodity to the free market, which is less predictable but also more profitable.

Conclusion

It is possible to conclude this study with two main assertions, namely: renewable energy communities, if effectively structured and managed, are capable of providing significant economic benefits to the members, other than the social and environmental ones, and the role and contribution of electric utilities to the projects is decisive and fundamental to ensure a large-scale success of the initiative and its stability.

The analysis conducted in chapter 3 regarding the three models of RECs that can be currently implemented has proved that, regardless the specific configuration adopted, energy communities are capable of generating important earnings and they enable their members to reduce their electricity expenditures, therefore their electricity bills.

More specifically, the results have shown that the **pluralist model** can be the one that provides greater gains to the communities since, if considering the case in which the participants exclusively invest their own resources without asking for a bank loan, there are no third parties involved in the project and so all the earnings remain within the community and its members.
However, this model presents several downsides and limits that significantly hinder its successful functioning. Firstly, it is based on a bottom-up approach, meaning that the initiatives start from individuals or groups of people, so, it can be extremely difficult to create the needed engagement. Moreover, the communities based on this model can be jeopardized by the impossibility to collect the amount of funds necessary for the initial investment. This issue derives from the lack of willingness of members to provide their own money. Lastly, another important obstacle of the model consists in the likely inability of the participants to manage the project on both the administrative and technical sides. In fact, individuals nor cooperatives or other similar types of organizations possess the competences that are fundamental and required to enable the correct functioning of RECs.

Then, through the analysis of the **community energy builders model**, it was possible to notice that, besides the minor earning that the community can obtain due to the obligation to share them with the electric utility, the RECs can largely benefit from the contribution of experts and can present greater scalability and growth possibilities.
These advantages can all be attributed to the involvement of companies operating in the energy industry. They, in fact, provide all the capital needed to establish the community and they also employ their technological knowledge and managerial albites to solve malfunctioning or other technical and bureaucratic issues and to foster the proper functioning of the project. For this reason, it is possible to define these companies as **facilitators**, since they significantly simplify the organization of the

community and they alleviate members from several responsibilities, first of all the need to invest their own money in the community.

Lastly, the study of the **public lead model** has led to the following conclusions. Differently from the pluralist one, in this case the initiative is launched by the municipality, consequently there are higher chances to involve the right amount of people and organizations. Moreover, the municipality is also able to partially finance the realization of the community using public resources.
Anyhow, additional sources of capital are needed since the town hall must employ the fundings also for other needs, therefore, a bank loan is necessary and it is exactly the reason why this model provides lower earnings compared to the first one. The members must, in fact, repay the bank in the following years. However, if the municipality is constituted by up to 5.000 inhabitants, it is also entitled to receive the **non-refundable aid of the RRP** for a maximum amount of 40% of the total initial investment.

Lastly, through the study of a real-life renewable energy community, namely **Solisca** established in Turano Lodigiano, Lombardy, it was possible to provide a concrete outcome of a project that is based according to the CEB model. The community is in fact managed with the collaboration of **Sorgenia**, an electric utility that operates in the free market of both electricity and natural gas.

Solisca has been fully operational for a year now and it has generated about **5.000€** of electricity savings and a total earning of approximately **8.200€**. The fulfillment of the initiative, however, has only been possible thanks to the involvement of Solisca as a third party.
The company plays a substantial role in managing the Community for what concerns bureaucracy and administration, and the technical side, meaning the management and the maintenance of all the technologies employed within the community.

Therefore, notwithstanding the growing "in-house" tendencies to self-generate electricity rather than purchasing it on the market, the role and the business opportunities of the companies belonging to the energy industry may not be significantly hindered.
Electric utilities can in fact embrace their role of facilitators in renewable energy community projects and they can take advantage of the greater proximity to enlarge and **strengthen their networks of clients**. They can, for instance, offer new products and services and they can open up to **new business strategies and opportunities** that are more compliant with the energy transition objective set by the European Commission.

Anyhow, it is also fundamental for Italy to partially **loosen up the current legislation** in order to enable a greater involvement of electric utilities in RECs. Their contribution is, in fact, crucial in order to increase the scalability and efficiency of the projects and, consequently, to reduce the underdevelopment of the Country in the sector and to accomplish the **5GWe** goal of installed power capacity through RECs.

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Abstract

In a global scenario, whose equilibriums are currently damaged and harmed by the energy crisis, therefore by the scarcity of primary energy sources and by the consequent uncontrollable price increase, the main and most impactful solution that has been identified consists in fostering the energy transition throughout all countries worldwide. In fact, it allows the switch towards renewable energy sources that are less polluting, more affordable, and more widespread throughout the world.

Their employment can firstly put an end to the numerous energy dependency relations among countries, and it can also lead to a greater autonomy and empowerment of single individuals through the development of electricity self-generation and self-consume practices.

Renewable energy communities (RECs) are one of the many instruments to foster the transition and they are currently playing an important role in the European Union, which aspires to reach a consume of electricity produced using RES of at least 42,5% by 2030.

The objectives of the study are principally two: the analysis of the economic benefits that RECs can generate on the participants, and the analysis of the role that electric utilities can assume as facilitators for what concerns the establishment and management of the projects.

Prior focusing on RECs, it has been provided an excursus on the history and evolution of the electricity industry and market, in order to better understand the impacts of the current situation.

The electric industry was initially highly fragmentated, due to the presence of numerous operators and the electricity value chain was constituted by the activities of generation, transmission and distribution. The former regards the purchase of the primary sources, the building of the plants and the production of the commodity. The second transports electricity through long distances and at high voltages. The last, delivers medium to low voltage electricity to end-users.

At that time, the main issue of the sector was the incomplete electrification of national territories, that led to deep social gaps, particularly between urban and rural areas. So, in the years between 1930s and 1960s many countries worldwide have started the nationalization process, therefore the abolishment of the full competition in favor of monopoly. Each country concentrated all the steps of the value chain and the entire sector within a single state-owned electric utility, whose purpose was to accomplish the full electrification.

However, in the early 1980s, once the goal was achieved, it arose the urge to liberalize the sector again; with the increase of users and with the extreme consumption growth a single company was not able to meet the electricity demand and to ensure the security of supply anymore. The process has led to the re-opening of the generation activity to competition and, to the introduction of the new segments of trading and retail, both operating according to a regime of full competition. On the other

hand, transmission and distribution have continued operating as natural monopolies due to their extreme management complexity.

In Italy, the nationalization begun in 1962 with the establishment of ENEL, a state-owned electric utility. The full electrification was achieved after approximately 10 years. Then the liberalization occurred in 1999 after the issue of decreto Bersani. The industry was, then, opened to competition, and numerous companies were created and stated to operate in the market. ENEL was listed and privatized.

Nowadays, the electricity market is articulated in the already mentioned activities of generation, trading, transmission, distribution and retail. Particularly, it is important to focus on the newest segments, which are the ones that truly enable the exchange of the commodity according to mechanisms of full competition. Trading takes place in the wholesale market, which is where large volumes of electricity are exchanged. Generation companies and suppliers are the main participants and they respectively sell and purchase electricity at competitive prices. Then, suppliers resell the electricity purchased to end-users in the retail market.

The trading activity is extremely complex and it requires numerous adjustments over time to ensure the balance between demand and supply, so, it takes place during multiple timeframes, from long-term to short-term negotiations. The wholesale market is constituted by Forward and Spot markets. In the former are traded large volumes and long-term bilateral contracts, which may present delivery and withdrawal obligations. Trading can begin from years to months before the actual delivery and it is conducted through continuous sessions that occur every month during weekdays. The partecipants can trade by submitting their orders in which they must specify the selling or purchasing price, the period of delivery and the number of contracts that they want to trade. Two are the purposes of trading in this market, namely speculation and hedging.

Then, the Spot Market is mainly used for short-term adjustments to the volumes of electricity and to solve real-time issues and imbalances to ensure the security of supply and the reliability of the service. It is the most liquid market one and it is articulated into: Day-Ahead Market, Intraday Market, Daily Products Market and Ancillary Services Market.

The Day-Ahead Market (MGP) manages most of the electricity transactions. It is an auction market since it enables participants to simultaneously enter competitive bids, so, it exclusively follows market rules and it does not allow negotiations. Generators and suppliers respectively submit asks and bids and the price is the result of the intersection between demand and supply.

The Intraday Market (MI) is used to make further adjustments to the outcome of MGP. The participants submit additional asks and bids to create a more efficient equilibrium. The market operates in real-time and it can be differentiated between auction market and continuous cross-border European market.

Following, the Daily Products Market (MPEG) is where electricity is traded with the obligation of delivery. Trading takes place two days and the day before delivery on a continuous basis from Monday to Friday.

Lastly, there is the Ancillary Services Market (MSD) through which it is possible to further regulate the electricity injected in the transmission system through the activities of regulation and reserve, and to implement real-time adjustments. All the other markets that are managed by market operators, while this one by TSOs to ensure the correct functioning of the transmission activity.

As anticipated, in the Spot Market prices are set according to the intersection point between supply (asks) and demand (bids). Two are the possible pricing mechanisms: the System Marginal Price (SMP) and the Pay-As-Bid (PAB).

The former sets a uniform price for electricity that is the same for all suppliers regardless the energy source employed. This method correlates the price of the commodity to the production costs that power plants must face; each generation company offers electricity at a price equal to its marginal cost, leading to the “merit order curve”. The clearing price is set where this curve meets with the demand and it is equal to the marginal cost of the most expensive power plant accepted by the system, that currently is the natural gas power plant. It follows that all the plants on the left of the marginal one sell electricity at a price that is progressively higher than the expenses faced during the production process.

The PAB, instead, sets different clearing prices depending on the intersections between specific offers and bids. So generators are incentivized to ask for a price that they expect to be the highest accepted by the system and that is greater than the production costs. This is obviously not beneficial for suppliers but mostly for end-users and it is also the reason why the EU relies on the SMP, which also has its flaws, for instance a grater price volatility and the correlation with natural gas prices, but still is more efficient and fairer.

The electricity market has experienced important changes over time for what concerns the energy sources employed. Moreover, the current energy crisis and its consequences, i.e. the rise of fuels prices, the cut of dependency relations with foreign suppliers, are giving a push to many courtiers, including Member States, to accelerate the energy transition towards RES.

The EU has in fact managed to decrease the quantity of natural gas purchased from Russia from 41% (August 2021) to 9% (August 2022) and the percentage has even lowered in the following months.

However, the sudden abandon of the fuel has led to scarcity issues, inflation and extremely high electricity prices. In order to contain and solve the situation the European Commission has enforced many measures, among which the REPowerEU Plan in May 2022. It aims to safeguard Member States from the consequences of the crisis and to foster the energy transition.

The Plan is based on three pillars, namely: the diversification of suppliers and energy sources, the generation of clean energy and the related investments in the most advanced technologies, and energy savings.

Then other important initiatives of the UE Commission were the enforcement of the Renewable Energy Directive 2018/2001/EU (REDII) and of the Internal Electricity Market Directive 2019/944/EU (IEMD). Other than setting a target for the consume of renewable energy of at least 32% of the total share by 2030, that has been recently increased to 42,5% (REDII) and establishing common rules for the effective management and regulation of the different activities of the energy industry and market (IEMD), these two Directives have properly defined for the first time the topic of energy communities.

They are initiatives centered on the self-generation and self-consumption of electricity within a limited geographical area. The role of these communities is becoming more and more central in the field of energy transition, since, if appropriately implemented, they can lead to a grater empowerment and autonomy of individuals and organization and to significant energy savings.

They can be distinguished in renewable energy communities and in citizen energy communities, the former are regulated by the REDII, while the latter by the IEMD.

Both communities share the same purpose, meaning the self-generation of electricity to rely progressively less from the electricity market. Moreover, they also pursue the same economic, environmental and social goals, which respectively are the lowering of the electricity expenses, the improvement of air quality and the decrease of CO_2 emissions produced by the electric industry, and the rise of social awareness and commitment towards the transition and energy efficiency solutions.

Anyhow, RECs and CECs also present several differences; firstly, the latter are technology neutral, so they do not require the employment of specific technologies. RECs on the other hand exclusively generate electricity through renewable energy sources. Then, RECs also require the proximity of members to the project while CECs do not. Lastly, the former only allow the participation of households, organizations of citizens, public authorities and SME, so large companies cannot join the communities. This measure has been taken to safeguard the autonomy of the initiatives and to detach them from profit-driven interests. CECs, instead, also involve big and powerful companies.

However, the main focus is, currently, on renewable energy communities since they are the ones that best comply with the energy transition and with the 2030 and 2050 objectives.

Both Directives have been transposed into the Italian legislation initially through the legislative decree 162/2019, also known as Milleproroghe Decree and then with the legislative decrees 199/2021

and 210/2021 that have progressively adjusted the regulation of RECs. Particularly, the Milleproroghe Decree has firstly introduced the concept of Renewable Energy Communities with the art. 42-bis, and it has enforced an initial and more restricted regulation for their establishment.
It has set a maximum power capacity of 200kWe and it has stated that it was only possible to create a community among physical and legal persons connected to the same secondary processing cabin, leading to an extremely limited perimeter. However, the two following decrees have increased the power capacity threshold from 200kWe to 1MWe and have enlarged the operational area to the same primary substation.
The process of creating a REC can be summarized into three principal steps: the establishment of a legal entity, the identification of a suitable area, and the installation of smart meters by all the members of the community.
RECs can be organized according to a multiplicity of legal forms (i.e. co-operatives, public utility companies, PPP) and they can follow numerous business models that differs depending on the actors involved and the rules agreed upon. Then, the location must be suitable for the establishment of the community and for the installation of the power plants and enabling technologies. Lastly, each member must install a smart meter that is a device which enables the collection, transmission and exchange of information and data to constantly monitor generation and consume of electricity for balancing purposes.
An important objective of energy communities consists in empowering citizens and in allowing them to be more involved in the energy-related decisions. So, RECs have led to the rise of a new fundamental figure: the prosumer. The term is used to appoint all the individuals or organizations that perform a proactive role within the community, therefore as both consumers and producers of the commodity. Anyone who is willing and economically able to purchase a small size power plant, can automatically become a prosumer and decrease the dependency from national grid and suppliers. When prosumers operate within a community, they have the responsibility to sell a portion of the electricity generated to other members who take part to the project as consumers.
The distribution process is allowed by using micro-grids which are similar to the distribution ones, however they operate at lower voltages.
Prosumers are not entirely self-sufficient since their power plants may not be able to generate enough electricity; consequently, they still partially rely on the market.
Three are the renewable energy sources that are currently most employed in the Italian RECs: solar, wind and hydropower.
Solar energy is the most widespread because of the greater ease of installation and lower investment costs of solar panels, compared to the other technologies. Photovoltaics are the most flexible solution,

since they can be located in many places, i.e. rooftops, gardens and country lands, and they do not generate issues of social acceptance thanks to the absence of noise. Moreover, the Italian territory boasts a good exposition to sunlight.
Wind, due to the greater complexity related to its management is less employed. Firstly, it is fundamental to have a high exposure to winds in the community, then it is necessary to purchase micro-wind turbines, which are the small-scale version of traditional wind turbines. However, differently from traditional ones, micro turbines can only be located onshore, and their production capacity can amount to a maximum of 100kWe. If strategically located, they can offer significant power generation performances, since the power produced by wind corresponds to the cube of its speed.
The principal issues related to these technologies are economic, due to the extremely high investment cost, and social, because of the lack of acceptance due to noise, visual impacts and risk of animal strikes.
Lastly, there is hydropower that requires the purchase of hydroelectric turbines, which enable the conversion of more than 90% of the kinetic energy of water into electricity. The entire establishment is extremely complex; it requires a long planning process, the collaboration of a deeply committed group, and numerous funds. Moreover, the employment of this source is strictly related to the availability of a river or watercourse in the area of the community.
Moreover, due to the considerable financing required, members become full-fledged investors, so they own proportional shares with respect to what invested; so, they actively participate, control the process, and exert proportional voting powers.
Unlike solar and wind, hydro ensures a greater stability of supply, it is both programmable and dispatchable, and hydropower water batteries can be used as storage solutions.
The main benefits that RECs can generate are the reduction of electricity expenses, of electricity prices and of energy poverty, the decrease of the emissions generated during the electricity production process and the improvement of health conditions. These organizations are also highly transparent and democratic, leading to the creation of an extremely inclusive environment. Furthermore, they create new numerous job opportunities, both within the community and outside of it; so, they also generate positive externalities on the entire Country.
However, there are still many barriers and imperfections that must be overcome, for instance the lack of well-defined legislations and regulations, the lack of clarity and the numerous delays. Moreover, there may still occur issues of social acceptance, the unwillingness to take part to the projects and to invest in them, and the inability to exert leadership and to engage individuals. Lastly, there is a general

incapability of members to manage RECs technically and administratively, due to the dearth of the required knowledge and expertise. The only way to overcome this issue is to involve electric utilities.
In order to encourage the establishment of RECs and to increase their economic feasibility, the Italian government has introduced several incentives that are, at present, regulated by the Milleproroghe Decree, accordingly to art. 42-bis, and by the related enforcement resolutions of ARERA and MiSE. The former has validated the virtual regulatory model for the remuneration and concession of the economic benefits resulting from the amount of electricity consumed within the Community. While the latter has identified two incentive tariffs to be applied on any renewable power plant employed in collective self-consumption initiatives and on RECs. The value of the tariff corresponds to 110€/MWh for Energy Communities.
Then, the Rilancio Decree 34/2020 has introduced the Superbonus, a 110% tax deduction, whose rate is supposed to progressively decrease to 65%. This measure, however, is principally addressed to single individuals or to CSC initiatives rather than on RECs since it cannot be cumulated with the incentive tariff. Additionally, the Decree has also introduced the practice of Ritiro Dedicato, which enables energy communities to sell the surplus of electricity directly to Gestore dei Servizi Energetici (GSE) without the need to rely on the free market. The current price amounts to 44€/MWh. This method is characterized by a greater practicability and efficiency, and it safeguards prosumers from the volatility of electricity prices.
Anyhow, at present, the Italian government is waiting for the approval of the draft of the MASE implementing Decree by the European Commission. This new legislative instrument aims at introducing an improved incentive system to simplify the establishment of RECs and to accelerate the energy transition of the Country.
Two are the main innovations in the incentive and financing area that will be introduced, namely: the premium tariff and the non-refundable aid. The former is exclusively applied on the percentage of self-generated electricity that is self-consumed within the REC; it is structured into a fixed and a variable part, whose values vary according to the power capacity of the renewable plants employed. The variable amount can range from 0 to 40€/MWh, while the overall tariff can be distinguished into three clusters depending on the power capacity of the plants: 120€/MWh (< 200kWe), 110€/MWh (from 200 to 600kWe) and 100€/MWh (> 600kWe). Once the incentive has been granted, it is provided for a duration of 20 years from the entry in operation of the renewable plant.
Additionally, if RECs employ solar panels, the Decree has planned some price corrections in consideration of the different exposure to sunlight and, therefore, availability of the resource throughout the Country. So, the central regions of Italy are entitled to receive an extra of 4€/MWh, while the northern ones will obtain an extra of 10€/MWh.

Then, the Decree has also introduced some non-refundable aids provided using the resources of the RRP, which amount to 2,2€bln and through which the Italian government aspires to install a total power capacity of at least 2GW and to reach an annual electricity production of 2.500GWh. The primary requisite to receive the subsidy is that the REC must be established in a municipality that counts a maximum of 5.000 inhabitants. The total value of the aid cannot surpass the 40% of the initial investment costs and it can cover the building of power plants, the purchase of the equipment, the feasibility analysis, and the connection of the REC to the national transmission and distribution systems.

The RRP non-refundable aid can be cumulated with the premium tariff, however the latter must be granted for a maximum of 40%.

Additionally, correlated to the MASE Decree, there is Testo Integrato dell'Autoconsumo Diffuso (TIAD), which is an ARERA resolution aimed at providing a more precise regulation and a procedural simplification of the practices and steps needed for the establishment and management of both RECs and CSC projects. It has quantified the avoided grid costs of REC and CSC participants deriving from self-consumption practices. In the case of RECs, they amount to 8,48€/MWh.

For the analysis of the economic benefits generated by RECs, it has been taken in consideration the recent research «Community Energy Map», which provides a classification of renewable energy communities into three models: pluralist, community energy builders and public lead. These models differ in terms of driving forces, financing methods and management, however they all pursue the same economic goals: the decrease of energy bill expenses and the gain of extra earnings.

The pluralist model is based on a bottom-up approach, meaning that the initiative is launched by individuals or, more likely, by local organizations (i.e. cooperatives). The communities based on this system can either opt for self-financing, so every member of the project must invest a part of its own resources in it, or for a bank loan.

The main issue of this model consists in the possible incapability to generate the adequate engagement and in the lack of knowledge and technical skills to manage the community.

The community energy builders model is more heterogeneous, and it is based on the mixture between top-down and bottom-up approaches. The RECs are established through a public private partnership (PPP) between local groups or authorities, and electric utilities, that partially or fully finance the initial investment. Therefore, this model allows members to be relieved from the need to invest their own resources or from the obligation to repay a bank loan. This system, if effectively managed is the most performing one since it enables the establishment of more technological and efficient communities, and it also ensures a greater scalability.

Lastly, the public lead model occurs whenever the initiative is launched by municipalities or other local public authorities, so according to a top-down approach. The main financing source usually are public funds. However, in the case of town with up to 5.000 inhabitants it is also possible to receive the RRP non-refundable financial contribution to cover maximum the 40% of the initial investment.
All the aforementioned models share the same goal of lowering the electricity expenses of the members by decreasing the purchase of the commodity from the market, however each system also peruses additional economic objectives.
The pluralist model aims to make additional earnings out of the community in order to share them among the members and to reinvest them within the project. The community energy builders model, because of the contribution of electric utilities, aims to repay them for the initial investment and to allow them to make extra profits. Lastly, the public lead model is mainly oriented in making additional earnings from the community to pursue the fight against energy poverty of the households that are members.
After having conducted the analysis of the revenues and expenses foreseen by the three models, and after having computed the potential and approximative earnings and payback times, it has been possible to draw the following conclusions and considerations on the impact of the economic benefits.
Firstly, the partial substitution of the purchase of electricity from the national grid with the practices of physical and virtual self-consumptions, has permitted individuals to rely on a more stable and more unexpensive source, leading to greater savings on the electricity bills and to the establishment of a protection mechanism against the price fluctuation of the commodity.
Moreover, RECs enable to decrease the degree of energy poverty and to improve economic and social welfare among the participants.
Additionally, energy communities are also a source of earnings, mainly thanks to the practices of Ritiro Dedicato or the sale to the electricity market, and to the remunerations related to the incentive tariffs and to the avoided grid costs.
Moreover, RECs also represent a source of profits and of business opportunities for electric utilities. The analysis has shown that the potential earnings directly related to the project are quite limited, especially considering the profits that these companies are usually used to make. However, the participation to energy communities represents a smart business strategy, since it enables to establish tighter connections with users and to spread new proposals, such as energy efficiency options and investments.
Then RECs also lead to important social achievements including the growing awareness of members towards energy topics, the increasing commitment in the initiatives and the progressive acceptance of the technologies required, i.e. solar power plants.

Anyhow, there are still numerous downsides that hinder the correct establishment and management of RECs. Firstly, the current regulation, mainly regarding to the incentive and financing schemes, whose application is still limited and unclear, and the extremely strict limits to the participation of electric utilities. All these problems necessarily lead to strong delays and underdevelopment in the matter compared to the other Member States.

Moreover, the eligibility requirement for the RRP non- refundable aids is considered too limited and counter-productive since the establishment of energy communities in extremely small municipalities cannot foster their scalability, leading to a general lack of efficiency. Additionally, most of the eligible municipalities are in the northern regions of Italy, which are the ones with the minor exposition to sunlight. Therefore, it may be more efficient to provide the subsidy also to larger municipalities that can invest in more powerful plants, that can reach economies of scale and that mainly contribute to the transition of the Country.

Lastly, the management of the bottom-up approach should be improved since, due to the lack of expertise and know-how it is usually complex and not successful. It is also necessary to increase the commitment of members in the financial area, so, their willingness to contribute to the initial investment.

If the Country wants to meet the 42,5% renewable electricity consumption goal by 2030 that has been set by the EU Commission, it must approximately produce 6TWh of electricity from RECs and the installed power capacity required corresponds to about 5GWe. However, up to now, it amounts to around 60MW, with only 30 RECs are effectively operative.

The main cause of this underdevelopment depends on the limits to the participation of large companies, particularly electric utilities, to the establishment and management of energy communities, that have been set by the current Italian legislation. This decision is driven by the necessity to strictly guarantee the respect of the economic, social and environmental pillars of RECs, and to avoid the prioritization of profit-driven goals.

So, the RECs currently existing in Italy are mostly established according to the Public Lead and Pluralist models. Anyhow the promoters of both lack the competences and the abilities that are necessary to effectively build and manage the communities, leading to the hindering of scalability and to the slowdown of the transition.

On the other hand, the community energy builders model is the most performing one thanks to the involvement of electric utilities in the establishment process and in the technical and administrative management of the community. This model also simplifies the financial operations, since it allows to relieve members from the expenses correlated to the purchase of the equipment. This contribution drastically eases and accelerates the creation process and prevents issues related to the unwillingness to provide private capital. However, due to the strict legislation and to the difficulties related to finding a suitable balance between the interests of the parties involved, the CEB model is the most controversial and the less widespread.

However, TIAD has introduced the possibility for energy communities to delegate the representative role to a third party that can be a company that belongs to the energy sector. This decision complies with the growing necessity to allow experts to contribute to RECs to accelerate their diffusion throughout the national ground. So, although companies continue not to be part of the energy communities as members, they will be more involved in the design and implementation stages.

Electric utilities will also benefit from the participation to the initiatives by expanding and strengthening their network of customers and by enlarging their business model with new activities. Lastly, they can also increase their commitment towards more sustainable sources and energy generation practices.

On the other hand, members will be relieved from the expenditures and will be continuously supported by the utilities, which will play the role of facilitators, in the solving of technical issue, malfunctioning and administrative problem.

Additionally, utilities will ensure the growth and scalability of the initiatives, leading to greater economic, social and environmental benefits both inside and outside the community, by generating positive externalities such as the reduction of CO_2 emissions.

To properly analyze the economic benefits of a PPP with an electric utility for the establishment and management of a REC, it has been considered the energy community of Solisca.

It is located in Lombardy, precisely in the 1.500 inhabitants municipality of Turano Lodigiano near Lodi and it was founded with the contribution of Sorgenia S.p.A., a company that operates in the free market of both electricity and natural gas.

This model can actually be considered a combination of the community energy builders model, because of the presence of the electric utility, and of the public lead model, since the initiative was launched by the town hall. Consequently, the project is also deeply committed in the fight against energy poverty.

The planning and design of the project has begun in 2020, prior the entry into force of the RECs legislation, while the Community was inaugurated and has become officially operative and productive since April 1st, 2022.

The Community employs two solar power plants for an overall capacity of 46,5kWe and it provides electricity to 23 low-income households, 9 public buildings and one church. Solisca takes advantage of virtual self-consumption and also, for a smaller percentage, of the physical one, given the sharing of the same PODs between the two power plants and the public buildings over which they are installed, namely the gym and the sports field.

Sorgenia has provided the technical and administrative knowledge and has contributed to the management of the bureaucracy, but, most importantly, the company has fully covered the initial investment and the related expenses for a total amount of about 70.000€.

The Community has been organized as a free association so that it is possible for its members to freely abandon the project, whenever and without any obligations. Additionally, Solisca foresees just the town hall as prosumer, while the other members are exclusively consumers.

An important feature of the Community consists in its full digitalization thanks to the MyCER platform, developed in collaboration with Higeco Energy, and related App. Both enable to constantly monitor the outcomes of the project and to collect insight regarding collective and individual behaviors to progressively reduce wastes and to become more efficient. The purpose of the platform also consists in rising social awareness towards energy consumption and its environmental impact.

The comparison between the outcomes of the feasibility analysis, which was conducted prior the establishment of the Community and the ones of the first year of functioning has demonstrated a few differences.

Firstly, the expected operating hours were fewer than the effective one, therefore the electricity generation during the first year of activity of Solisca was significantly higher compared to what forecasted. Consequently also the overall earnings were greater: they amount to about 8.200€, while according to the feasibility analysis they were approximately 5.500€.

Then, the real percentage of virtual self-consumption (40%) is slightly lower compared to what estimated (45%). Leading to a drastic decrease of the potential remunerations related to the incentive scheme and to the avoided grid costs, which largely contribute to the profitability of the project.

Instead, most of the electricity self-produced (60%) has been sold to GSE through Ritiro Dedicato for about 44€/MWh.

Two are the main conclusions of this study, namely: RECs, if effectively structured and managed, are capable of providing significant economic benefits to the members, and the role and contribution of electric utilities to the projects is decisive and fundamental to ensure a large-scale success of the initiative and its stability.

Regardless the specific configuration adopted, energy communities can generate important earnings and they enable members to reduce their electricity expenditures.

The pluralist model provides greater gains when there are no third parties involved, since all the earnings remain within the community and its members. However, the model is based on a bottom-up approach, so, the creation of the needed engagement can be very difficult. Then, the communities based according to this model can also be jeopardized by the impossibility to collect the amount of funds necessary for the initial investment due to the lack of willingness to pay of members. Lastly, participants are usually incapable to properly manage the project on both the administrative and technical sides.

The community energy builders model, besides the fewer earnings that the community can obtain due to the obligation to share them with the electric utility, enables participants to largely benefit from the contribution of experts and it fosters scalability and growth possibilities.

These advantages can all be attributed to the involvement of electric utilities that provide the capital and that employ their technological knowledge and managerial albites.

Lastly, the public lead model, thanks to the participation of the municipality, leads to greater chances of engagement. Moreover, the municipality is also able to partially finance the initial investment with public resources; anyhow, additional sources (i.e. bank loan) are still needed. However, if the municipality is constituted by up to 5.000 inhabitants, it is entitled to receive the non-refundable aid of the RRP.

Anyhow, the community energy builders model remains the one that is capable of generating greater and more widespread economic benefits, that are not exclusively provided to the community itself and to its members but also to companies operating in the electric industry. These companies have the possibility to expand and to renovate their business strategy by undertaking a new path which is more compliant with the energy transition objectives and that is capable of coexisting and cooperating with alternative electricity generation and consumption practices that are decentralized and autonomous from the traditional industry.