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THE RENEWABLE ENERGY MARKET: Benchmark Analysis Between Italy And Europe

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Abstract

Renewable energies are sources of **clean**, almost **inexhaustible** and increasingly **competitive** energy. They differ from fossil fuels principally for their diversity, abundance and potential for use **anywhere** on the planet. Their growth is very significant, and it will be more and more persistent in the future. Their potential is enormous, and in the last years they have received important backing and blessings from the international community. Lastly and most important, through the Paris Accord signed at the World Climate Summit held in December 2015.

Many factors are driving the rapid uptake of renewable energy: from the fight to **climate change** and the attempt to reduce **local air pollution**, to the creation of **local economic value** and **jobs**.

Inside this scenario, the European Union (EU) is at the forefront of the global energy transformation. Its devoted commitment and long-term vision are laudable, but once again, the internal differences among its countries make difficult to appreciate and understand deeply both achievements and potential bottlenecks.

2020 renewables target seems very likely reachable, and its 2030 of a 27% share of renewable energy was on track to be met. For this reason and many others however, 2030 target was modified and upgraded to a more ambitious **32%**. Energy ministers reached this agreement after 18 months of negotiations. It was welcomed by the renewables industry and the trade body for European energy utilities called it “a well-balanced compromise”. This challenging objective will be monitored and backed by a new policy framework: the **Winter Package** that consists of a new package of measures with the goal of providing the stable legislative framework needed to facilitate the clean

energy transition and thereby taking a significant step towards the creation of the Energy Union. In particular, Renewable Energy installations start again to grow massively, and it has been recorded growth for the fourth consecutive year. However, we are well past the point where EU led the global scenario. As in other geopolitical aspect, the gravity centre is shifting eastwards. European Installed Capacity of Renewable Energy Sources (RES) of **540 GW** has been indeed overcome by one of the most influential and powerful players of the near future: **China (670 GW).**
This study aims at introducing and explaining the most important characteristic of the European market of renewable energy and to provide a benchmark analysis between Italy and the biggest European players in the sector. For each of these countries we will identify cost-effective renewable energy options, spanning a wide range of sectors and technologies.
Data recorded will emphasize ***total installed capacity*** for each source, ***plant sizes*** and ***supportive tools*** to monitor and control innovation. The analysis will focus on the AS-IS situation in each country, but it will also provide middle/long term estimates of what will potentially be the status of RES in the near future, taking inspiration by the national leaders in this market.

Before starting with the core analysis, it is important to highlight how renewable energy sources are an enormous opportunity for every living being on planet Earth. Rapid improvement of renewable energies and technological diversification of energy sources would result in significant climate and economic benefits. It would reduce environmental pollution and improve public health. This experience clearly showed me what can be the impact of this change. I am proud to have contributed even a little to the spread of renewable energies awareness, and I hope you will be able, after reading this report, to embrace this topic with a bit more consciousness and care than before. Knowledge can give men the necessary strength to pursue this transformation.

Sintesi

Le energie rinnovabili sono una fonte di energia **pulita**, quasi **inesauribile** e sempre più **competitiva**. Differiscono dai combustibili fossili principalmente per la loro diversità, abbondanza e per il loro potenziale utilizzo in qualsiasi parte del pianeta. La loro crescita è molto importante e sarà sempre più persistente in futuro. Il loro potenziale non è da sottovalutare, e negli ultimi anni hanno ricevuto il sostegno e il supporto di importanti esponenti della comunità internazionale. Per ultimo, e forse più importante, attraverso l'Accordo di Parigi firmato al World Climate Summit tenutosi a dicembre 2015. Molti fattori stanno guidando la rapida diffusione delle FER (Fonti energetiche rinnovabili): dalla **lotta al cambiamento climatico** e al tentativo di **ridurre l'inquinamento atmosferico**, alla **creazione di valore economico** locale e posti di lavoro.

All'interno di questo scenario, l'Unione europea (UE) è in prima linea nella trasformazione energetica globale. Il suo profondo impegno e la sua visione a lungo termine sono lodevoli, ma ancora una volta le differenze interne tra i suoi paesi rendono difficile apprezzare e comprendere profondamente sia i risultati positivi che i potenziali problemi.

L'obiettivo per il 2020 sembra con molta probabilità raggiungibile, mentre quello per il 2030 di uno share del 27% di produzione di energia da fonti rinnovabili è sulla buona strada per essere raggiunto. Sull'onda dell'entusiasmo infatti, questo obiettivo è stato addirittura modificato e aggiornato a un più ambizioso **32%**. I ministri dell'Energia hanno raggiunto questo accordo dopo 18 mesi di negoziati. È stato accolto con favore dall'industria delle energie rinnovabili e l'ente commerciale per i servizi energetici europei lo ha definito "*un compromesso ben equilibrato*". Questo obiettivo ambizioso sarà monitorato e supportato da un nuovo quadro politico:

il **Winter Package**. Un nuovo pacchetto di misure con l'obiettivo di fornire il quadro legislativo stabile necessario per facilitare la transizione verso l'energia pulita e quindi compiere un passo significativo verso la creazione dell'Unione Energetica. In particolare, le installazioni di energia rinnovabile hanno ricominciato a crescere in maniera massiccia, registrando una crescita per il quarto anno consecutivo. Tuttavia, abbiamo superato da decenni il tempo in cui l'Europa guidava lo scenario globale. Come in altri aspetti geopolitici, il centro di gravità si sta spostando verso est. La capacità installata europea da FER di **540 GW** è stata infatti superata da uno dei più influenti e potenti attori del prossimo futuro: la Cina (670 GW).
Questo studio intende introdurre e spiegare le caratteristiche più importanti del mercato europeo dell'energia rinnovabile e fornire un'analisi di benchmark tra l'Italia ei maggiori attori europei del settore. Per ognuno di questi paesi identificheremo le varie opzioni di investimento, coprendo una vasta gamma di settori e tecnologie.
I dati analizzati si focalizzeranno sulla ***capacità cumulata*** per ciascuna fonte, le ***dimensioni degli impianti*** installati e gli ***strumenti di supporto*** per monitorare e controllare l'evoluzione tecnologica. L'analisi si concentrerà sulla situazione AS-IS in ogni paese, ma fornirà anche stime a medio / lungo termine su quale sarà potenzialmente lo stato delle FER nel prossimo futuro, prendendo spunto dai leader internazionali in ogni mercato.

Prima di iniziare con l'analisi di base, è importante sottolineare come le fonti di energia rinnovabile rappresentino un'enorme opportunità per ogni essere vivente sul pianeta Terra. Il rapido miglioramento delle energie rinnovabili e la diversificazione tecnologica delle fonti di energia comporterebbero vantaggi climatici ed economici significativi. Ridurrebbe l'inquinamento ambientale e migliorerebbe la salute pubblica. Questa esperienza mi ha chiaramente aperto gli occhi su quali possono essere gli impatti di tale cambiamento. Sono orgoglioso di aver contribuito anche solo un minimo alla diffusione di questo argomento, e spero che, dopo aver letto questo report, sarete in grado di abbracciare questo argomento con un po' più di consapevolezza e cura rispetto a prima. La conoscenza può dare all'uomo la giusta forza per portare avanti questa trasformazione.

Contents

List of Figures

List of Tables

CAPITOLO 1
METHODOLOGY

1.1 Methodology and Approach

The following analysis represents a methodology to assess the performance of renewable energy installations in Italy and the trend in the production of energy from renewable sources, with particular attention to future target. All the main technologies are going to be deeply analysed and compared: photovoltaic, wind, hydroelectric, biomass and geothermal. They are considered the 5 mainstream sources, both in terms of diffusion and investments. Photovoltaic systems and wind energy will be the undisputed leader of the installations of the next future, replacing what hydropower have done all along the 20th century. Biomass and geothermal power are still not fully exploited, partly due to expensive projects but also to more social issues like NIMBY (not-in-my-back-yard) problem. Still, their potential forces us to include them in the analysis.

The report will try also to update the reference regulatory frameworks (*National Energy Strategy* for Italy, *Winter Package* for Europe), with particular attention to the mechanisms of support for renewable installations, with a close focus on the strategies through which each country is preparing to achieve the objectives in 2030.

The study will be developed as a benchmark analysis at European level, with reference to **production mix (installed capacity)**, "**plant sizes**", and **regulatory framework**.
As I introduced before, this report will provide a benchmark analysis for the Italian market. The countries that have been chosen for the comparison are: **Germany**, **France**, **United Kingdom**, **Spain** and **Poland**. Together they represent more than 60% of the total demand of electric energy in EU and therefore they can be considered a *significant sample*. (see figure 1.1)

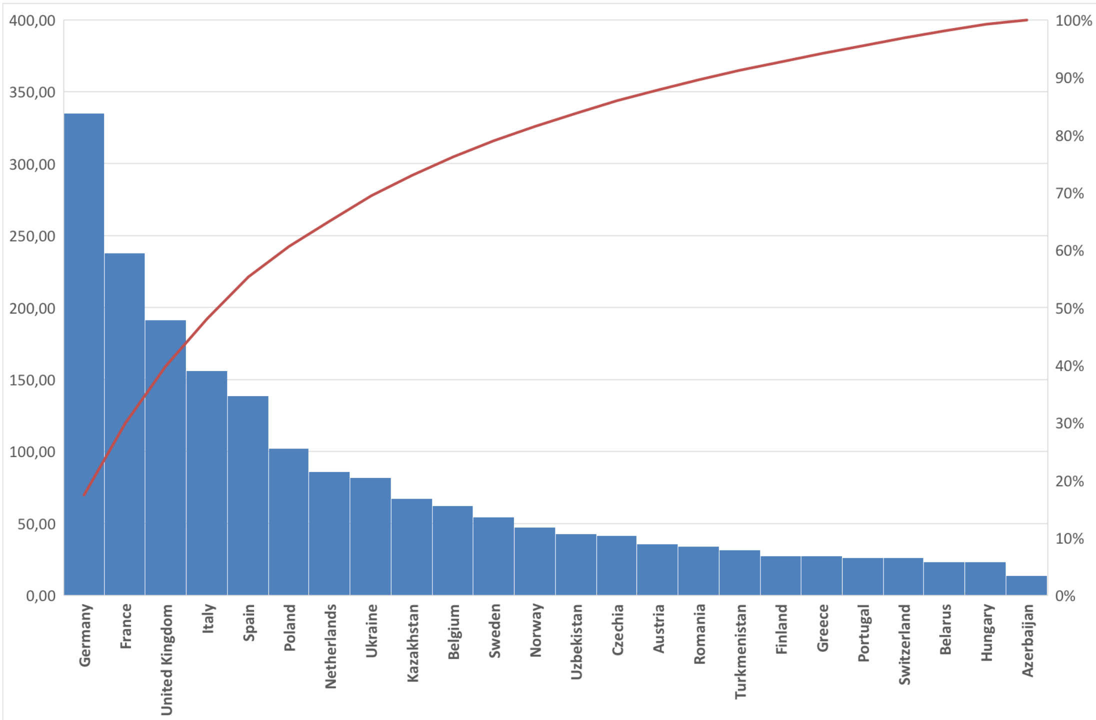


Figure 1.1 Primary Energy Consumption in selected European Countries (2017)
(in million metric tons of oil equivalent) – Source: Eurostat Data

This, however, is not the only reason why we chose to investigate these nations. They are also a priceless source of information that will help us in understanding which are the best (and worst) practice for each technology and how is it possible to maximize their potential.
In particular, Germany and UK can be considered as a perfect example of best practice, in terms of investments and efficient policy framework. Germany in particular, is the only European country that can compete under every

technology with the 2 great leaders in the market: USA and China, while UK is an excellent example in terms of management of wind power. France represents a very interesting case study, given the fact that it is still relying upon nuclear energy for more than 70% of its energy consumption, while Spain is the most similar country in Europe to Italy under numerous aspects, giving us the chance to analyse strengths and weaknesses of our system even from an external point of view. Finally, we chose Poland to have the opportunity to discuss and analyse the evolution of renewable energy market in a developing country where the main sources adopted are still fossil fuels, particularly coal.

We can classify the approach used for this research can be classified as **documentary analysis**. The set of documents gathered for the study have been thoroughly analysed and information extracted and interpreted thanks to the support of a ''***University Database***''. Two were the types of documents that I used:

- **Public Records** (EUROSTAT, IRENA, governamental sites etc.)
- **Private Documents**

The study aimed at being the most scientific possible. The process followed can be sum up in six main steps:

- Gather relevant texts
- Develop a strategy to manage the amount of information
- Assess authenticity of documents
- Explore document's notes, links, references
- Answer questions about document (Who produced it? Why? When? Type of data?)
- Extrapolate and elaborate content

Thanks to quantitative data, it was then possible to develop a qualitative analysis of the actual and future status of renewable energy sources in the main European countries. The report will be structured in 4 main sections:

1) **Introduction:** here it will be developed and discussed briefly the evolution of energy exploitation through human history, highlighting how human being has always relied upon energy management and also how energy availability shaped our world.
   Secondly, each technology is introduced and commented.
2) **Analysis:** it is the core part of the report. Here the actual potential for every country is assessed and commented. After an introduction to the European energy management system, Italy and its benchmarks are reviewed based on the three factors that we have previously quoted: installed capacity, plant size and regulatory framework.
3) **Discussion about the findings:** the results of the previous chapter are then analysed, and every technology is commented based on the achievements reached in every country.
4) **Conclusion:** in response to all the data and comments gathered so far, the report tries to compute some prospects for the future and assesses whether the target set at international level is it reachable or not.

CAPITOLO 2
INTRODUCTION

How important is energy for human beings? What are the main technologies of renewable sources? Moreover, what is the policy landscape? How our European countries behave in managing these resources, especially and compared to Italy?

The objective of Section 2 is to answer to these questions and to dig even deeper in order to give a first explanation of what is the environment in which we are going to operate.

2.1 Energy Use in Human History

Energy has always been among the most essential resources that permitted the progress, evolution and prosperity of human societies. Every scientific and technologic revolution has always been driven by new or improved energy sources. It is now as ever, the essential fuel of our economic system. However, non-renewable sources appeared only in the last stage of human history. It will sound strange, but our ancestors already used renewable sources even thousands and thousands of years ago. Humankind is probably the last living being on earth to make use of this kind of resources. Almost every organism in fact relies upon the energy of the sun. Let us think for example to the photosynthetic conversion of solar energy in plant biomass.

Let us see now briefly how energy utilization evolved in human societies along our History.

2.1.1 The Mastery of Fire and Agriculture

The very first turning point for our species was the discover of fire. The exploitation of solid natural waste, such as wood and other biomasses, to extrapolate their energy through burning process, was the first utilization of renewable sources in human history. The achievements that this breakthrough let us realise were immensurable. From cooking, allowing men to survive even in the harshest environment on earth thanks to an improvement in physical health, resistance and strength, to light, increasing safety in human settlements and promoting demographic expansion. In addition, we must not underestimate the importance of crafting, derived by the creation of new multi-function tools; pottery and metals are just two great examples of what men were able to produce once mastered fire power.
Soon after, a new milestone was achieved: *agriculture*. Human beings started to become sedentary, and through new agriculture technics and with the support of fire, the amount of available food increased. This caused immediately an expansion of population growth.
Demographic growth is often a necessary condition for the development of complex societies, promoting scientific and human progress by increasing the need and the chances for technologic inventions. Wind and water mill are two perfect examples. Using these tools, we were able to master two more elements together with fire.
In this context however, population growth and the limited energy availability imposed by non-cutting-edge technologies, gradually forced a transition towards a new energy regime, the era of *fossil fuels*.

2.1.2 Transition to Fossil Fuels

The invention of steam engine during the 18th century is another of that turning point that demonstrates once again how new energy sources impacted on human history. The new engine and the beginning of the "*industrial revolution*" is one of that "chicken and egg" scenario without a real answer. The steam engine was born thanks to the revolutionary wind of change, or on the contrary, the industrial revolution began thanks to the invention of the new power source? Since my goal is not finding answers to philosophical questions, I would just like to highlight the impact of such breakthrough. From that moment on, nothing has been the same. The request and the consumption of coal at first, and in the following centuries of oil and gas, have shaped our world dramatically, as we can see in figure 2.1. They undoubtedly played an essential role for the fostering of technical innovation, industrial production and the cultural and artistic movement. However, is also clear that the usage of these resources has gone beyond any feasible limit.

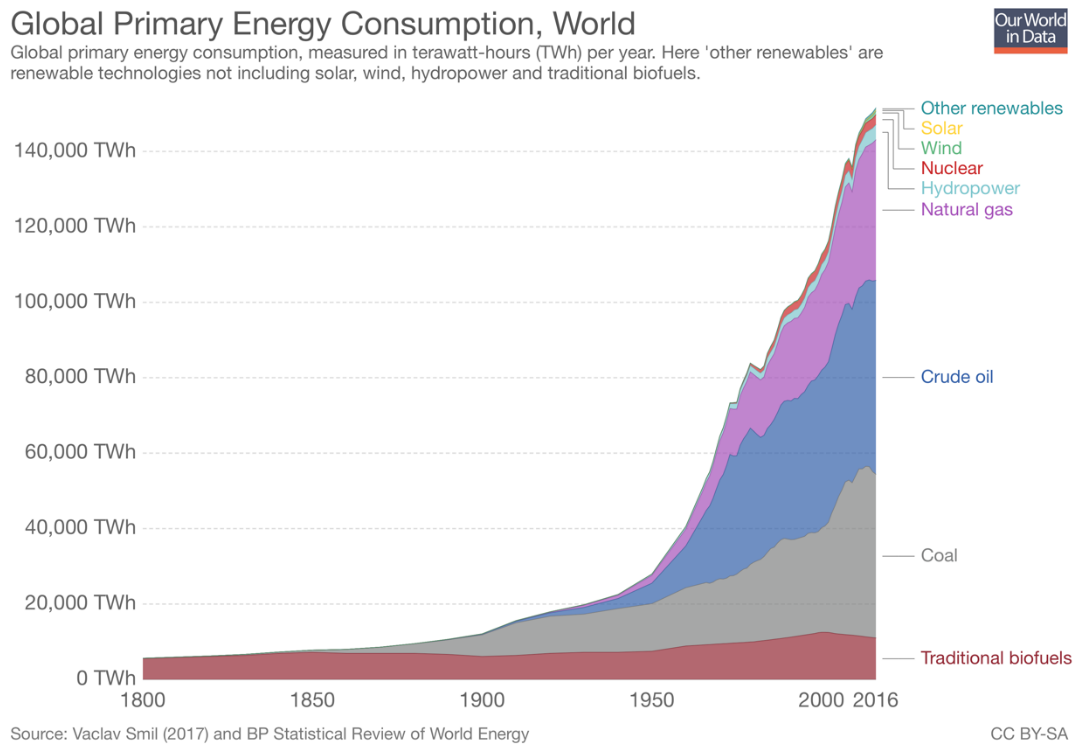


Figure 2.1 Vaclav Smil (2017). Energy Transitions: Global and National Perspectives - Source: BP Statistical Review of World Energy.

The three main fossil fuels continue nowadays to boost our industrial and economic activity as well as bringing comfort to society in the form of lighting, heating, cooking, and mobility in the form of cars, trains, planes and boats.

Furthermore, the lack of a suitable and immediate replacement for aviation engines, for examples, combined with increasing world population and industrialization in overpopulated country like India, China and many others will probably postpone the end of the global fossil fuel age for some decades.
There is still room for growth, however. The uncontrollable and insane exploitation of fossil fuel was so exaggerated that the collateral effects and its correlated damage for our health and our planet became too evident to be hidden. It was during the last decade of the 20th century that we witnessed the issuing of global guidelines that had to be followed in order to start tackling and mitigate the problem. This was possible mainly thanks to the effort and commitment of the United Nations (UN).

2.1.3 From Kyoto Protocol to Paris Agreement

In the 1992 was established by UN the “United Nations Framework Convention on Climate Change” (referred to as the UNFCCC or the Convention). It provides the foundation for multilateral action to combat climate change and its impacts on humanity and ecosystems. The 1997 **Kyoto Protocol** and the 2015 **Paris Agreement** were the direct results of the convention.
The objective of the UNFCCC is to “stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. In pursuit of this objective, the UNFCCC establishes a framework with broad principles, general obligations, basic institutional arrangements, and an intergovernmental process for agreeing to specific actions over time, including through collective decisions by the Conference of the Parties, and as well as other international legal instruments with more specific obligations – such as the Kyoto Protocol and Paris Agreement” [1].
As we said before, a century and half of uncontrollable exploitation of our resources were leading to terrible consequences for our environment. There was therefore an absolute need to act. Deforestation combined with fuels

emission had increased quantities of Green House Gases (GHGs) in the atmosphere. GHGs are responsible for the Green House Effect, i.e. "the trapping of the sun's warmth in a planet's lower atmosphere, due to the greater transparency of the atmosphere to visible radiation from the sun than to infrared radiation emitted from the planet's surface" [2]. From the end of the 19th century to modern days, average temperatures increased by 0, 85°C, causing an increase also of ocean levels and melting of polar ice. With this rate of changing, consequences would be devastating for every living being on earth. A first attempt to solve the problem was made with the **Kyoto Protocol**.

It was adopted in 1995 but it entered into force only in 2005. It was the very first ''global'' effort to at least try to deal with the GHG problem, and it consisted in a series of rules and best practices that commit industrialised countries to limit and reduce their GHGs emissions in accordance with agreed targets. Countries were just asked to report periodically about their results and at the same time their policies and measured adopted were often reviewed by a commission. It was in fact established a powerful monitoring, review and verification system to take under control every little detail.

The Kyoto Protocol stood on two pillars:

1) Binding Emission reduction commitment for developed countries.
2) Flexible Market Mechanisms, which were based on trade of *emission permits*.

Further information regarding monitoring tools will be provided later on.

A second and more decisive hit were given in 2015 at COP 21 with the signing of the so-called **Paris Agreement**. It was a landmark accord because it gathered for the first time all the nations into a common cause. The great weakness of the Kyoto Protocol was the absence of industrialised leaders (and main contributors to global pollution) like U.S.A., China and India. It set for this reason a new course in the fighting for climate change. The Paris Agreement's main goal is to strengthen the global effort to the threat of climate

change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. The Agreement also provides for an enhanced transparency framework for action and support.
The Paris Agreement requires all Parties to put forward their best efforts through "nationally determined contributions" and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts. [3]
Here below the key aspects and the major areas, that need constant focus and monitoring at the eyes of the Parties:

- *Long-term temperature goal* (Art. 2) – The Paris Agreement, in seeking to strengthen the global response to climate change, reaffirms the goal of limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees.
- *Global peaking* (Art. 4) –To achieve this temperature goal, Parties aim to reach global peaking of greenhouse gas emissions (GHGs) as soon as possible, recognizing peaking will take longer for developing country Parties, to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of the century.
- *Mitigation* (Art. 4) – The Paris Agreement establishes binding commitments by all Parties to prepare, communicate and maintain a nationally determined contribution (NDC) and to pursue domestic measures to achieve them. It also prescribes that Parties shall communicate their NDCs every 5 years and provide information necessary for clarity and transparency.
- *Sinks and reservoirs* (Art.5) –The Paris Agreement also encourages Parties to conserve and enhance, as appropriate, sinks and reservoirs of GHGs as referred to in Article 4, paragraph 1(d) of the Convention, including forests.

- *Finance, technology and capacity-building support* (Art. 9, 10, 11) – The Paris Agreement reaffirms the obligations of developed countries to support the efforts of developing country Parties to build clean, climate-resilient futures, while for the first time encouraging voluntary contributions by other Parties.

2.1.4 Rise of Renewable Energy Sources

The strong UN support for climate change however, was not the primary reason to the development of RES. Although it had a formidable impact on the speed up of renewable energy implementation, this phenomenon has already started some decades before. A part for nuclear energy, that was strongly developed soon after the end of the world war II, and hydro power, that was born even before during the late XIX century, thanks to the invention of the highly efficient *Pelton wheel impulse turbine*, Governments of the most developed countries in the world began to fear the undisputed monopoly of Arab countries of oil reserves. This fear evolved in real terror during the 1973 oil crisis, that exposed how fragile and vulnerable were western democracies and their economies, that at that time relied almost exclusively upon oil and gas energy.

A Chinese proverb said: "*in a crisis, be aware of the danger, but recognize the opportunity"*. This could explain perfectly what happened after the shock of oil prices in the early 70s. The most developed economies began to build a defensive strategy against fossil fuels monopolies. The immediate reaction was the development of alternative energy sources.

From that moment on, RES has known a steady growth (sometimes more volatile, sometimes less).

The same process happened 30 years later in the first decade of the new millennia, where another ''oil shock" and the financial crisis put at risk many countries and push them to rely even more on RES.

Therefore, concern for **climate change** and **global warming,** mixed with high **oil prices** and increasing **government support** ended up with new renewable energy legislation, incentives and technological development.

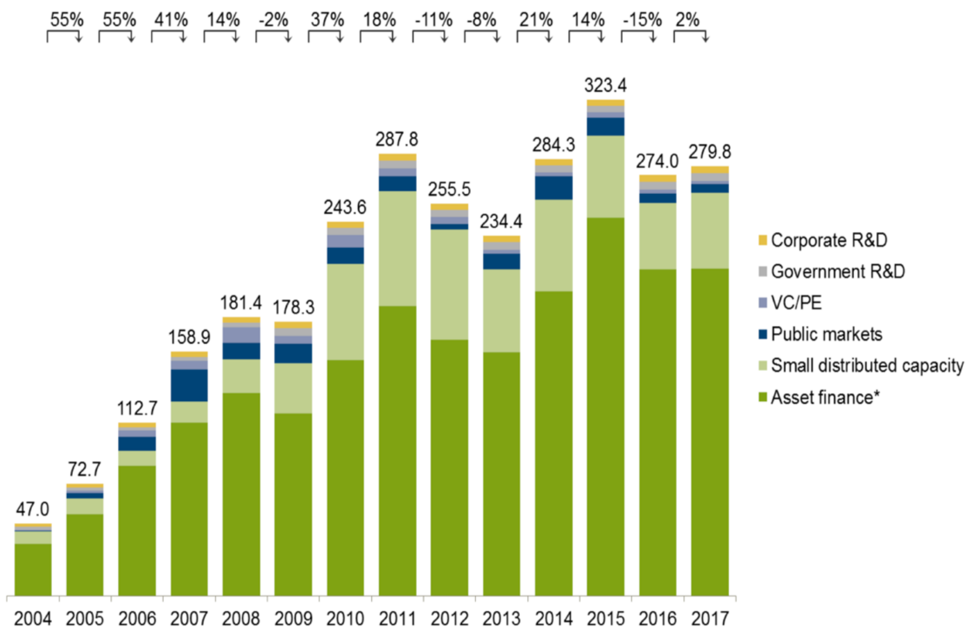


Figure 2.2 Global new Investment in Renewable Energy by Asset class, 2004–17 ($bn) – Source: FS-UNEP Centre, Un Environment, Bloomberg New Energy Finance

Figure 2.2 shows the level of investments in the world for renewable energy since 2004. Although some ups and downs, in the last decade the amount of money invested has been well above the 200 billion of dollars. This is much due to powerful economies such as China and United States (see figure 2.3), but this does not prevent us to demonstrate how fast is growing the market of RES and how unstoppable is now its increase.

The year 2017 was in fact a record-breaking one for renewable energy, characterised by the largest ever increase in renewable power capacity as well as by decreasing costs, increases in investment and advances in enabling technologies. [4]

Furthermore, many achievements of these past few years will probably have important effects on the renewable energy sector in the near future. We should highlight some the most noteworthy:

- The decision of China to launch the world's largest emissions trading scheme. [5]

- The commitment of European Commission in creating and structuring a joint venture to help countries in Africa in identifying, organizing and developing renewable energy projects. [6]
- The EV30@30 Campaign launched by the global Electric Vehicles Initiative. It set a collective goal of a 30% market share for electric vehicles. [7]

Despite the positive facts and the confident progress, we should highlight also the other side of the coin. We must not forget two important aspects:

1) Development in RES is heavily unbalanced across the world. Particularly in most of African nations, energy access and consumption remain very low and approximately 1 billion of people around the world lives without electricity in 2016. [8]
2) Fossil fuels continues to be the vigorous leader in global total final energy consumption (TFEC). As of 2016, renewables accounted for approximately 10.4% of TFEC. (See Figure 2.4).

   Still, the overall share of renewable energy in TFEC has increased only modestly in recent years, despite tremendous growth in some renewable sectors, because of continued growth in overall energy demand. The actual value of energy consumption should be considered a success.

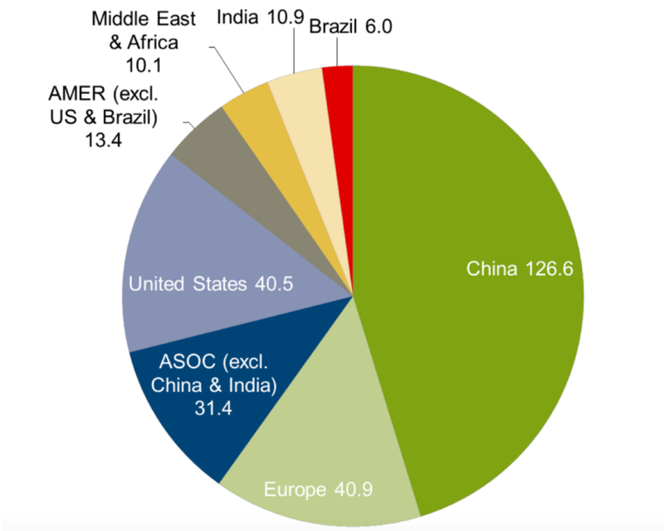


Figure 2.3 Global new Investment in Renewable Energy by Region in 2017 ($bn) – Source: FS-UNEP Centre, Un Environment, Bloomberg New Energy Finance

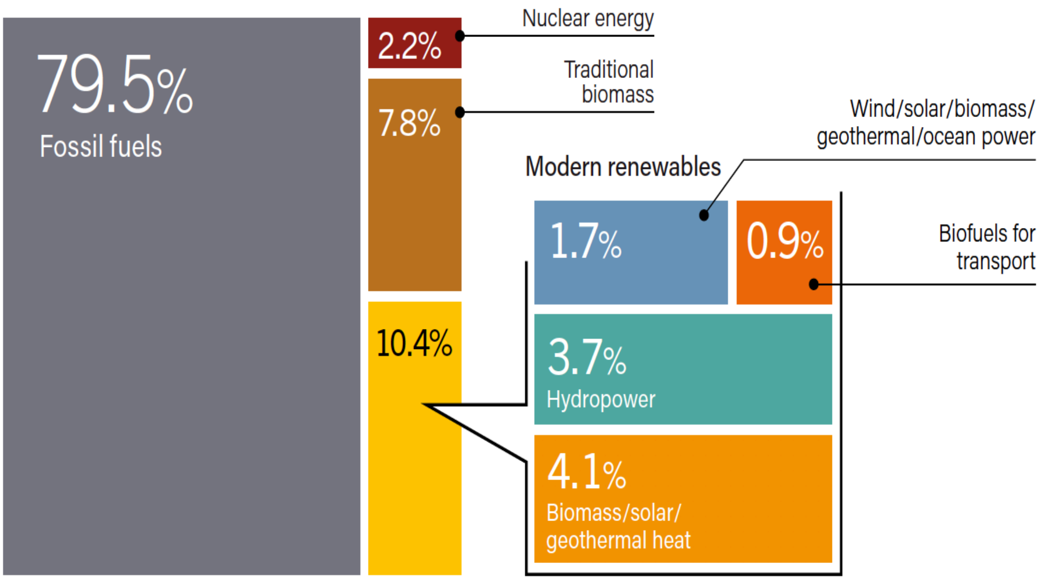


Figure 2.4 Estimated Renewable Share of Total Final Energy Consumption, 2016 based on 357.9 EJ for 2015, from IEA, op. cit. note 17, and escalated by the 1.24% increase in estimated global total final consumption (including non-energy use) from 2015 to 2016, derived from IEA, World Energy Outlook 2017 (Paris: 2017)

2.2 Brief Literature about Renewable Sources

As we said, Renewable energy is energy from sources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited for energy that is available per unit of time.

The major types of renewable energy sources are:

1) Wind Power
2) Solar Energy
3) Hydropower
4) Biomass
5) Geothermal

Let us see in detail each source.

2.2.1 Wind Power

With the development of electric power and its exponential increase in demand during the 20th century, wind power has become one of the most important assets in our world. Energy from this resource was used as long as men have put sails into the wind. For more than 3000 years, thanks to wind power, humans have ground grain and pumped water, allowing the achievement of some of the most incredible engineering project in our history. The drained polders of the Netherlands are probably one of the greatest examples.

Figure 2.5 14th century Windmill - John Langdon: Mills in the Medieval Economy. England 1300-1540. Oxford 2004 ISBN 0-19-926558-5, p. 289 pl. 6.1.

Nowadays, wind power exploits use of airflow through wind turbines to generate mechanical power and turn into electric energy. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land [9]. The best and most efficient way to exploit wind power is to aggregate several turbines in so called ''Wind Farms'', where each individual turbine is linked to the electric power transmission network. Thanks to the huge investments and support of government in the last years, wind power has become one of the cheapest sources of electric energy worldwide [10].

Like most of the energy sources on our planet, wind power in the 20th century has known two different period of development. The turning point was the famous 1973. Before that date, wind energy use was spread among individual generators, which competed against fossil fuel plants. After that year, as we saw before, the investigation of non-petroleum energy sources exploded, and for wind power in particular, the development was massive, both in terms of technologic improvement (see figure 2.6) and in its spread among countries (see figure 2.7).

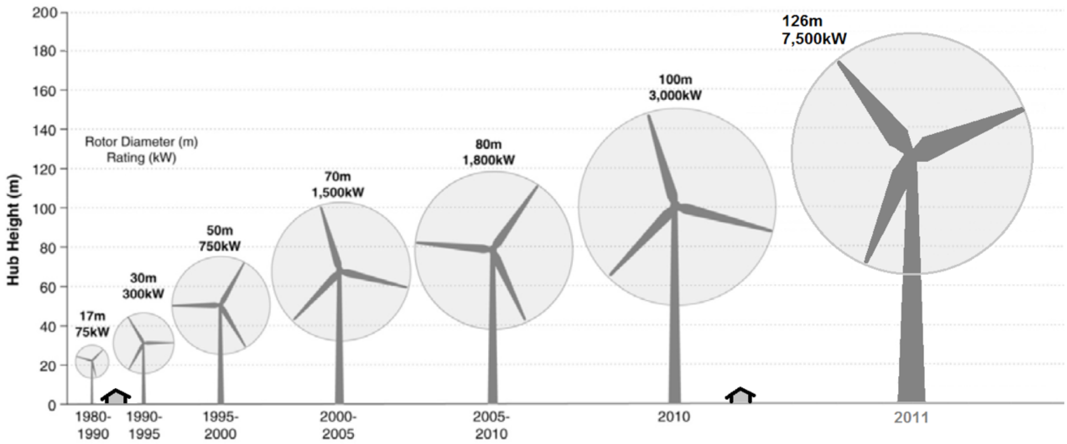


Figure 2.6 Size comparison of modern turbine size

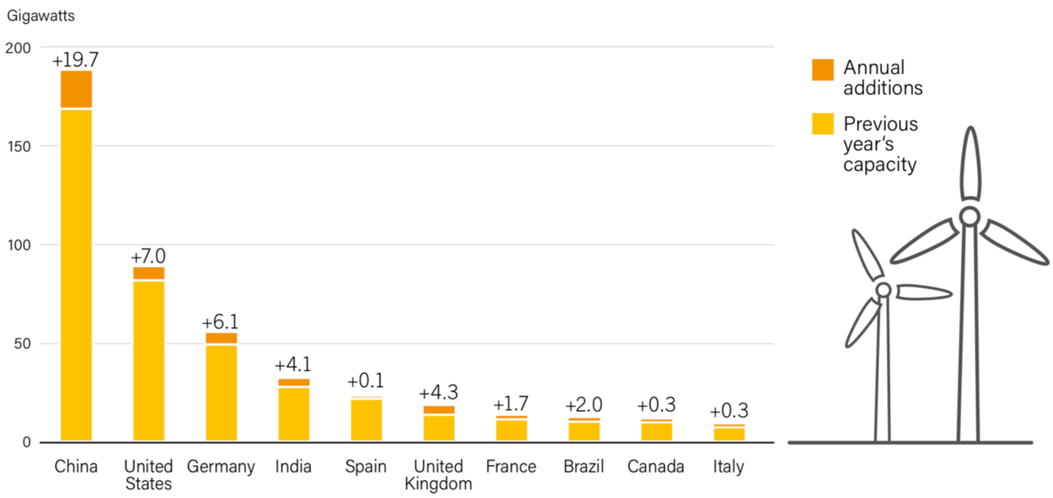


Figure 2.7 Wind Power Capacity and Additions, Top 10 Countries, 2017 - Based on data from GWEC, op. cit. note 1, and WindEurope, Wind in Power 2017: Annual Combined Onshore and Offshore Wind. Statistics (Brussels: February 2018), p. 9.

The key success factor for wind energy is clearly the **turbine**. A wind turbine is a device that converts the wind's kinetic energy into electrical energy.

There are two type of turbine: vertical axis and horizontal axis. Arrays of large turbines create the so-called **wind farms**, used by many countries as part of a strategy to reduce their reliance on fossil fuels.

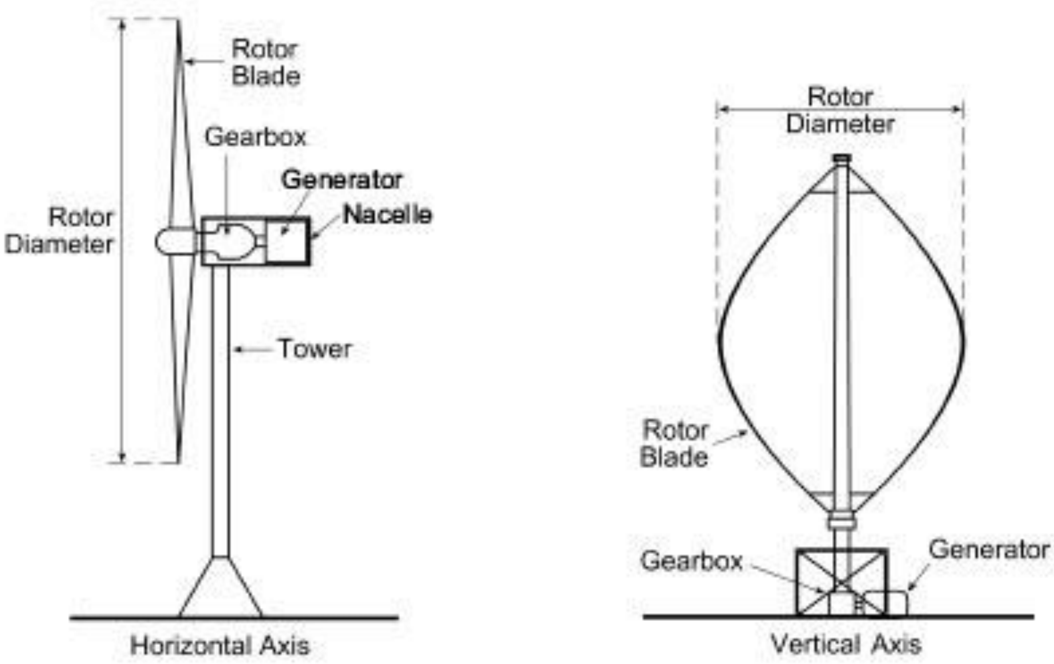


Figure 2.8 Horizontal and vertical axis

- Horizontal-axis wind turbines, with the blades upwind of the tower, produce the overwhelming majority of wind power in the world today. These turbines have the main rotor shaft and electrical generator at the top of a tower and must be pointed towards the wind. Simple wind vane points small turbines, while large turbines generally use a wind sensor coupled with a yaw system. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.

  Turbines used in wind farms for commercial production of electric power are usually three-bladed. These have low torque ripple, which contributes to good reliability. Furthermore, they produce more electricity than two bladed turbines and cost less than four-bladed turbines (or more) in terms of OPEX and maintenance. Blades are usually colored white for daytime visibility by aircraft and range in length from 20 to 80 meters.

- Vertical-axis wind turbines instead, have the main rotor shaft arranged vertically. One advantage of this arrangement is that the turbine does not need to be pointed into the wind to be effective, which is an advantage on a site where the wind direction is highly variable. It is also an advantage when the turbine is integrated into a building because it is inherently less steerable. In addition, the generator and gearbox can be placed near the ground, using a direct drive from the rotor assembly to the ground-based gearbox, improving accessibility for maintenance. However, these designs produce much less energy over time, which is a major drawback.

Conventional horizontal axis turbines are divided into three components:

1) The **rotor**, (20% of the wind turbine cost): includes the blades for converting wind energy to low speed rotational energy.
2) The **generator**, (34% of the wind turbine cost): includes the electrical generator the control electronics, and most likely a gearbox (e.g. planetary gearbox), a component for converting the low-speed incoming rotation to high-speed rotation suitable for generating electricity.
3) The **surrounding structure** (of the wind turbine cost): includes the tower and rotor yaw mechanism.

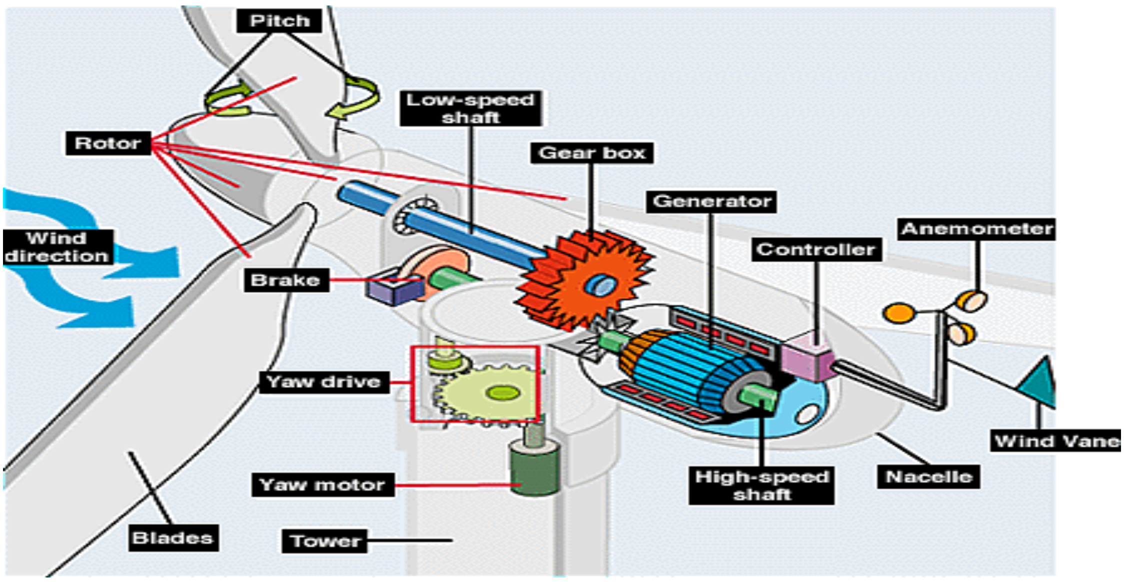


Figure 2.9 Turbine components

Offshore Wind Power

Speaking about wind energy oblige to introduce necessarily one of its fundamental innovation of the past few years: Offshore wind power. Differently from onshore farms, offshore ones are constructed not on mainland but in in the middle of water, usually ocean or continental shelf. Since higher wind speeds are available compared to classic site on land, electric generation is higher per amount of capacity installed. Furthermore, unlike onshore wind, offshore breezes can be strong in the afternoon, matching the time when people are using the most electricity [11]. On the other hand, installation and OPEX costs are much higher, due mainly to their complexity and distance from mainland.

This special technology is still very young and very concentrated. All the largest offshore wind farms are in northern Europe, especially in the United Kingdom and Germany, which together account for over two thirds of the total offshore wind power installed worldwide. Cost reduction however, is decreasing much quicker than expected, thus helping to increase the attractiveness for this technology and its future prospects.

The offshore segment in 2017 in fact, had a record year with 4,334 MW of installations, an 87% increase on the 2016 market. It is still only about 8% of the global annual market and represents about 3.5% of cumulative installed capacity, but its growth seems steady, quick and unstoppable, even if some environmental issues could slow down its growth.

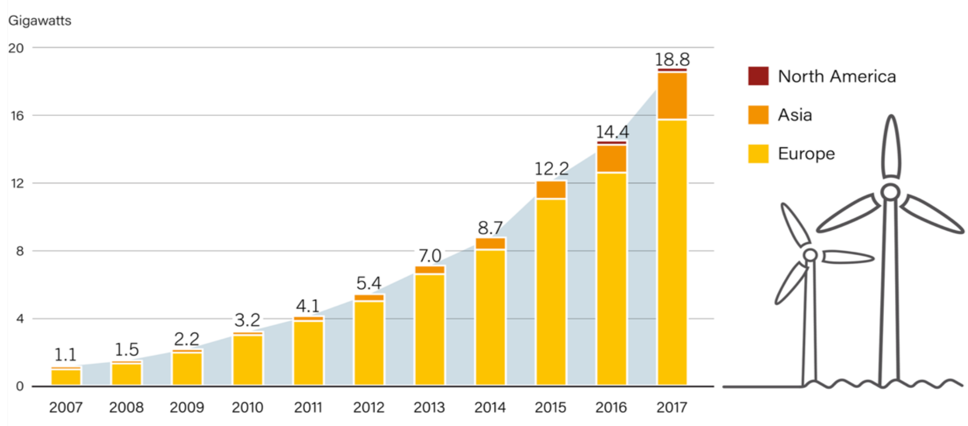


Figure 2.10 Wind Power Offshore Global Capacity by region 2007 - 2017 - Based on data from GWEC, Global Wind Report

Environmental Impact

Wind turbines have some negative effects on the environment.

- **Visual Impact**: They are very large machines, and they may affect the landscape.
- **Noise**: The sound that wind turbine blades make as they turn in the wind can be very annoying for people who lives in the nearby.
- **Biodiversity** danger: They may cause bird and bat deaths. These deaths may contribute to declines in the population of species also affected by other human-related impacts.
- **Usage of rare earth minerals**: mining these minerals can have negative effects on the environment.
- Producing the metals and other materials used to make wind turbines and the concrete used for their foundations requires energy that may have been produced by fossil fuels.
- **Tourism Impact**: offshore wind turbines may affect heavily on the willingness of tourists to reach a beach or a sea place if wind turbines are installed few kilometres off the beach. This is one of the reasons why in Italy still we do not have offshore wind farms.

Cities therefore are very much reluctant in doing heavy investments in wind farms, fearing revenues losses for all the reasons we have listed before.

Actual Status of the Market

Cumulative Installed Capacity	**539 GW**	**+ 9,6%**
Annual addition	**+52 GW**	**-3%**

Regarding the actual status of the market, 2017 has been a positive year for this particular source. Europe, India and the offshore sector have set new installation record, allowing the global market to remain above the 50GW per year of added capacity. Compared to 2016 (see figure 2.11) we must notice a slightly decrease of almost 3%, due mainly to the fact that Chinese installations were down of about 20GW. The rest of the world however compensated this decrease.

The most important aspect however, beyond the statistics, is the fact that wind power is becoming rapidly a fully commercialized, unsubsidized technology. Very soon, it will have to be considered as a real and dangerous competitor by fossil and nuclear incumbents.

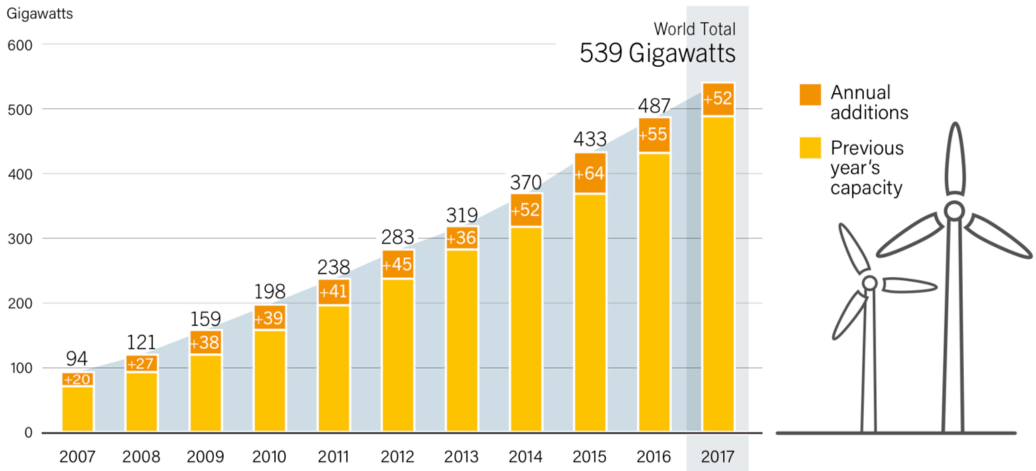


Figure 2.11 Wind Power Global Capacity and Annual Additions, 2007-2017; based on historical data from GWEC, op. cit. notes 1, p. 20;

2.2.2 Photovoltaic Energy

A photovoltaic system (PV system), is a power system designed to exploit solar energy and transform it in electricity by means of photovoltaics. It is made of different components, mainly represented by **solar panels** that effectively absorb solar power and convert it in electricity. Then there is a **solar inverter**, which transforms the electricity generated from direct current (DC) to alternating current (AC), and several other parts known as **balance of system** (BOS), including for example *mounting, cabling, battery bank, battery charge* and many other, depending on the typologies of the panels. It is important to remind that PV systems convert light directly into electricity and should not be confused with other technologies, such as concentrated solar power or solar thermal, used instead for heating and cooling purpose only. Actually, the market of PV systems is various. They range from **small**,

rooftop-mounted or **building-integrated** systems with limited capacities (1-20 Kw), to **commercial system** (from 50 to 500Kw) to **large utility-scale** power stations with much bigger capacities (hundreds of megawatts).
Being completely silent, with no moving parts or environmental emissions, PV systems have rapidly transformed themselves from being a niche market technology into a mainstream application used in numerous different industries and environment.
As we said before, we can find different typology of PV system on the market. They are generally categorized in three groups: *residential rooftop, commercial rooftop, and ground-mount utility-scale systems*. A typical residential system is around 10 kilowatts and mounted on a sloped roof, while commercial systems may reach a megawatt-scale and are generally installed on low-slope. Even if rooftop mounted systems are smaller and therefore have a higher cost per watt than large utility-scale installations, they account for the largest share in the market.
Speaking about numbers, last year was a landmark one for solar photovoltaics: the added capacity in the world of solar panels was more than any other type of renewable source. Furthermore, more PV was installed than the net capacity additions of fossil fuels and nuclear power together [12]. Globally, total capacity increased more than 30%, reaching a cumulative amount of more than 400 GW (see figure 2.12).

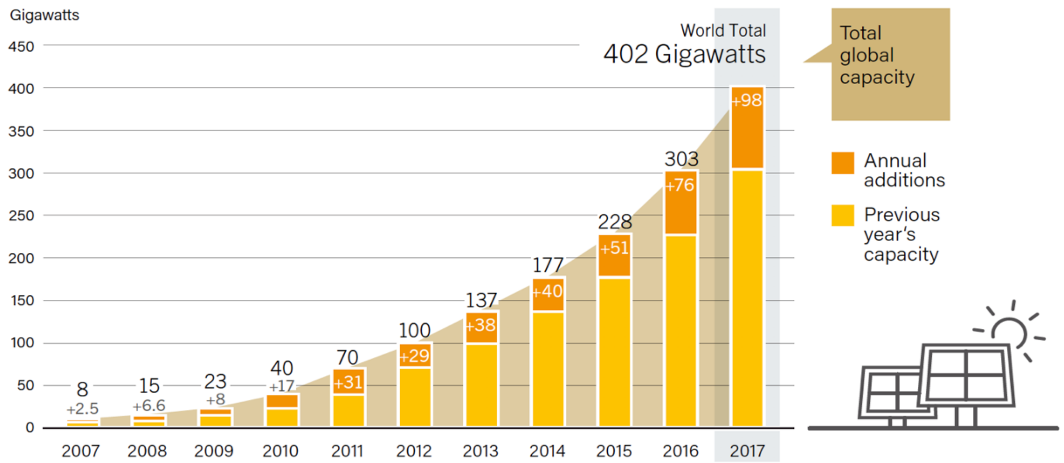


Figure 2.12 Solar PV Global Capacity and Annual Additions, 2007-2017; based on data from IEA PVPS, Snapshot of Global Photovoltaic Markets 2018

It is however important to highlight how the photovoltaics market is still a very concentrated scenario (see figure 2.13). China, where new installations were more than 50% [13], eclipsed all the other countries. However, at the end of 2017, every continent had installed at least 1 GW and 29 countries had 1 GW or more of capacity [14].

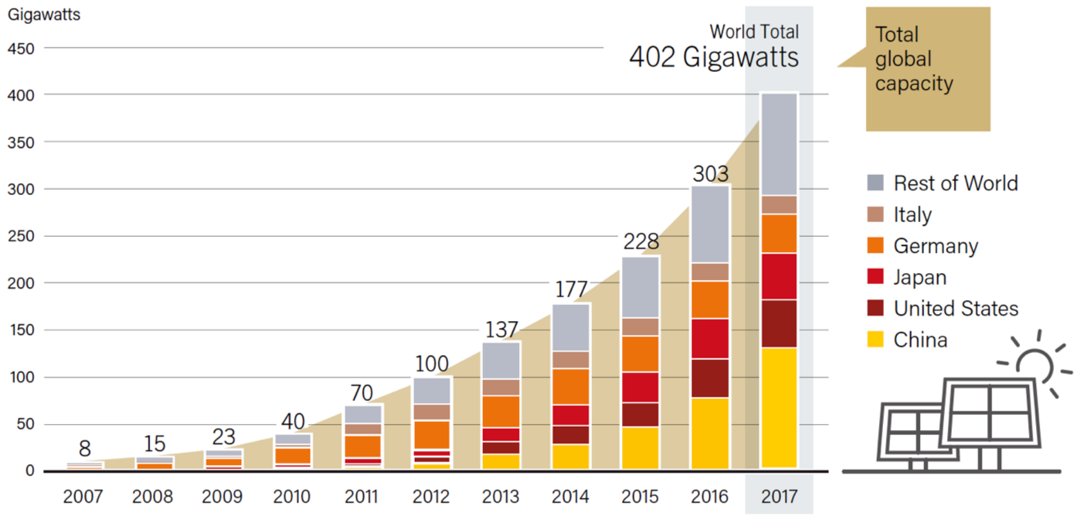


Figure 2.13 Solar PV Global Capacity, by Country or Region, 2007-2017; based on data from IEA PVPS, op. cit. notes 3

Actual Status of the Market

Cumulative Installed Capacity	**402 GW**	**+ 24,3%**
Annual addition	**+98 GW**	**+22,4%**

We can mention some important achievements for 2017:

- record-low auction prices driven by intense competition;
- lower margins for producers and developers (mainly due to the shift in many countries from FITs to tenders);
- continuing advances in technology [15];

Every result that we have mentioned before is the consequence of all the hyper fast changings that this industry has seen in the last years. Mergers and acquisitions continue to shape the economic environment making it more competitive. Furthermore, new record cell and module efficiencies were achieved, as new advances in technology are always more frequent [16].

New policies and lower bids prices are also making government much keener to reach the objective of increasing efficiencies and lower LCOEs (levelized cost of electricity).

2.2.3 Hydro Power

Hydropower is power derived from the energy of water. Thanks to the invention of watermills, hydropower is one of the oldest renewable energies ever exploited in our history. Since ancient times in fact, hydropower has been used as a source for irrigation and the operation of various mechanical tools. It strongly contributed to the development of our civilization, and still does.
Since in the late 19th century hydropower started to produce also electricity, the two terms have been used almost exclusively together.
There are several typologies of hydropower stations: the majority of hydroelectric power comes from the energy of **dammed water** that triggers a water turbine and a generator. The power obtained from the water depends on the volume and on the difference in height between the source and the water's outflow (head). Usually large pipes deliver water from the reservoir to the turbine.
Other types of stations are known as **run-of-the-river (ROR)** hydropower. Here no storage is provided. They rely almost entirely on river flows, thus being examples of intermittent energy source. The logic behind a ROR project is clearly the same of a classic dam, but here reservoirs are not part of the scenario, reducing the potentially environmental disadvantages associated with it (flooding for examples). That is why ROR are considered much greener and more sustainable than common hydropower projects.
Pumped storage (PSH) instead, is a type of hydroelectric energy storage used by power systems for **load balancing**. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation. During periods of high electrical demand, the stored water is released through turbines to produce electric power. Another noteworthy source of hydropower comes from **tide** power. It is a form of

hydropower that, as suggested by its name, converts the energy obtained from tides.

Even if it is not yet widely used, tidal energy has potential for future electricity generation. Their strength lies in their predictability. They are more predictable than the wind and even the sun.

Actual Status of the Market

Cumulative Installed Capacity	**1273 GW**	**+ 1,9%**
Annual addition	**+22,6 GW**	**-17,8%**

If we look at the market of hydroelectricity, global added capacity in 2017 were an estimated 22, 6 GW. While significant, this is the smallest annual increment seen over the last five years [17]. Hydropower development remained relatively strong across the rest of Asia, while in Europe the rate is much more negative. Except for Norway, that possesses huge amount of water sources, many of them yet unexplored, old Europe has already saturated the majority of hydropower sites. Italy in this case is a strong example. The leading countries for cumulative capacity nowadays are China, Brazil, Canada, the United States, the Russian Federation, India and Norway. (See figure 2.14)

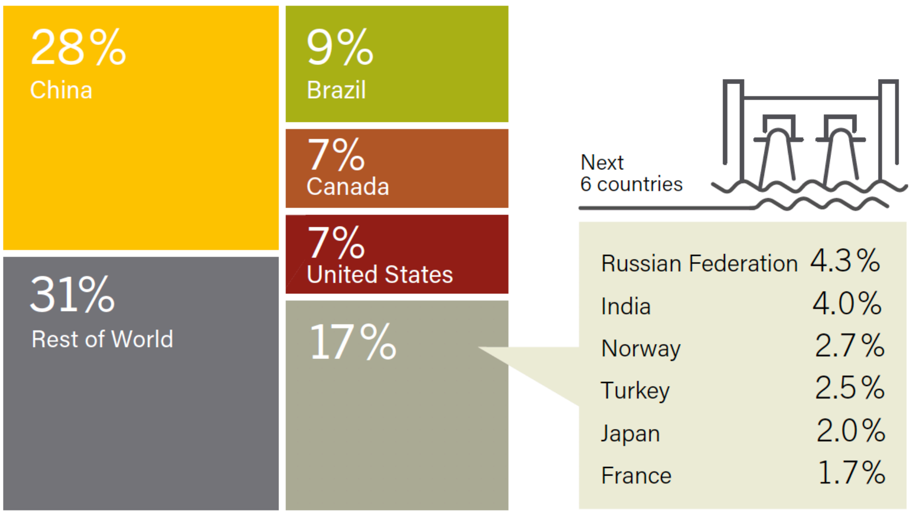


Figure 2.14 Hydropower Global Capacity, Shares of Top 10 Countries and Rest of World - based on capacity and generation sources provided in IHA, Hydropower Status Report 2018

The priorities for the industry in 2017 were mainly focused on finding new models for a more sustainable development of hydropower industry and a deeper penetration in the so called ''third economies'', through modernization of already existing projects and digitalization of facilities. Many hydropower farms in fact are decades old, if not centenary. Modernization and rehabilitation of these plants is thus a fundamental task for the industry.

2.2.4 Bio Mass Energy

Bio Energy is a broadly term used for describing a type of energy obtained by burning wood and other organic matter. Burning biomasses are classified as a renewable energy source from a legal point of view only in case of replacement of plant stocks with new ones. As an energy source, they are multipurpose. They can be used directly to produce heat, or indirectly as a source for biofuels and for electricity.
Actually, the major sources are the so-called **biofuels** (mostly ethanol), that account for almost half of the of energy produced (48%), then we have **plant-based biomass** (41%) and lastly **municipal wastes** (11%) [18].
Many bioenergy technologies are well developed and fully marketable, while others are still at the R&D stage. Regarding the production of electricity however, most bio power plants use direct-fired combustion systems. They burn biomass directly to produce high-pressure steam that drives a turbine generator to make electricity.
This particular source plays a leading role in many low-carbon scenarios and can be particularly useful in the long term for the transportation sector, if other alternatives will not be readily available.
Their expansion remains the subject of debate and many controversies have risen in the last years regarding the sustainability of production and use. Using biomass as a fuel produces air pollution in the form of carbon monoxide. Furthermore, it requires a more complex supply chain than other RES, including feedstock suppliers and processors as well as transport of the fuel to end-users. However, when produced and used in a sustainable way, bioenergy

can undoubtedly contribute to decrease GHGE and provide a range of other environmental, social and economic benefits [19].

Policy contexts have greatly determined the Bioenergy markets of specific countries and regions. Some decided to support the development, like for examples India and Brazil, while other remained more conservative, like EU. However, the electricity sector has seen the highest rate of growth in bioenergy consumption. Still, the usage for industrial and building heat exceeds its use in electricity and transport, even when the traditional use of bioenergy is excluded; (See Figure 2.15).

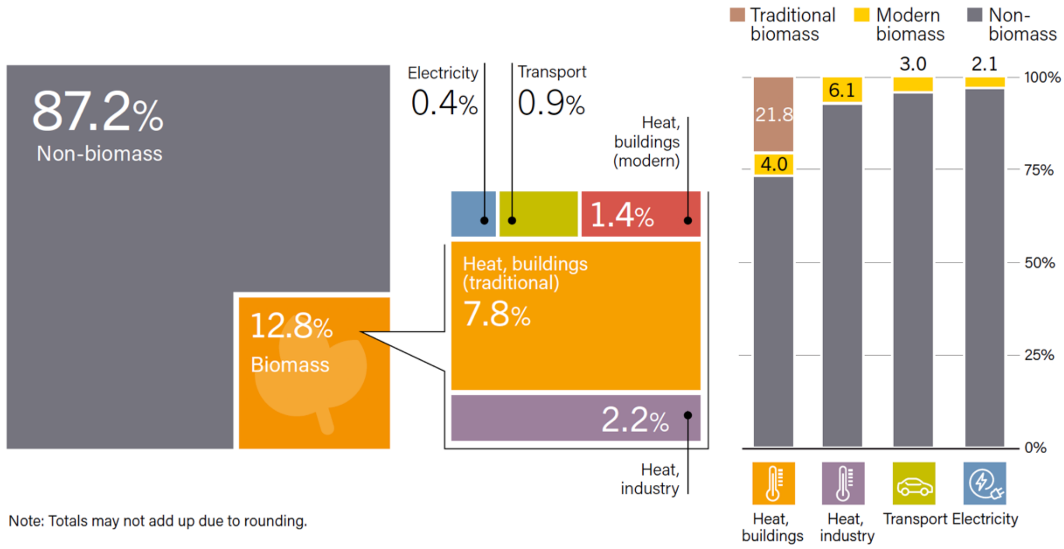


Figure 2.15 Shares of Bioenergy in Total Final Energy Consumption, Overall and by End-Use Sector, 2016 - from IEA, World Energy Statistics and Balances, 2017 edition (Paris: 2017).

Actual Status of the Market

Cumulative Installed Capacity	**108, GW**	**+ 4,6%**
Annual addition	**+5,2 GW**	**-35%**

Global bioelectricity (electricity generation from bioenergy) capacity increased 5% between 2016 and 2017, to 109 GW. China has now overtaken the United States as the largest producer of bioelectricity while In Europe, generation rose 11% in 2017 compared to 2016, driven by the Renewable Energy Directive and maintaining the strong growth of the previous decade.

Europe's largest bioelectricity producer is Germany, where capacity increased 4% in 2017 to 8.0 GW, with significant rises in biogas, bio methane and sewage gas capacity.

2.2.5 Geothermal Power

Geothermal resources provide electricity and thermal energy services exploiting heat from the depths of the earth. Italy is one of the leaders of this sector (see figure 2.16), being able to exploit several natural geothermal sites, especially in Toscana region. The first geothermal plant was opened in Lardarello, Italy, in 1904.

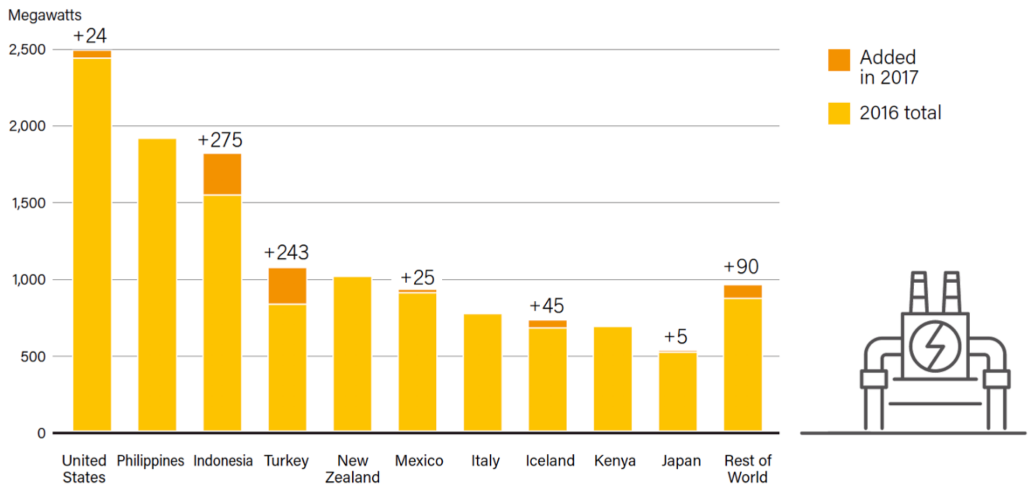


Figure 2.16 Geothermal Power Capacity and Additions, Top 10 Countries and Rest of World, 2017 – International Energy Agency (IEA) Geothermal, 2016 Annual Report.

There are three types of geothermal power plants: dry steam, flash, and binary.

- Dry steam, the oldest geothermal technology, takes steam out of fractures in the ground and uses it to drive a turbine.
- Flash plants pull deep, high-pressure hot water into cooler, low-pressure water. The steam that results from this process is used to drive the turbine.
- In binary plants, the hot water is mixed with a secondary fluid with a much lower boiling point than water. This causes the secondary fluid to

turn to vapor, which then drives a turbine. Most geothermal power plants in the future will be binary plants.

There are still some environmental problems. The main concern is the release of **hydrogen sulphide**, a gas that smells like rotten egg at low concentrations. Another concern is the disposal of some geothermal fluids, which may contain low levels of toxic materials. Although geothermal sites are capable of providing heat for many decades, eventually specific locations may cool down.

Actual Status of the Market

Cumulative Installed Capacity	**12,9 GW**	**+ 1,9%**
Annual addition	**+0,6 GW**	**+51%**

The geothermal industry in 2017 remained constrained by several specific issues, such as long project lead-times and high resource risk. The most important future achievements will be to reduce development risk and potential environmental problems. The uncertainty about the geothermal power in the past has often discouraged investors, especially private ones, to fund the expensive exploratory operations that must be done in order to assess the profitability of a site. New methods however, are helping to overcome some of these challenges. Continuing technology innovation, particularly in the United States and Europe, ‘’has raised the prospect of exploration and development of geothermal resources that previously were out of reach, even in areas with an average or low geothermal gradient, by reaching deeper into the earth and by better means of heat extraction’’ [20].

2.3 Renewable Energy Policies Landscape

Renewable energy technologies have achieved massive technological advances and strong cost reductions. They have becoming the leaders of the global energy transition, with nearly every country adopting a renewable energy target.

Yet progress has not been homogeneous in different countries and sectors. Compared to power generation, the regulatory framework for end-use sectors lags behind. Actually, the renewable energy policies landscape is very heterogeneous. The most significant examples of incentives are *feed-in tariffs*, *premiums* and *auctions*.

Grant, *loans* and *tax incentives* are mainly used for **heating and cooling** technologies; *Decarbonisation* of the **transport** sector has tended to focus on improving energy efficiency, expanding the use of biofuels and encouraging public transport, biking, walking, etc. In the **power** sector instead, competitive auctions are the main form of policy support for renewables, and many countries are moving from set tariffs or premiums toward auctions for the deployment of new projects. In particular, looking in detail to this last sector, governments have committed themselves to the advance and the deployment of all types of renewables through targets and policies. At the beginning, investments (particularly for PV systems and wind power), were largely pushed by fixed feed-in tariffs (**FITs**), since they provide a stable income to generators and help increase the bankability of projects. Their main goal is to set the right level for the tariff or the premium and adjust it when is needed. As renewable technologies have evolved however, and their costs have fallen, large-scale power projects have been increasingly supported by **auctions** (see figure 2.17).

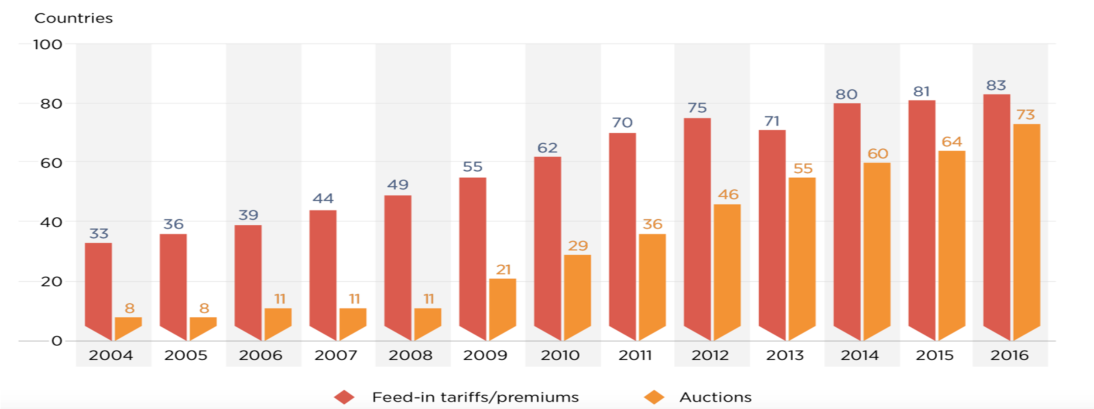


Figure 2.17 Trends in the adoption of FITs/FIPs and auctions, 2004-16

In figure 2.18 it's summed up the main policy tools according to their characteristics.

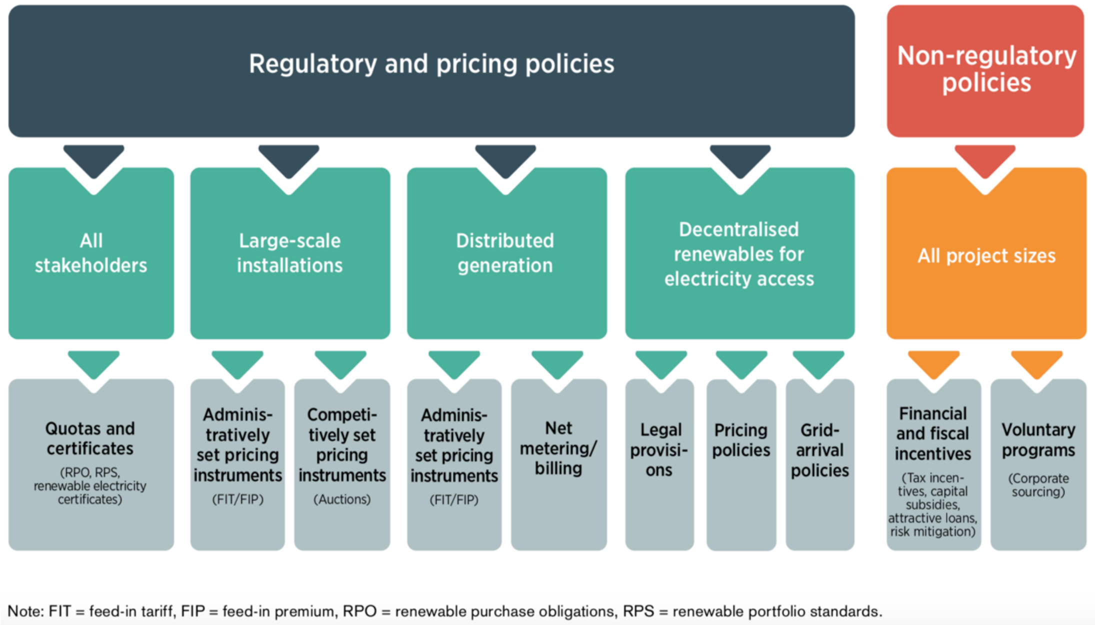


Figure 2.18 Classification of power sector policies

Let us see now in detail the major policy tools used for supporting Renewable Energy Sources.

2.3.1 Feed-In Tariffs (FITs)

Feed-in tariffs (FITs) and feed-in premiums (FIPs), have been crucial in spreading renewable energy projects in the world. By 2017, FITs and FIPs were adopted by more than 80 countries. They are a policy mechanism designed to accelerate investment and growth in renewable energy technologies. They achieve this by offering long-term (from 15 to 25 years) contracts to energy producers, typically based on the cost of generation of each technology [21].
More precisely, FiT are ''a support scheme which provides for a technology-specific remuneration per unit of renewable energy payable to eligible renewable energy producers. A proper, periodic review of FiT rates is often undertaken with the aim to prevent both too high FiTs so as to minimise regulatory rents, i.e. supra-normal returns and too low FiTs to preclude below-

target market uptake because of FiT levels that are perceived by market participants to be less attractive.

In addition, feed-in tariffs often include "*tariff digression*", a mechanism according to which the price (or tariff) ratchets down over time". FiP instead are '' *a scheme which provides for a support level per unit of renewable energy to eligible renewable energy producers, typically for a period of 10-20 years, at a pre-set fixed or floating rate*. The premium is typically adjusted periodically to exactly offset change in the average energy wholesale market price, based on a pre-specified benchmark market price. A floating FiP may move freely or may only be allowed to move within a pre-set interval" [22].

How Feed-in are determined?

Regarding FITs, we can directly quote the Renewable Energy Sources Act (2000): "*The compensation rates have been determined by means of scientific studies, subject to the provision that the rates identified should make it possible for an installation – when managed efficiently – to be operated cost-effectively, based on the use of state-of-the-art technology and depending on the renewable energy sources naturally available in a given geographical environment"*.

FIPs instead, are generally of two types:

6) A **fixed premium** set on top of the market price.
7) A **floating premium**, where a reference value ("strike price") is set and the premium is calculated as the difference between the reference value and the reference market price. Upper and lower bounds can be introduced to limit excessive profits or risks for generators when the electricity market price rises too high or falls too low.

Effectiveness

Even if the exploitation of FiT has been heterogeneous and the results and its effectiveness depended much on geographic, social, technological and climate characteristics, its success in boosting the development of RES has been largely accepted. Feed-in tariff policies are now in place in 87 different jurisdictions, and Germany became the first country to achieve grid parity by using FITs when its PV technology became cost competitive with other sources of electricity in 2014. (See figure 2.19)

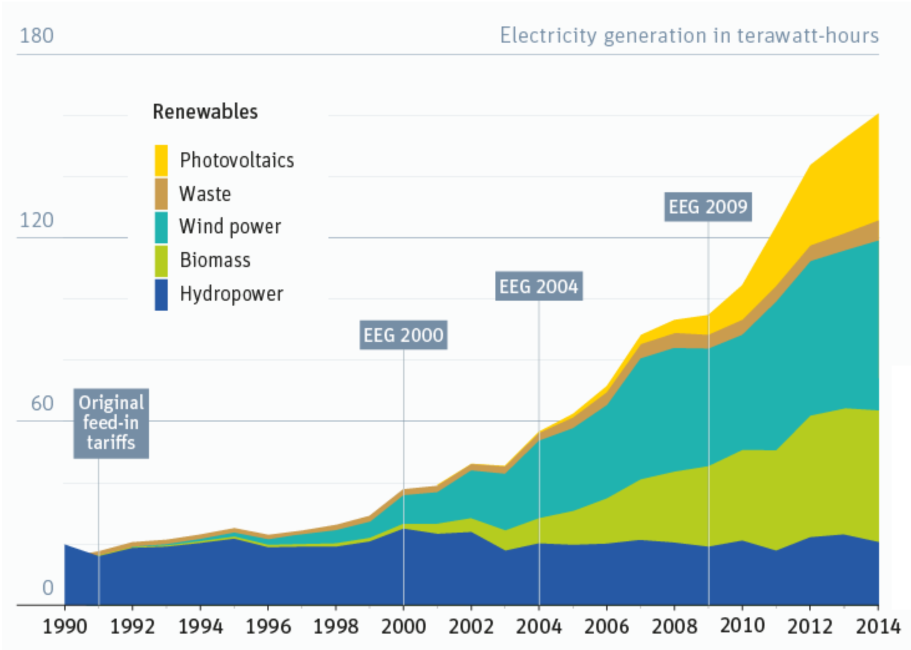


Figure 2.19 Growth of electricity generated by renewable sources after introduction of feed-in tariffs in Germany – Source: Eurostat

The example of Germany is relevant not only for the results that they achieved but also on the consequences that have created. This success in fact became a strong supporting evidence for what European Commission declared in 2010, that FITs are "the most efficient and effective support schemes for promoting renewable electricity." [23]

France and China have followed Germany's example to become leaders in the FIT space. They have each set aggressive goals for their renewable energy programs: by 2020, France aims to have 5400MW of solar energy produced, and China wants 15% of its total energy consumption to come from renewable sources. Each of those objectives is within reach if current progress continues [24].

This tool however is not exempt from mediocre results. In South Korea, for example, the mechanism has received many critics because it may be awarding excess profits to electricity suppliers, which would indicate wasteful government spending [25].

2.3.2 Auctions

With the need for policies that are more sophisticated and increasing cost-competitiveness of renewables, mainly solar PV and onshore wind, countries have increasingly moved to auctions.
Auctions own to their flexibility of design their popularity of recent years. They can be customised and tailored to the country-specific context and objectives. Furthermore, in addition with a suitable legal framework, they can ensure two of the most desired qualities: **transparency** and **commitment**.
Another important aspect to highlight is also the possibility to mix auctions with other policy frameworks. In this case, two countries are particularly famous for this experiment: Italy and Germany. This strategy, known as "*the hybridisation of auctions and premiums*", uses auctions for large-scale projects and FITs/FIPs for smaller projects.
In the last year this mechanism has benefited from the rapidly decreasing costs of renewable energy technologies, the increased number of project developers, their international exposure and expertise, and the considerable policy-design experience acquired. When well designed, the price competition increases cost efficiency and allows price discovery of renewable energy-based electricity, avoiding underpayments. While auctions have become very attractive however, they have a side effect: they only benefit the successful bidders and tend to favour large players that are able to afford the associated administrative and transaction costs.
Differently from FiTs, auctions' literature is still scarce, and detailed and clarifying study on its effectiveness lack. We will review the results obtained by this mechanism country by country.

2.3.3 Financial and Fiscal Incentives

Financial and fiscal incentives are the last big family of policy frameworks. They can be used often in parallel with regulatory and pricing policies to improve access to capital, lower financing costs, reduce the burden of high upfront costs or the production costs of large-scale renewable energy projects. They can be introduced in the form of tax incentives, rebates, grants, performance-based incentives, concessional loans and guarantees, and measures to mitigate risk.

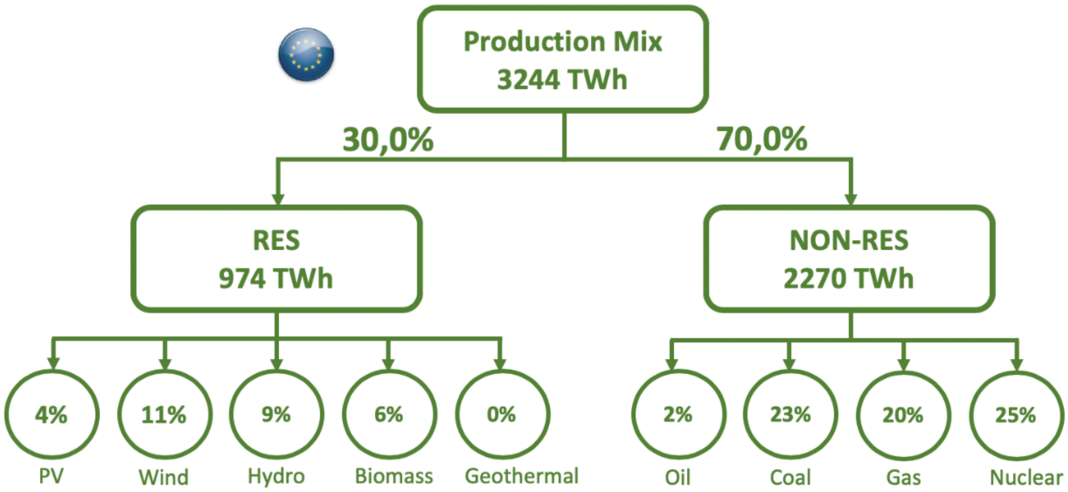
CAPITOLO 3
ANALYSIS

What is the actual situation in Italy and Europe? What have been the trend so far? Is our country up to date regarding the management of energy resources? What is the national strategy to succeed in this context? How does Italy perform compared to its ''European colleagues''?

Welcome you inside the heart of the report. Here we are going to assess, with a particular focus on Italy, if the main countries in the old continent are doing well with their energy operations and what are the results respectively achieved so far in the main technologies we have introduced before. The report will analyse also the distribution of plants by size for new installed capacity and its evolution in time. The Italian situation and the benchmark analysis are anticipated by a global view on Europe and by a discussion on international strategies.

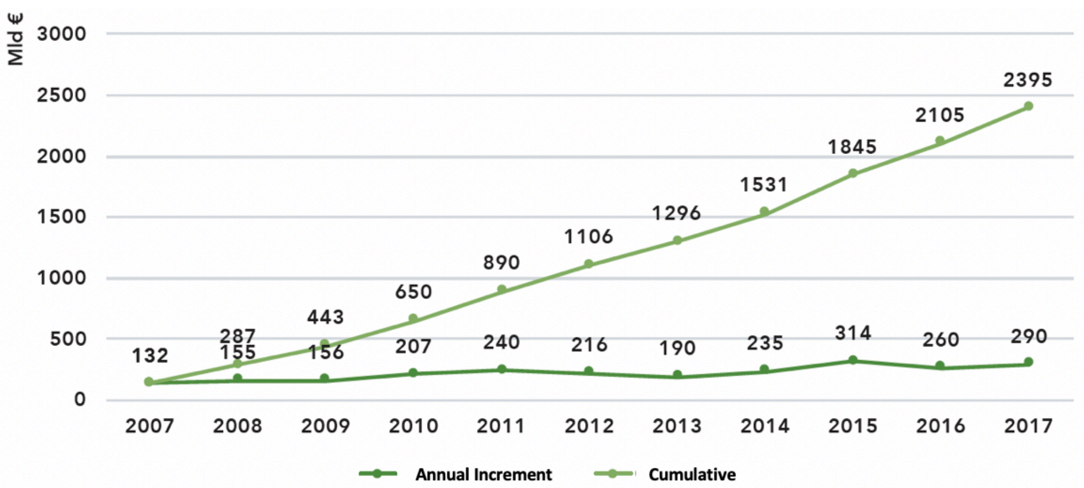
3.1 Energy Management in Europe

Table 3.1 Europe Production Mix – Source: Energy Strategy Group2018, Politecnico di Milano



Before diving deeply in the analysis and in the review of the data collected, let us introduce the scenario we are observing in Europe in these days. Italy, Germany, France, UK, Spain and Poland are the countries with the highest percentage of energy produced through renewable sources. Before analysing in detail each country for each technology, let us give a look at the global view. In 2017, it has been invested for the realization of new installation nearly **290 billions of €,** with an increase of 11, 5% compared to 2016 but still lower than the record of 2015 (-7,6%).

Table 3.2 Global investments in RES in the last 10 years - Source: Energy Strategy Group 2018, Politecnico di Milano



Looking from the EU perspective, the energy production was nearly **3200 TWh** (Italy accounts for approximately 10%), with a role for RES not yet predominant (roughly 30% with the wind power in the role of the *lion*, 40% of the total). However, as we said at the beginning of our analysis, Europe has a very heterogeneous mix.
Installed capacity in Italy in the last year was about **900MW**, more than 120 MW compared to 2016 (+15%). This growth has to be considered significant, given the chaotic political scenario that lately characterized Italy governments. The leader of this expansion is the photovoltaic, with about **410 MW** installed, followed by wind power, **360MW**, hydropower, **90MW**, and finally biomass, with only **50 MW** of net capacity installed.
The 2017 overall installation contributed to bring the **cumulative installed capacity** from RES in Italy up to **53GW**. Breaking down this value, we notice the following situation: 20GW of PV system installed, 18 GW of hydropower, 10GW of wind power and the rest divided by biomass and geothermic energy.
What is truly astonishing, are the **production** and **consumption rate** of electricity from renewable sources, respectively **36,2%** and **32,4%** (the national electric demand reached the new peak of 320TWh)**.**
Germany produced almost **650TWh** of energy, more than double compared to Italy. RES account for around **33%,** with still a prevailing role from **coal** and **nuclear** energy. During 2017, the Teutonic country installed more than **8 GW** of new power from renewable sources (almost 10 times Italy!), with the **offshore wind** absolute star (**5, 3 GW**).
In **France,** the production of energy was of **530 TWh,** with RES that accounted only for **18%**. Here the reason is easily given, with nuclear energy that provide **72%** of the national supply. In 2017 the net installed capacity was of **2,7 GW** of RES (3 times Italy). Regarding **UK**, energy production was similar to Italian results, with **336 TWh** produced. In addition, the weight of traditional sources is still dominant, in particular gas and nuclear, respectively

41% and 21%. Net installation of RES accounted instead for **5, 3 GW**, with a significant result of off-shore wind like in Germany.
From this snapshot It is clear how modest are the Italian results compared to these European countries. However, we should not focus our attention only on mere numbers and jump to conclusion. First, because Italy is still the leader in Europe regarding the production rate from RES, reminding us how essential is the exploitation of these energy sources. Secondly because these data are not computed *pro capite* but are absolute value.
Here in the following tables are resumed the percentage of energy produced by each source in every country, with information also about the average value of EU.

Table 3.3 electricity production rate per country in 2017– Source: Energy Strategy Group 2018, Politecnico di Milano

%	*PV*	*Wind*	*Hydro**	*Bio*	*Geo*	*RES*	*Oil*	*Coal*	*Gas*	*Nuclear*
ITA	9	6	14	6	2	37	6	12	45	0
GER	6	10	3	8	0	33	4	37	13	12
ES	5	18	8	2	0	33	13	17	16	21
EU	4	11	9	5	0	30	2	23	20	25
UK	3	15	3	8	0	29	1	7	41	21
FR	2	5	10	2	0	19	1	1	7	72
PL	0	8	1	6	0	15	3	77	5	0

3.1.1 The Winter Package

On 30 November 2016, the Commission published its so-called 'Winter Package' of eight proposals to facilitate the transition to a 'clean energy economy' and to reform the design and operation of the European Union's electricity market. This package of proposals can be grouped into three categories:

1) Proposals amending existing energy market legislation;
2) Proposals amending existing climate change legislation;
3) Proposals for new measures.

The big dream of EU Commission is to make EU citizens to switch to electricity for not only power and light, but also heating, cooling and more important transportation. To reach this objective will of course be mandatory the usage of low carbon sources, from which nuclear is excluded.
Aimed at enabling the EU to deliver on its Paris Agreement commitments, the proposals are intended to help the EU energy sector become more stable, more competitive, and more sustainable. With a view to stimulating investment in the clean energy transition, the package has three main goals:

1) **Putting energy efficiency first**
2) **Achieving global leadership in renewable energies**
3) **Providing a fair deal for consumers**

Let us see now which are the targets for 2030:

- A 40% cut in greenhouse gas emissions compared to 1990 levels.
- At least a 27% share of renewable energy consumption.
- Indicative target for an improvement in energy efficiency at EU level of at least 27% (compared to projections), to be reviewed by 2020 (with an EU level of 30% in mind).
- Support the completion of the internal energy market by achieving the existing electricity interconnection target of 10% by 2020, with a view to reaching 15% by 2030.

and the **policies** for 2030:

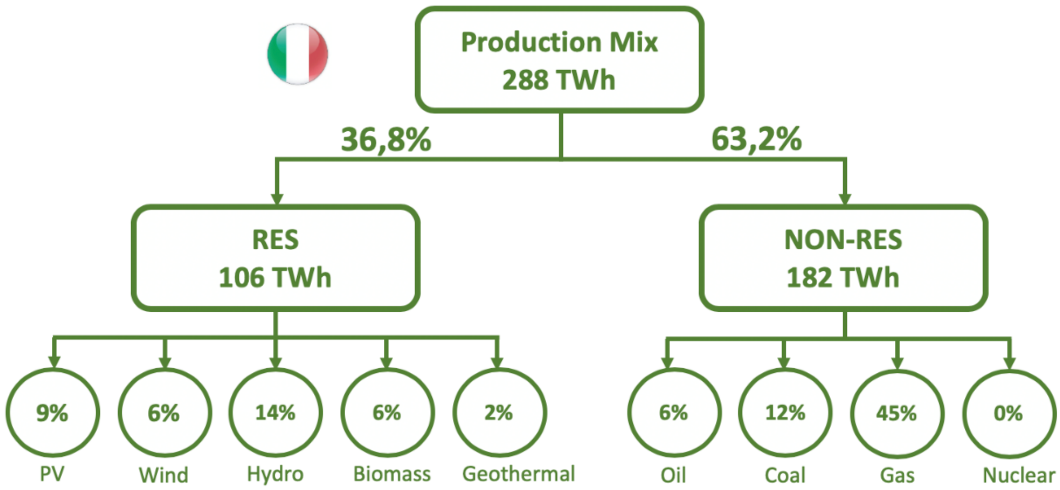
- A reformed EU emissions trading scheme (ETS)
- New indicators for the competitiveness and security of the energy system, such as price differences with major trading partners, diversification of supply, and interconnection capacity between EU countries
- First ideas on a new governance system based on national plans for competitive, secure, and sustainable energy. These plans will follow a common EU approach. They will ensure stronger investor certainty,

greater transparency, enhanced policy coherence and improved coordination across the EU.

This report will try to give an answer to the question whether Italy will be able to reach their objectives fixed for the next decades and outline the results obtained by the other actors so far.

3.2 Italy

Table 3.4 Italian Production Mix– Source: Energy Strategy Group 2018, Politecnico di Milano



3.2.1 Sen (National Energy Strategy)

The SEN2017 (Strategia Elettrica Nazionale) is the result of a joint and shared process which involved, from the preliminary stage, public figures operating on the energy field, operators of transportation networks and qualified experts in the energy sector. SEN has the objective of make the Italian energetic sector more:

- **Competitive**, through a stable reduction of costs and prices compared to the other European competitors.
- **Sustainable**, with a strong respect of the environmental target fixed by EU in terms of de-carbonisation.

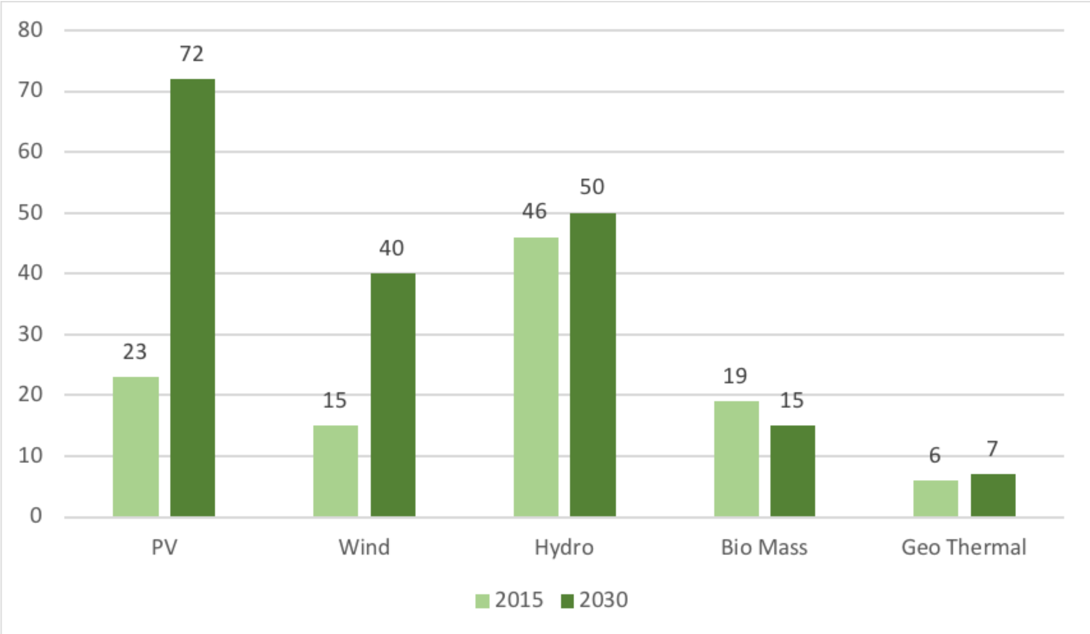
- **Safe**, by improving the security of supply chain and the flexibility of energy systems and infrastructures, strengthening Italy's energy independence.

Speaking about quantitative target, SEN traces the guidelines towards 2030 in terms of RES, energetic efficiency, coal phase out, safe and competitiveness of the energy environment. The text is easily readable on the website of the Ministry for economic development, however, the main points of the legislation comprehend:

- **Energy efficiency**: reduction of final consumption from 118 to 108 Mtep with a saving of about 10 Mtep to 2030;
- **Renewable sources usage growth**: 28% of renewables on total consumption in 2030 compared to 17.5% in 2015;
- **Electricity production** by RES of 55% in 2030, compared to 33.5% of 2015;
- **Thermal production** from 19,2% in 2015 to 30% in 2030;
- Share in **transportation** from 6,4% in 2015 to 21% in 2030;
- **Cessation** of the electricity production from **coal** with an acceleration target of 2025, to be achieved through a precise plan of infrastructural interventions;
- **Rationalization of the oil downstream**, evolving towards biorefineries and an increasing use of sustainable biofuels in place of oil derivatives;
- **Double investments** in clean energy research and technological development: from 222 million € in 2013 to 444 million € in 2021;
- **Reduction of energy dependence** from abroad from 76% in 2015 to 64% in 2030 (ratio between the import / export balance of primary energy needed to cover the needs and gross domestic consumption);

Thus, the real big goal of Italy will be to make disappear coal and oil from the electric generation mix already by 2025, substituting them with gas and mostly RES, with a target increase of 70%. In table 3.5, we can see the evolution of generation of energy for each source.

Table 3.5 Evolution of generation by RES (TWh) – Source: Energy Strategy Group 2018, Politecnico di Milano



As we can see, hydropower, PV System and wind power system will have to increase their generation, with PV intended to rise of almost 250% and wind nearly 300%.

Since 90% of the installations of the next 3 years will concern PV systems and wind plants, it is logical to focus our attention to the possible outcomes of these two technologies. Regarding PV systems in particular, it will be necessary an increase of **net installed capacity** of **36 GW**, i.e. a growth of approximately 200% compared to the actual installation. This means basically an average increase of 2,8 GW per year, of which 1 GW made by ‘’utility scale systems’’, while 1,8 GW made by medium and small size systems.

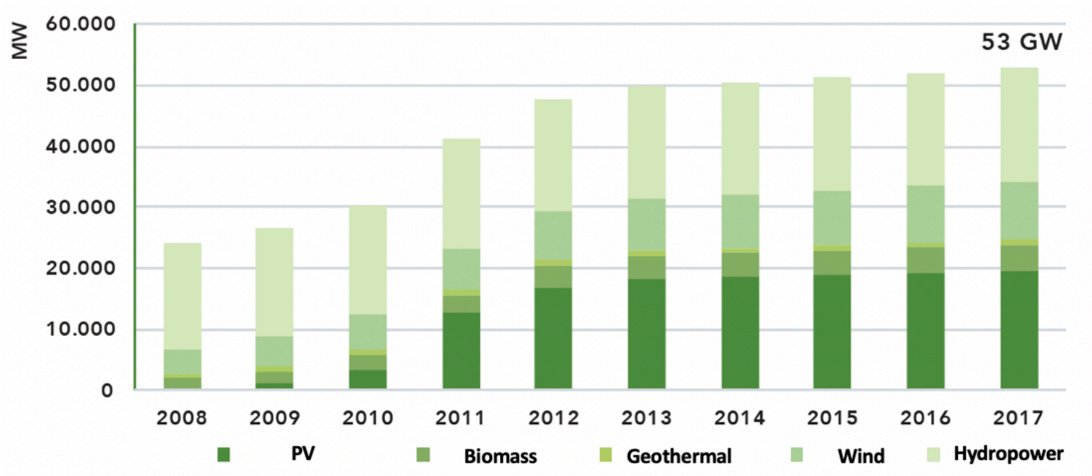
On the other hand, SEN has required an addition of wind installations of almost 10GW, that means nearly 770MW installed every year. Though it is evident that a market for RES in Italy is active and vivid, it’s at the same time manifest that reaching the objectives fixed by SEN seems a mammoth task.

The possible solutions are still well known. **Efficient** and **efficacy policy strategies** are undoubtedly the key, without forgetting of course that a solid and unified parliament will be the necessary condition for the achievement of all the objectives listed in the previous lines. We will see in the final section of this analysis if the Italian country will be able to fulfill his own duties. For the moment, we will move on drawing the actual status of the Italian market.

3.2.2 Installed Capacity & Plant Size

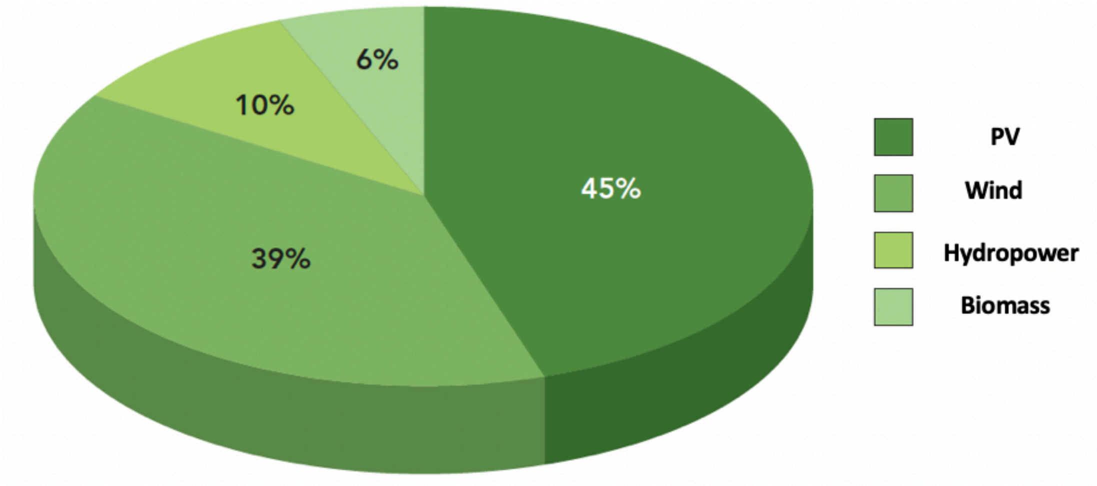
The new installed capacity during 2017 in Italy reached **900 MW**, with a net increase compared to previous year of **16%**. A steady growth despite the political turmoil that have characterised Italy governments.
The global capacity of renewable sources has hit the record of 53 GW (36 if we exclude the ''historic hydropower'', i.e. those plants installed before the 2000). Inside the Italian ''panorama'' is a result that can be considered positive, since it represents more than 40% of Italian energy generation (117GW).

Table 3.6 Evolution of installed capacity by RES (TWh) in Italy– Source: Energy Strategy Group 2018, Politecnico di Milano



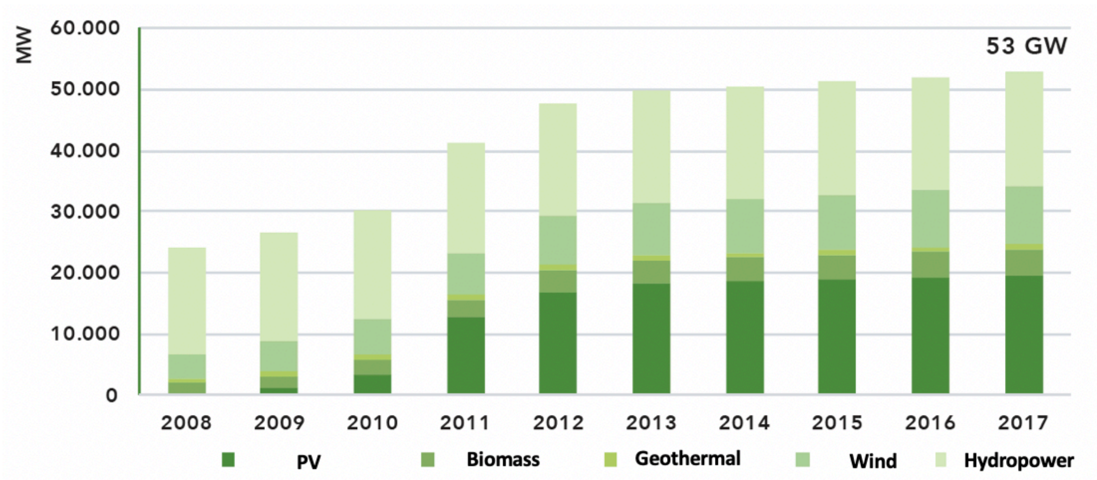
The 900 MW of installed capacity in 2017 are broken down as table 3.7 shows. PV Systems are the leader in this classification, with 410 MW installed. Second, we have wind power, with 360 MW, hydropower with 95 MW and biomass with 50 MW.

Table 3.7 Installed capacity by source in 2017– Source: Energy Strategy Group 2018, Politecnico di Milano



If we look at electricity production, renewables have contributed to **36,2%** of the entire production and **32,4%** of the internal demand for electricity, which has surpassed the 320 TWh. A sensational result, despite the critic reduction of hydropower production (-14,3%), caused by scarce rainfalls. This source has reached the lowest level of production in the last 10 years (see table 3.8).

Table 3.8 Electricity production by source during the years Source: Energy Strategy Group 2018, Politecnico di Milano

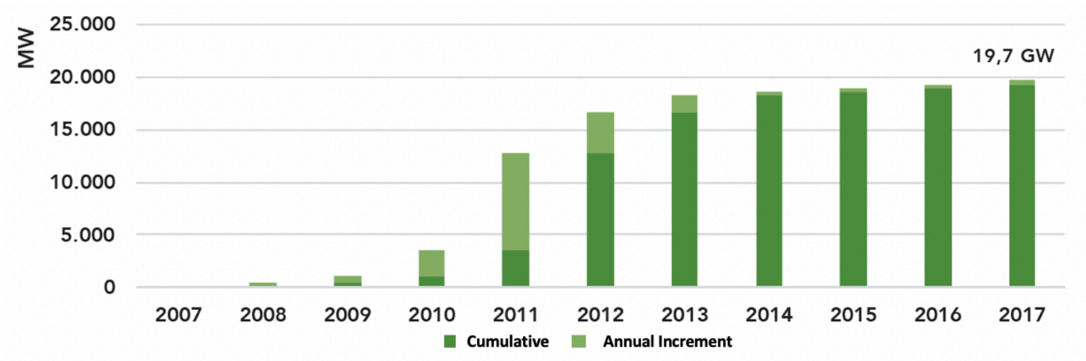


Let us now focus our attention analysing every source.

Photovoltaics Systems

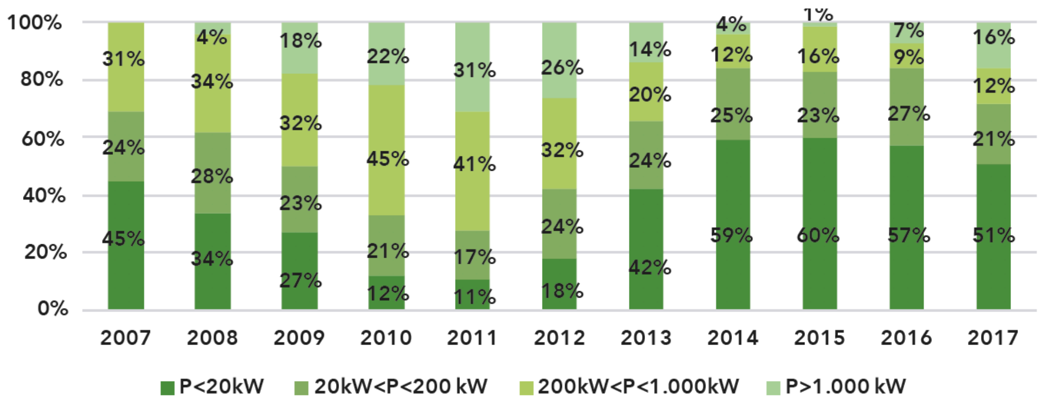
Globally in Italy, the total installed capacity accounts for **19670 MW** at the end of 2017. In the last year (+410MW) the installations increased of **10, 8%** compared to 2016. The renewed growth after the slowdown in 2015 represents good news, since it proves that by now new installations are almost completely independent from supportive systems, despite the results achieved from 2010 and 2013 are honestly difficult to be replicated.

Table 3.9 Installed Capacity in Italy (PV) – Source: Energy Strategy Group 2018, Politecnico di Milano



After the strong turn towards residential plants until 2015, it is interesting to highlight the turnaround happened after 2016 with big plants (>1MW). In 2017, in fact we registered an increase in large utility scale of 16%. This data is though biased by a big installation of an enormous plant of 64MW in **Montalto.** However, the general feeling of the operators is positive, and we prospect a steady and balance growth in the near future. (For the details on the size distribution see table 3.10)

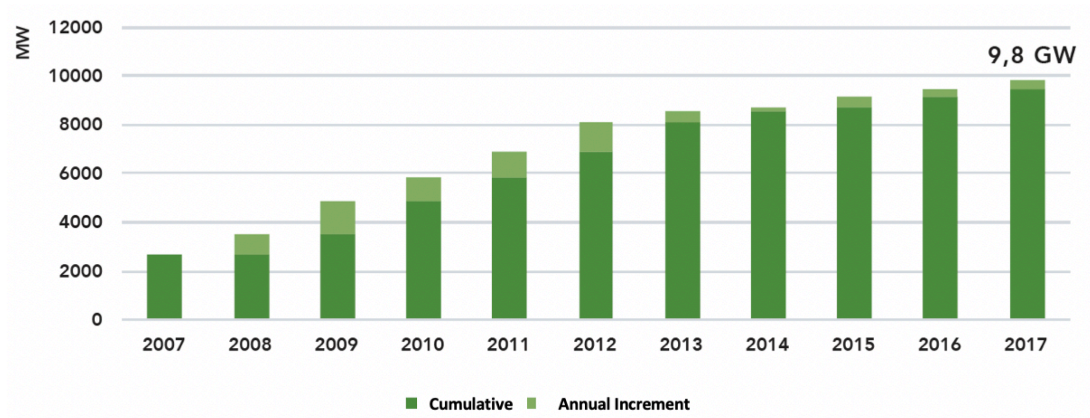
Table 3.10 Installed Capacity in Italy by plant size (PV) – Source: Energy Strategy Group



Wind Power

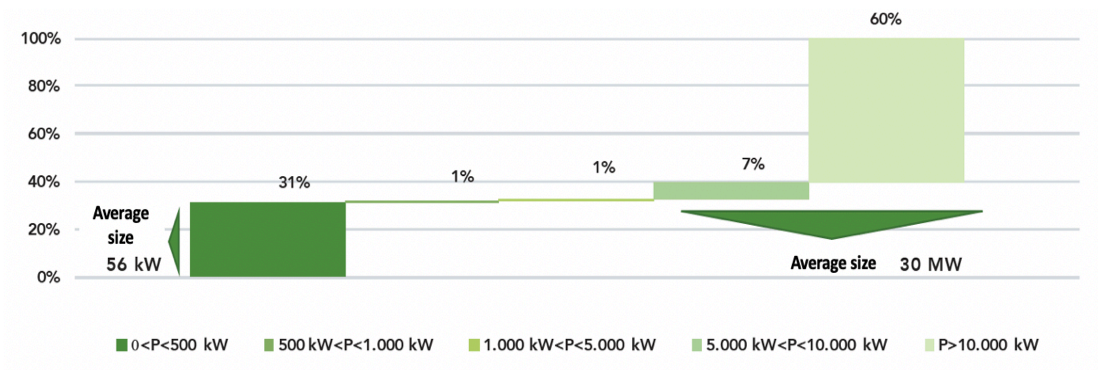
Global volume of installed capacity reached the total amount of **9811 MW** at the end of 2017. In the last year were installed nearly 359 MW (+23,8% compared to 2016). It's important to highlight how, given the geography of Italy, the whole wind farm built in our country are concentrated in the southern regions.

Table 3.11 Installed Capacity in Italy (Wind) – Source: Energy Strategy Group 2018, Politecnico di Milano



Installed capacity of wind power in Italy is divided in two poles. Plants bigger than 5MW each (almost 67% of the total), and micro plant (31%). In 2017 in fact it has been installed 1974 new plants under the 200kW, compared to the 863 of 2016.

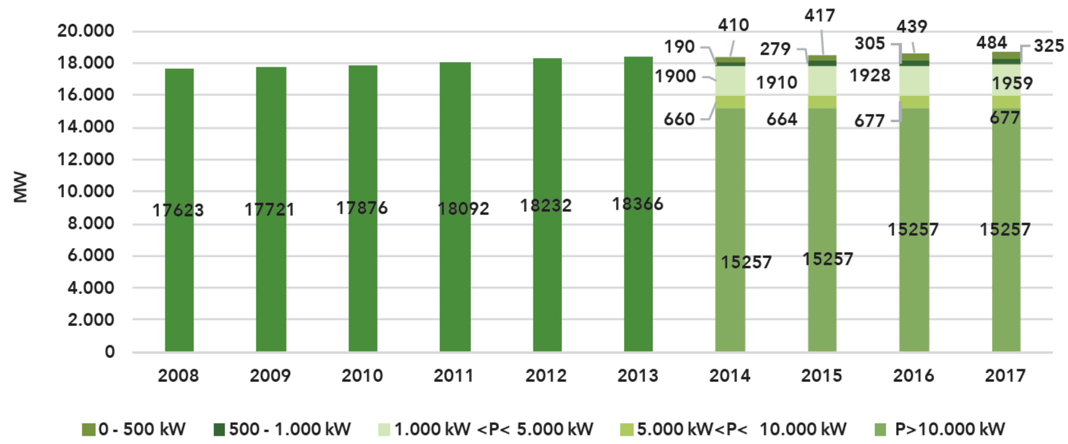
Table 3.12 Installed Capacity in Italy by size (Wind) – Source: Energy Strategy Group 2018, Politecnico di Milano



Hydropower

Regarding Hydropower, the total installed capacity at the end of 2017 is of **18702 MW**, with an annual increase of 95 MW from 2016. The regions which have installed more capacity in the last year are the same of the previous one: **Lombardia** (26,35 MW), **Piemonte** (21,8 MW) and **Trentino** (9,08 MW).

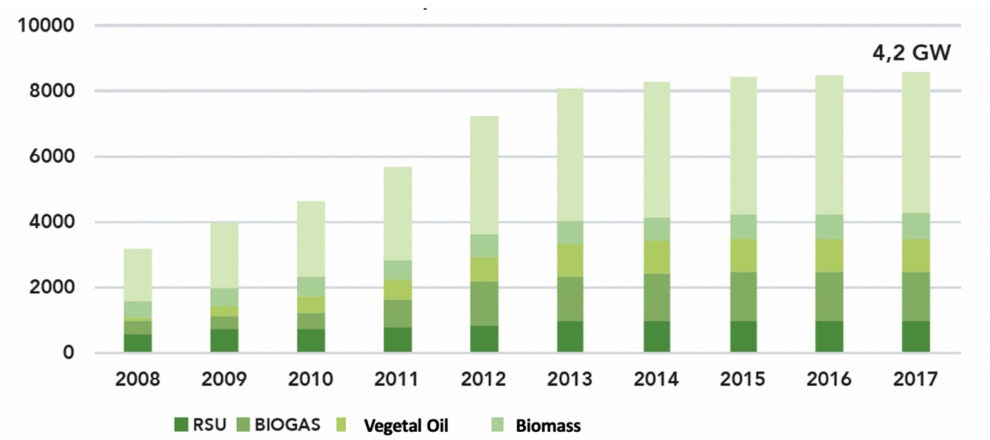
Table 3.13 Installed Capacity in Italy (HP) – Source: Energy Strategy Group 2018, Politecnico di Milano



Biomass

Cumulative installations, considering the 4 type of technologies (**RSU, Biogas, Biomass** and **vegetal oil**), have overcome at the end of 2017 the **4,2 GW,** with a limited growth of just 50MW in this year, compared to 40MW of 2016. The deadlock is persisting since 2014. It will be interesting to see if the new policy entered into force in 2018, will be able to revive this source.

Table 3.14 Installed Capacity in Italy (Biomass) – Source: Energy Strategy Group



Geothermal Power

Energy produced through geothermal power in Italy accounts for **2%** of the total. This is the result of operations inside the big plants in the **Toscana** region, more precisely in the plant of **Larderello-Travale-Valle Secolo** (707MWe) and **Monte Amiata** (114MWe).

Despite this source has not shared the evolution of the other technologies during last years, Italian total capacity installed moved from **772 MW** of 2010 to **824 MW** at the end of 2016, showing a relevant **+6%**. It is important to highlight how this increase is mainly due to the substitution of old plants and the development of new projects, like for example that of **Bagnore IV**, with **40MWe** of capacity installed.

These new installations are always located in the historical region of geothermal energy but made Italy one of the most advanced country in the exploitation of this technology. The development cannot be absolutely considered scalable for the moment, but important enhancement in the installation process, included decrease in the OPEX and CAPEX required, and solution to its environmental impact, are waited to be developed.

3.2.3 Regulatory Framework

Italy has different supporting polices for promoting renewable energy sources in the electricity, heating and cooling, and transport sectors. Electricity from renewable sources is mainly promoted through **feed-in tariffs** and **feed-in premiums**. Furthermore, there is a t**endering** scheme for larger RES plants. There are **tax exemptions** for photovoltaic and wind power plants. With respect to RES-H, there is a **tax regulation** scheme, **incentives** for small RES-H sources, as well as a **guarantee fund** for district heating. The main incentive for renewable energy use in transport is a **quota system.**

Here below in table 3.15 is listed a summary of the policy scenario in Italy.

Table 3.15 Brief description of key policy instruments aimed at promoting RES in Italy

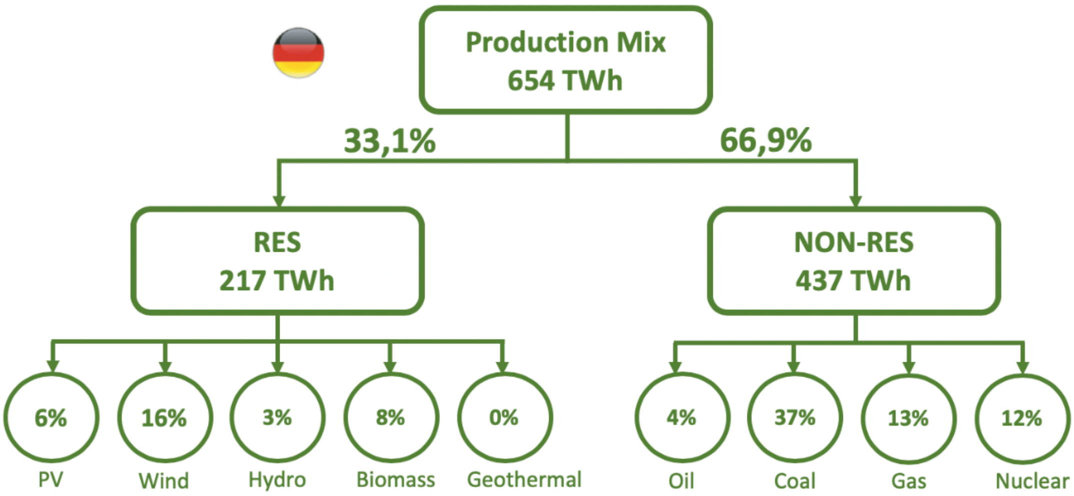
Instrument	*Description*
FiT	There are two different FiT. One applied to all RES plants (except photovoltaic) with an installed capacity between 1 kW and 0.5 MW. Another applied for PV plants connected to the grid with a minimum capacity of 1 kW.
FiP	The FiP can be applied for all RES plants except PV. The installed capacity must be between 1 kW and 5MW. Plants with a capacity below 0.5 MW can choose between this premium and the FiT.
Tenders	All RES plants with a capacity above 5MW, which are not eligible to use the FiT or -premium, are eligible for the tendering mechanism. There are different base tariffs for all RES and bidders offer prices and receive this premium in case of a successful tender.
Net Metering	Net metering is available for RES-E plants below 200kW of installed capacity for plants commissioned after 31 December 2007 as well as high-efficiency CHP plants with a capacity below 200 kW.
Incentive	For small-scale RES-H sources, there are incentives granted for a period between two and five years.
Tax Regulation	There is tax deduction for expenses for installing RES-H technologies.
Biofuel quota	Biofuels are promoted through a quota system. The quota is to gradually increase from 5% in 2015 to 10% in 2020.

Therefore, the electricity market is undergoing a significant transformation in terms of **structure** and **regulation**.

After the drop in 2015-2016, investments have increased and started to rise again. Over the last 12 months, the market structure has been shaped (and continues to be) by an ongoing sector consolidation.
From a regulatory perspective in particular, reform of electricity tariffs and changes to the capacity market will transform both consumer relationships and operator business models.
The Ministerial Decree of 23 June 2016 provided tariff incentives for electricity produced from RES based on different awarding procedures that depend on the kind of plant and its volume. It also introduced a premium (reward) policy for "virtuous" projects to stimulate competition in the hands of investors capable of efficiently managing both the realisation and the management of relevant assets during their entire life cycle.

3.3 Germany

Table 3.16 German Production Mix– Source: Energy Strategy Group2018, Politecnico di Milano



With a global production of **654 TWh**, Germany is the first European country for energy produced. More than 33% comes from RES. Just this statistic alone should be enough to understand why Germany is considered a heavy-weight player in the category. 217 TWh of energy produced by clean sources is an

incredible result for a single state. Still, it is not exempted for some critics. The first source in terms of percentage is in fact **coal**, with an astonishing 37%, followed by wind power with 16%. A phase-out of coal power is at the heart of debates on how Germany can reach its climate targets, particularly after the Ministry for Environment warned in autumn 2017 that the country was falling short of its 2020 emissions reduction target by a wide margin [26].
That is one of the reasons why Germany launched a highly anticipated task force on phasing out coal power. It is the most prominent blemish on the former climate action pioneer country's emissions reduction record. The coal exit commission is supposed to find economic perspectives for coal workers and regions, spell out measures to reduce carbon emissions in line with Germany's climate targets and name an end date for coal-fired power production by the end of 2018.
Speaking of new installation, Germany has increased its capacity of **8,5 GW,** 9 times what Italy did. Wind power is the lion regarding new installation, thus let us see in detail what is the status sources.

3.3.1 Installed Capacity & Plant Size

Photovoltaics Systems

In 2017, new installed capacity for PV Systems has been of **1750 MW**, more than 4 times compared to Italy and +20% compared to 2016. It is interesting to note how the **28%** of the installed capacity derives directly from large utility scale plants (>1MW) and that total installation almost equals the global installations in Italy considering all the energy sources.

Table 3.17 Installed Capacity in Germany (PV) – Source: Energy Strategy Group2018, Politecnico di Milano

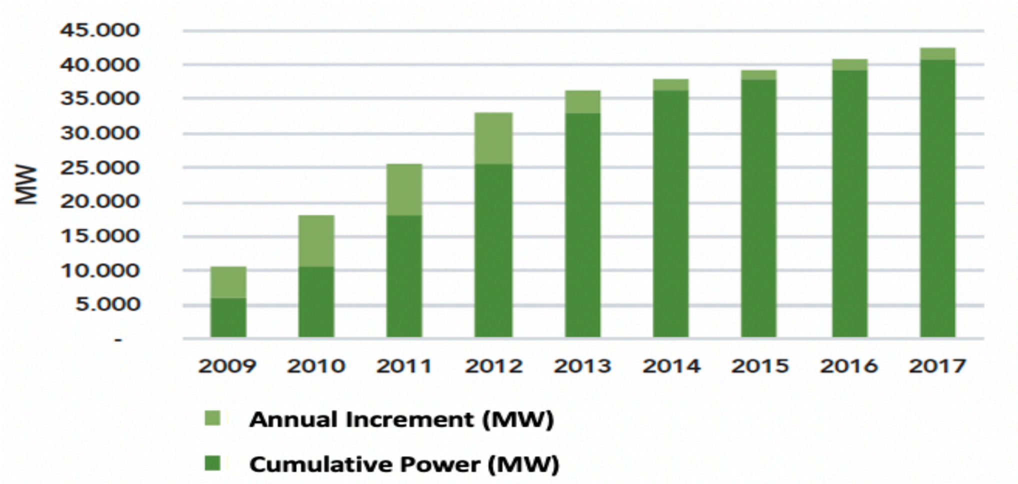
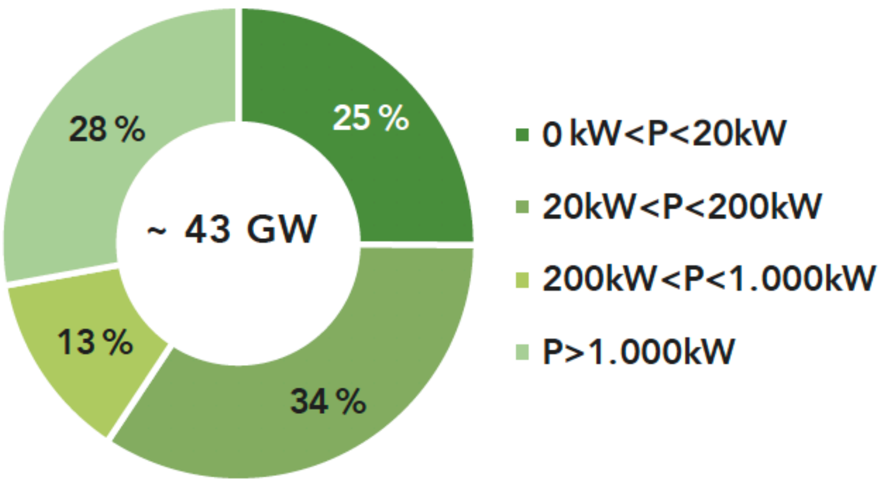


Table 3.18 Installed Capacity in Germany (PV) by size– Source: Energy Strategy Group 2018, Politecnico di Milano



Wind Power

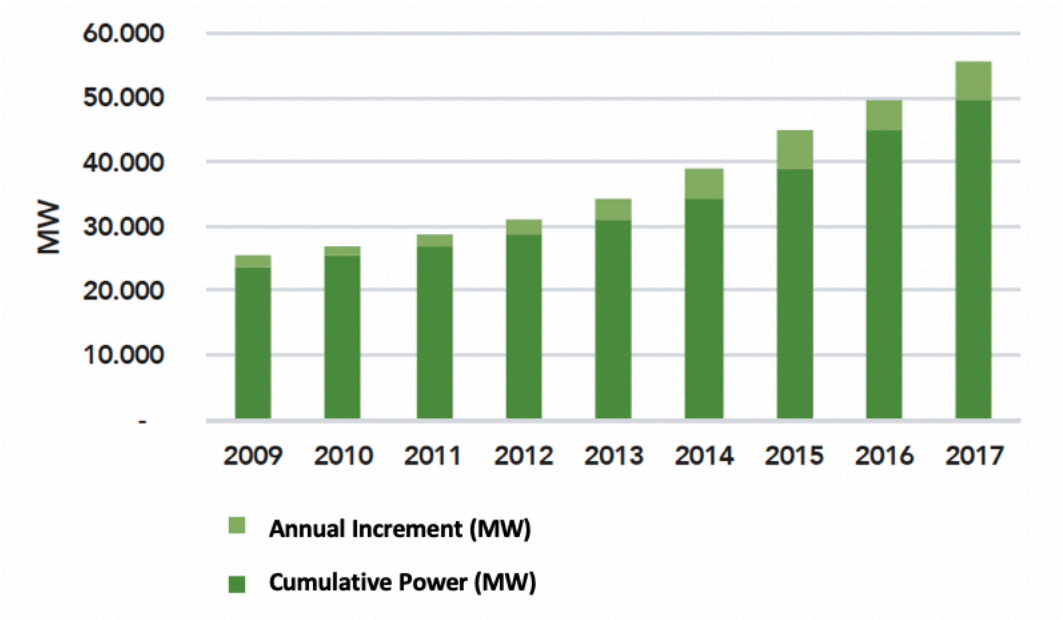
In 2017 Germany recorded extraordinary results for wind energy. Almost **5,3 GW** of new installations were made only for **onshore wind**, while **1,3 GW** for **offshore wind**. This numbers brought the total installed capacity to the staggering point of **56 GW** in total.

Talking about the relevance of wind power in Germany is trivial. The numbers themselves show how huge is the contribution of this resource.

More than 26,772 wind turbines were located in the German federal area by year-end 2015 and it was the third largest producer of wind power in the world by installations, behind only China and the USA [27].

Furthermore, hundreds of thousands of people have also invested in **citizens' wind farms** across the country and thousands of small and medium-sized enterprises are running successful businesses in a new sector that in 2015 employed 142,900 people. Clearly a holistic phenomenon is contributing actively to the success of energy transition of the first industry of EU.

Table 3.19 Installed Capacity in Germany (Wind Power) – Source: Energy Strategy Group 2018, Politecnico di Milano



Hydropower

Hydroelectric sector in Germany is surely not the leading sector, and it accounts for **11 GW** of installed capacity. As we can see in table 3.21, new installations were very limited and focused only on pump systems.

Table 3.20 Installed Capacity in Germany (Hydropower) – Source: Energy Strategy Group 2018, Politecnico di Milano

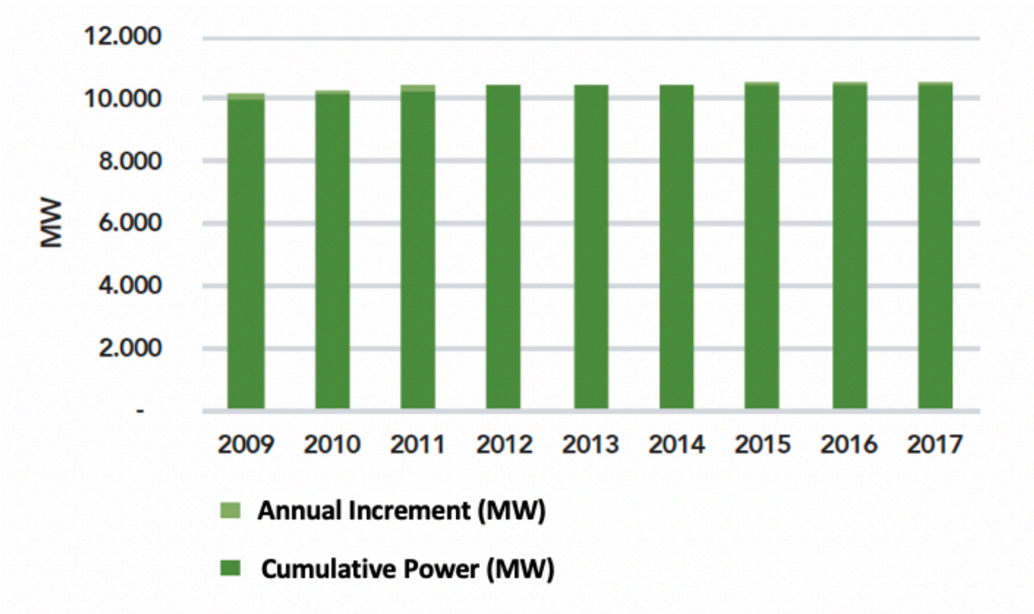
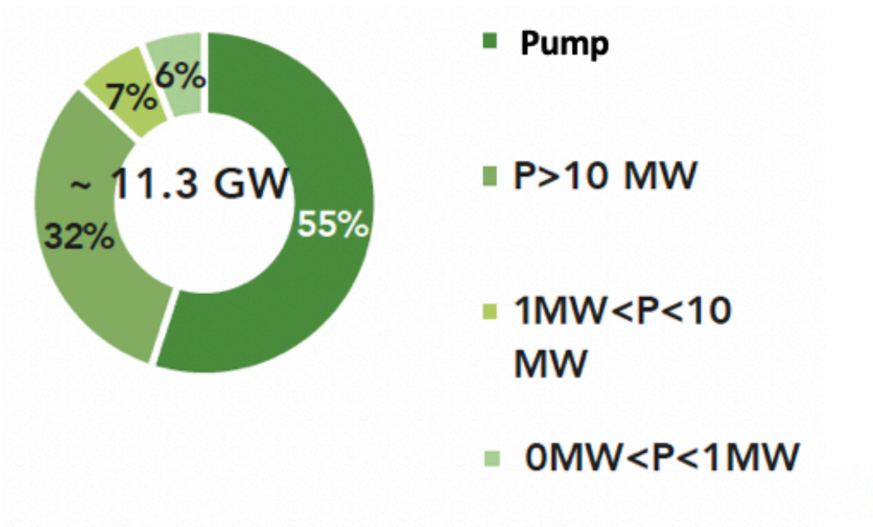


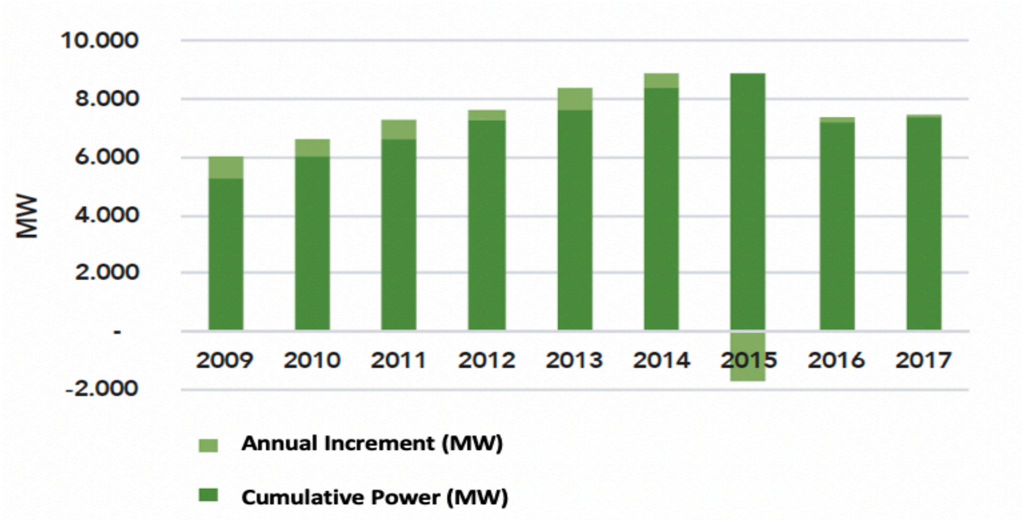
Table 3.21 Installed Capacity in Germany (Hydropower) by size – Source: Energy Strategy Group 2018, Politecnico di Milano



Biomass

Germany owns a biomass global capacity of nearly **8 GW**, but actually, the market is completely blocked. strong critics regarding the environmental and economical sustainability of the technology mainly cause slowdown of installations. Furthermore, in 2015 many plants were dismissed with a consequently decrease of installations of 1690 MW. (See table 3.22)

Table 3.22 Installed Capacity in Germany (Biomass) – Source: Energy Strategy Group 2018, Politecnico di Milano



3.3.2 Regulatory Framework

Since the EEG 2017, renewable electricity is mainly supported by **tendering procedures**. In general, there are three main typologies of incentives:

1) **Feed-in Tariffs** (FiT): they were introduced in Germany to encourage the use of new energy technologies such as wind power, biomass, hydropower, geothermal power and solar photovoltaics.
2) **Market premium**: it was intended to prepare renewables for the market and to eventually lower their dependence on explicit policy measures. The market premium is the difference between the EEG tariff and the average spot market price.
3) **Tendering**

Here below in table 3.23 is listed a summary of the policy scenario in Germany.

Table 3.23 Brief description of key policy instruments aimed at promoting RES in Germany

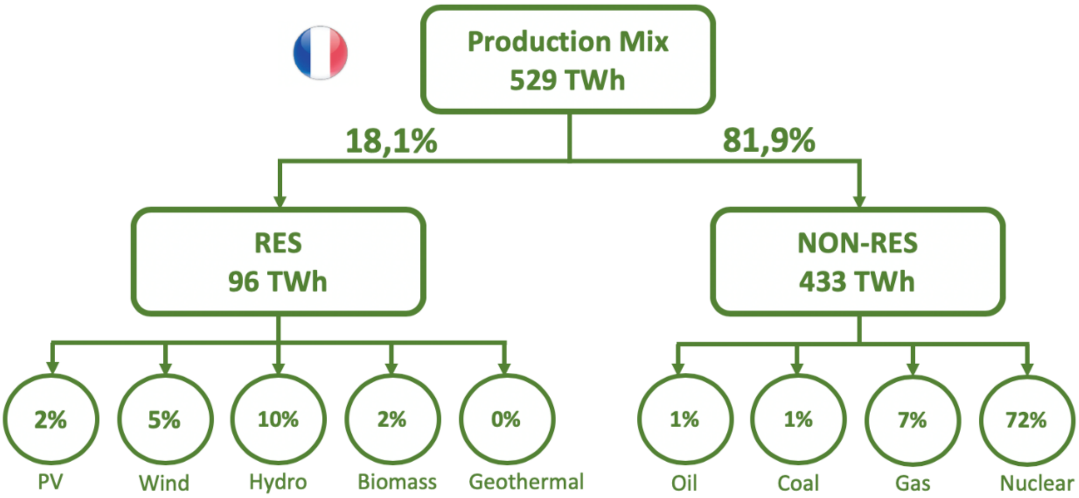
Instrument	Description
EEG 2017	Small RES-E plants up to 100 kW are eligible for feed-in tariff as set out in the EEG 2017. The level of the feed-in tariff is defined by law and varies according to specificities of the technologies. The tariff payment period is 20 years from the day of commissioning. For most technologies, there is an annual digression to organise the transition towards a self-sufficient renewables market. The digression rate depends on capacity additions of the past 12 months. The level of the feed-in tariff is hereby defined: • Wind Onshore: €ct 4.66 – 8.38 per kWh • Wind offshore: €ct 3.9 – 1.4 per kWh (until 2020) • Solar PV: €ct 8.91 – 12.70 per kWh • Geothermal: €ct 25.2 per kWh • Biogas from bio-waste: €ct 13.05 – 14.88 per kWh • Biogas from manure: €ct 23.14 kWh • Landfill gas: €ct 5.66 – 8.17 per kWh • Sewage gas: €ct 5.66 – 6.49 per kWh • Hydro power €ct 3.47 – 12.40 per kWh • Biomass: €ct 5.71 – 13.32 per kWh
Tenders	After the latest revisions of the EEG (2014 and 2017) tenders were introduced as RE support instruments with the objectives to: • Better steer development of renewables • Reduce costs and distribute financial burden, and • Improve market integration.

	PV, wind onshore, wind offshore and biomass are the eligible renewable energy technologies for tenders. For each technology target corridors have been defined: • Solar-PV: The annual capacity corridor is 2 400 MW to 2 600 MW • Onshore wind: The annual capacity corridor is 2 400 MW to 2 600 MW. • Offshore wind: There is no annual expansion target, but an overall target of 6 500 MW by 2020 and 15 000 MW by 2030. • Biomass: The annual capacity addition is 100 MW.

As we can see, the policy framework in Germany is quite complex. It covers every kind of technology. Globally this supportive tools have a cost for the government accounted for **30 billion €** per year, more than double compared to Italy (13,4 billion €). Despite the high costs however, the investments are well paid off: installations in Germany are much higher than in other country and their growth is steady and constant.

3.4 France

Table 3.24 French Production Mix– Source: Energy Strategy Group



With a production of **529 TWh**, of which the **18,1%** from RES, France is the second country in Europe for energy dimension. **Nuclear energy** is by far the dominant source, with **72%** of the total that comes directly from reactors. At the second place, we find **hydropower**, with 10%.

France is known in the world for its energy independency. This thanks to its **58 nuclear reactors** and **19 nuclear plants** spread out all over the French region. (See figure 3.1)

Figure 3.1 Nuclear plants distribution in France

This huge production of energy allows France not only to be more independent compared to other European country from other sources (oil and gas in particular), but also to export abroad. France in fact exports almost 50 TWh of energy to neighbouring countries (20 TWh to Italy).

3.4.1 Installed Capacity & Plant Size

Photovoltaic Systems

France has reached in 2017 a total installed volume of **7,7 GW** for PV Systems, thanks to **900 MW** of new installations in the last year, more than double compared to Italy and +55% than 2016. We can see from size distribution that in France there is a predominant trend of large utility scale plants. Here in fact the share of big installations accounts for 40%, much more than Italy and Germany, respectively 22% and 28%.

Table 3.25 Installed Capacity in France (PV) – Source: Energy Strategy Group 2018, Politecnico di Milano

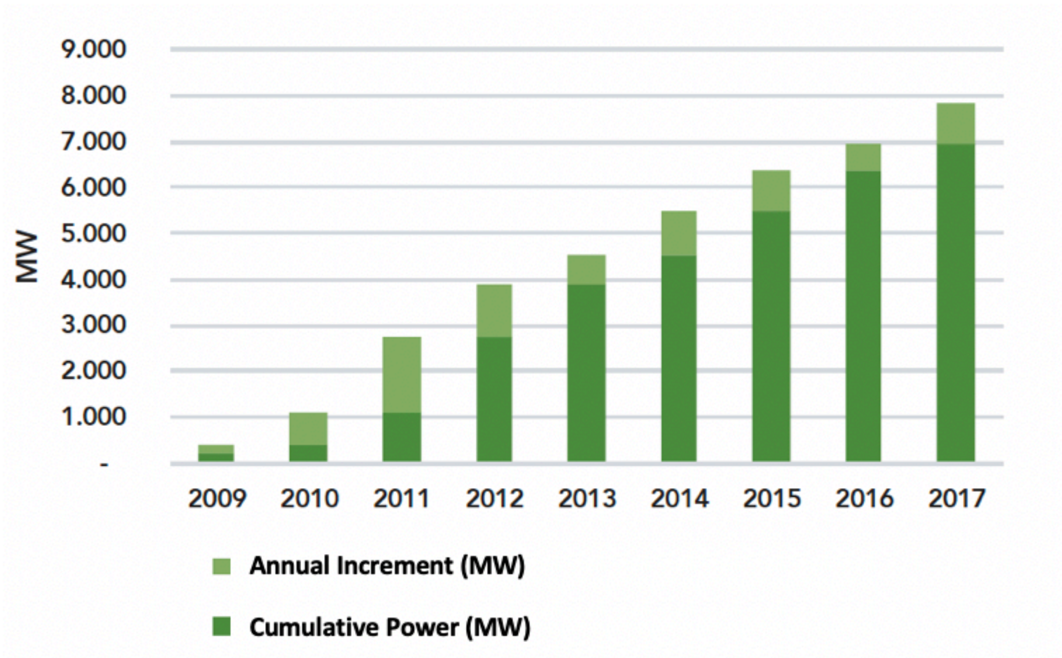
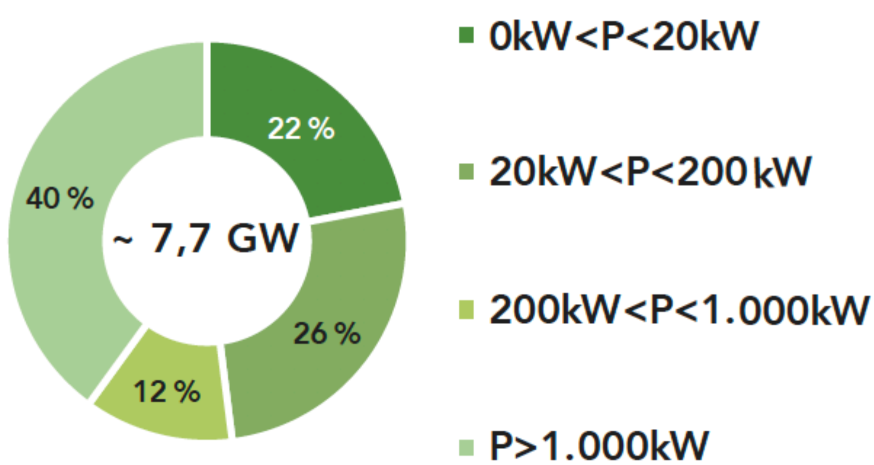


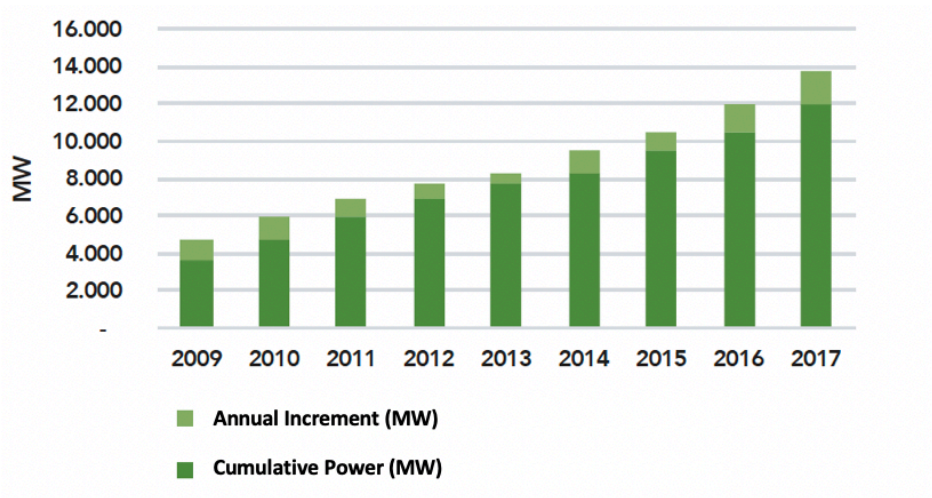
Table 3.26 Installed Capacity in France (PV) by size– Source: Energy Strategy Group 2018, Politecnico di Milano



Wind Power

New installations in France in wind sector are steadily increasing since 2015. In 2017 it has been registered an increase of **25%** compared to 2016, with a new capacity installed of **1,7 GW** (5 times Italy). Total installation has in this way reached the value of **14 GW**. Offshore is still underdeveloped with the exception in Germany and UK, where it is quite diffused

Table 3.27 Installed Capacity in France (Wind Power) – Source: Energy Strategy Group 2018, Politecnico di Milano



Hydropower

Hydropower sector in France with its **25,5 GW** of total installations, is almost constituted by ''historic and big plants'' (before 2000 and >10 MW), like in Italy. As we can see from the table below, new installation from 2009 onwards, have been always very small, in the range of few MW per year.

Table 3.28 Installed Capacity in France (Hydropower) – Source: Energy Strategy Group 2018, Politecnico di Milano

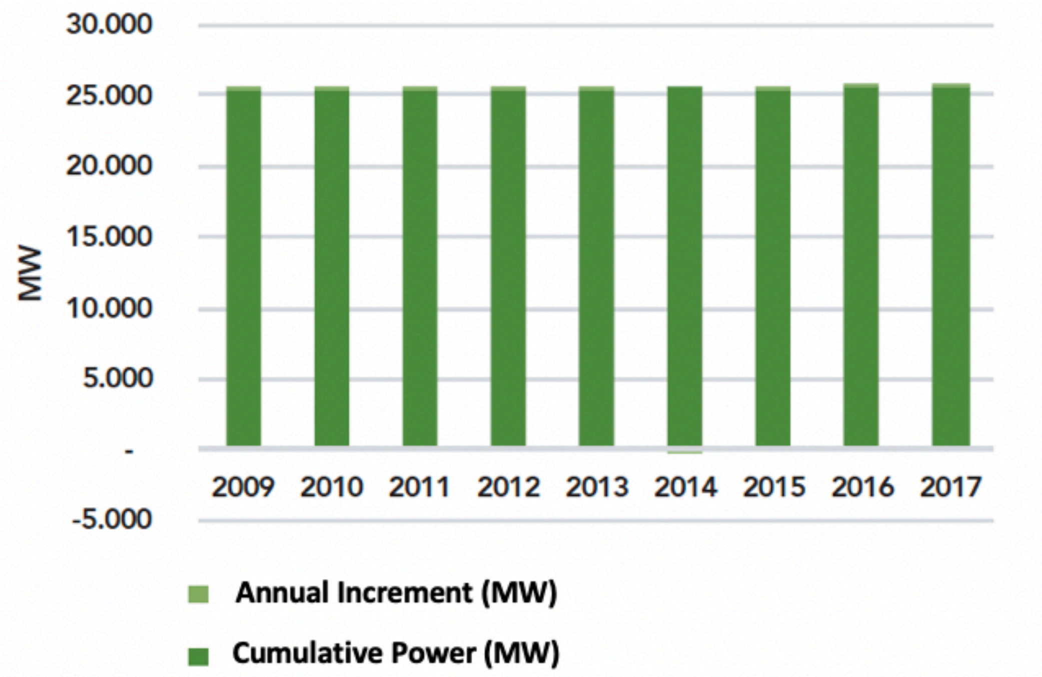
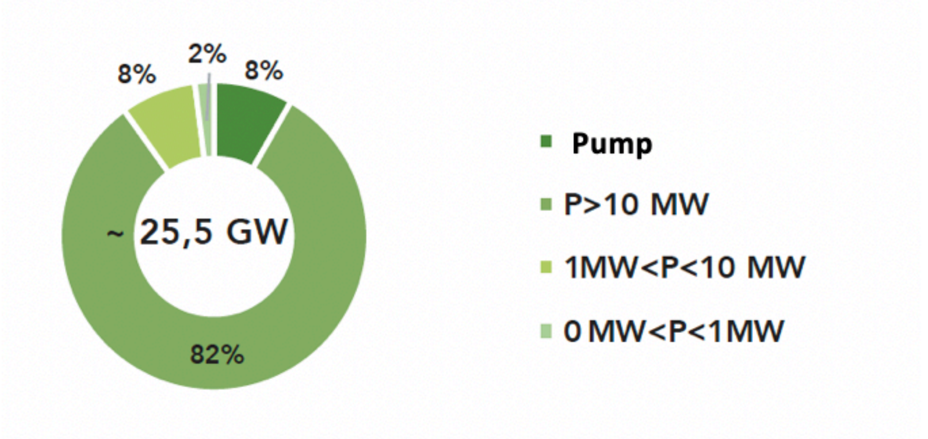


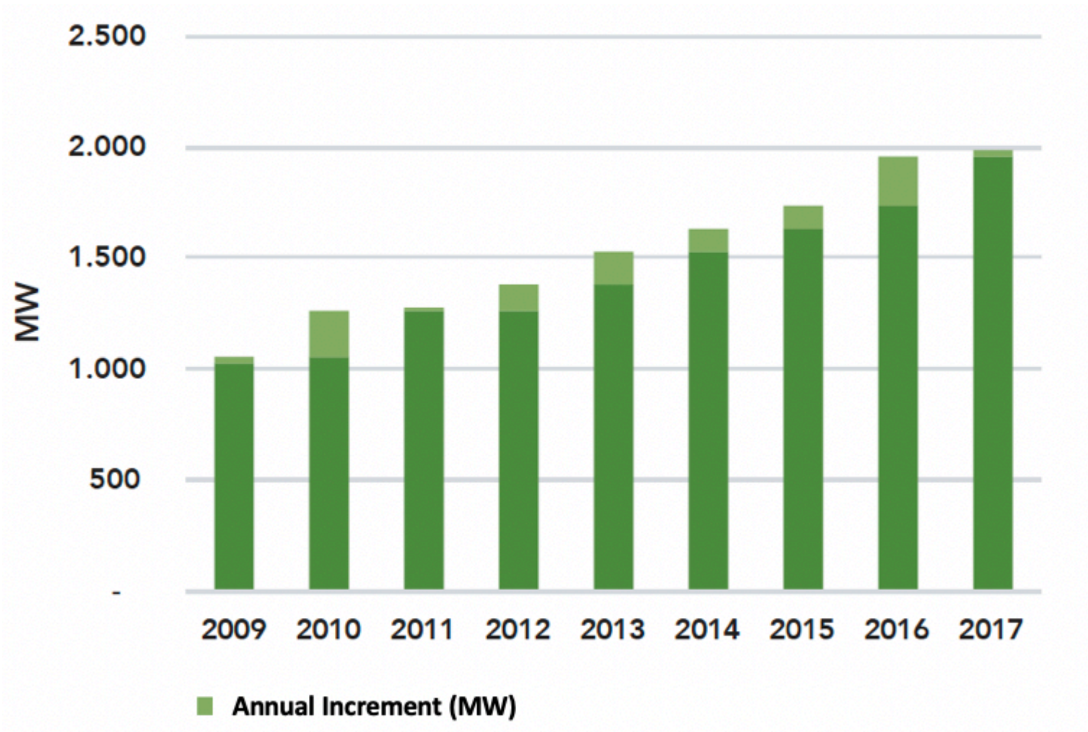
Table 3.29 Installed Capacity in France by plant size (Hydropower) – Source: Energy Strategy Group 2018, Politecnico di Milano



Biomass

In France the total capacity account only for **2 GW**. In 2017, new installations drastically decreased. For France the reasons are the same as for Germany and other European countries. Critics regarding possible pollution issue linked to long and complex supply chain have reduced heavily its development.

Table 3.30 Installed Capacity in France (Biomass) – Source: Energy Strategy Group 2018, Politecnico di Milano



3.4.2 Regulatory Framework

For RES electricity generation, a new support scheme has been implemented in the country in the last 2 years. This new scheme is based on a premium in addition to the market. This new guideline foresees the phase-out of the mechanism of purchase obligation of electricity from renewable energies and the limitation of the duration of support to 10 years. For the smallest plants (< 500 kW) the standard feed-in tariff scheme is still available.

Moreover, another permanent concern is constant efforts to ease the administrative procedures for the implementation of projects.

Table 3.31 Brief description of key policy instruments aimed at promoting RES in France

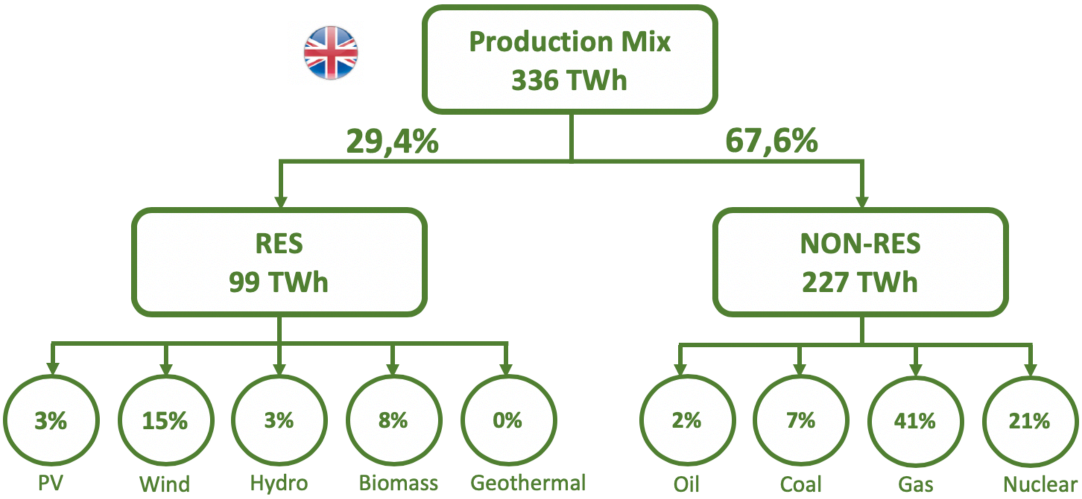
Instrument	Description
Premium tarif (Complément de Rémunération)	Premium tariffs are allocated through a quasi-tendering process, where energy producers compete against each other for feed-in premium support. For most of the RES technologies, FiP are reachable through calls for tenders auction published by Authority. The aim is to pilot the technologies growth as close as possible to the RES investment program define by the government in 2016.
Tax credit scheme (Crédit d'impôt pour la transition énergétique)	A tax relief programme which gives a direct financial advantage to individual consumers, which invest in energy-saving equipment and sustainable energy. Consumers may deduct 30% of the equipment costs over the calendar year in which the equipment was purchased. The list contains almost all the main RES-H technologies for individual houses. The measure, implemented in 2005, is the most popular scheme in France to support RES applications. In 2015, the cost of the measure only for RES technologies was evaluated around M€ 200.
Investments for the Future (Investissement d'avenir)	The Investments for the Future programme are intended to support projects fostering innovation and the creation of non-relocatable jobs in sectors with strong potential for the French economy. It is a matter of strengthening France's strategic competitive advantages. The implementation of the Investments for

	the Future program is steered by the General Investment Commission (CGI). Several operators, including ADEME, which is responsible for innovation for energy and ecological transition, support it. RES technologies and smart electricity grids are eligible to this programme.
Training programmes for Installers	The association Qualit´EnR was established in 2006 as an initiative of five national professional organisations in order to promote quality installations in the field of solar thermal energy, photovoltaic, biomass as well as heat pumps and geothermal probes. The association was established for private households willing to install a renewable energy plant, with the aim to ensure them a quality installation.
Biofuel quota	The act on energy transition of 2015 sets a target of 10% renewable energies in the total energy consumption of the transport sector by 2020 and of at least 15% by 2030. In order to reach these targets, the quota of biofuels to be blended within conventional fuels is defined for each fuel type. In case companies releasing fuel for consumption do not respect the biofuels quota, they are submitted to a higher rate of the tax on polluting activities (TGAP).

The French policy framework is therefore relatively young compared to the other European country. Currently is very similar to the German one, both in terms of typology of incentives and in terms of volume. Even so, Germany remains undisputed leader. In general, however, France is obtaining good results since 2014, with more than 1 GW installed annually for wind power and 500 MW for PV Systems.

3.5 UK

Table 3.32 UK Production Mix– Source: Energy Strategy Group 2018, Politecnico di Milano



Total energy production in UK has reached at the end of 2017 the amount of **336 TWh**, making UK the third country in EU for energy produced. RES account for almost 29%, with strong contribution by wind power, helped by a relevant share of **offshore** installations. However, first sources for energy production are **natural gas**, with 41% of the share, followed by **nuclear energy**, with 21%. Even if traditional sources are still predominant in the actual scenario, UK is pushing hard to change its production mix. In 2017 were installed **5,3 GW** from RES. Wind power lead the classification, with 4,3 GW, followed by PV Systems with 0,9 GW.

3.5.1 Installed Capacity & Plant Size

Photovoltaics Systems

At the end of 2017, UK has reached a total installed capacity of **12,6 GW**, with a reduced net installation compared to 2016 (-60%). This was due to the end of **Renewable Obligation Certificate (ROC)** for large plants (>5MW).

Consequently, at the end of the year have been installed ''only'' **900 MW**, still twice than in Italy. It is interesting to highlight how relevant is the share of large utility scale: **67%**. Little and medium plants are not very much diffused.

Table 3.33 Installed Capacity in UK (PV Systems) – Source: Energy Strategy Group 2018, Politecnico di Milano

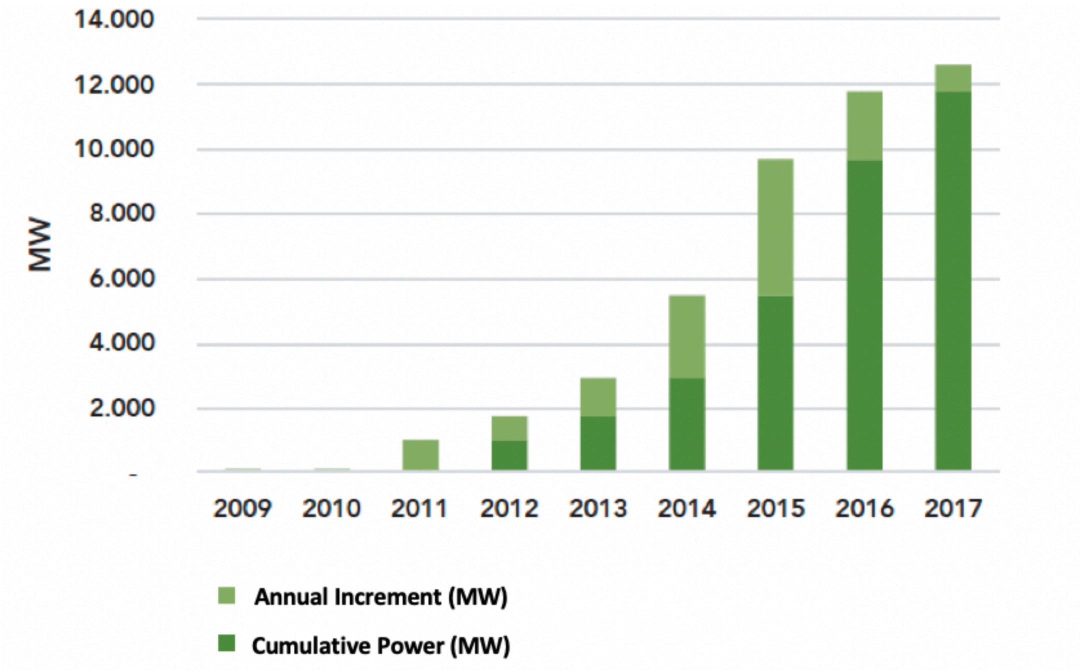
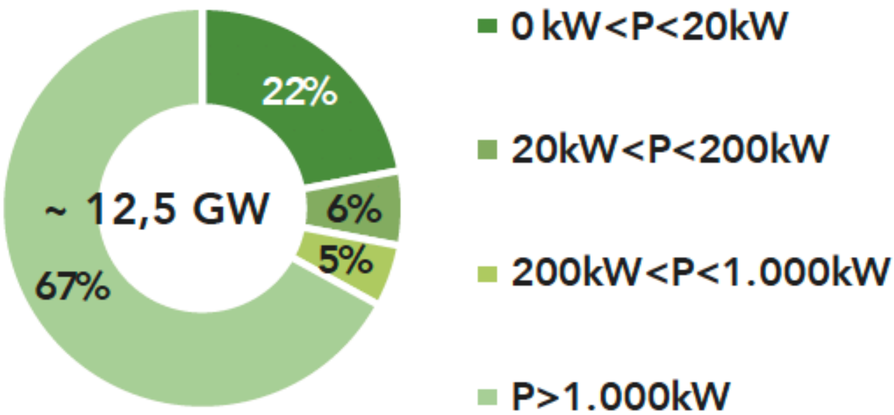


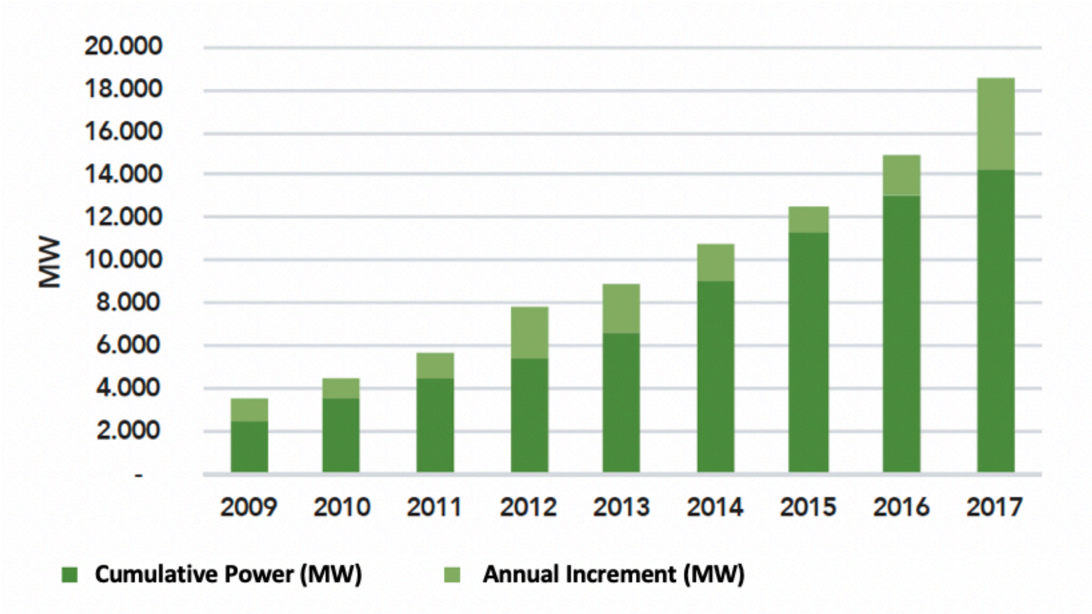
Table 3.34 Installed Capacity in UK by size (PV Systems) – Source: Energy Strategy Group



Wind Power

At the end of 2017 UK registered an increase in installation compared to 2016 of **+25%**. It has been installed **4,3 GW** of capacity, nearly 14 times Italy. A big share has to be allocated to **offshore installations (40%)**. Globally, at the end of 2017, wind power accounted for **18,9 GW**, of which the 34% is made by off-shore wind plants; the biggest share in all Europe.

Table 3.35 Installed Capacity in UK (Wind Power) – Source: Energy Strategy Group 2018, Politecnico di Milano



Hydropower and Biomass

As we saw for the other countries in Europe, also for UK the actual situation regarding these two sources is very much similar. Hydropower (since 2009) and biomass (since last year) installations have seen low investments and improvements compared to PV and Wind. Net installations are around some MW per year.

Table 3.36 Installed Capacity in UK (Hydropower) – Source: Energy Strategy Group 2018, Politecnico di Milano

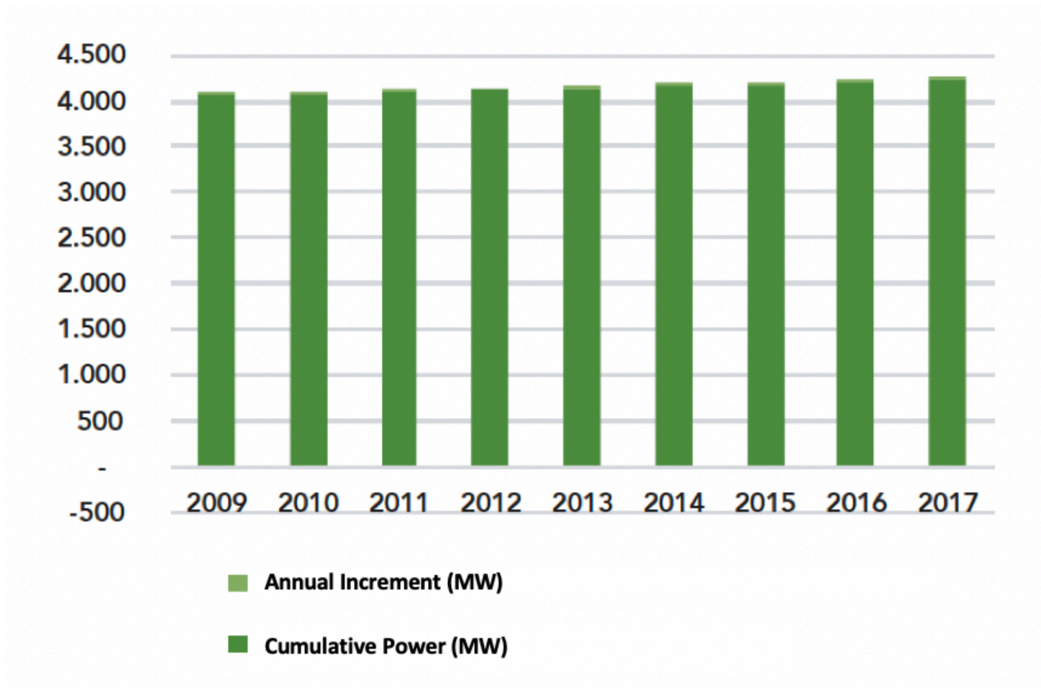
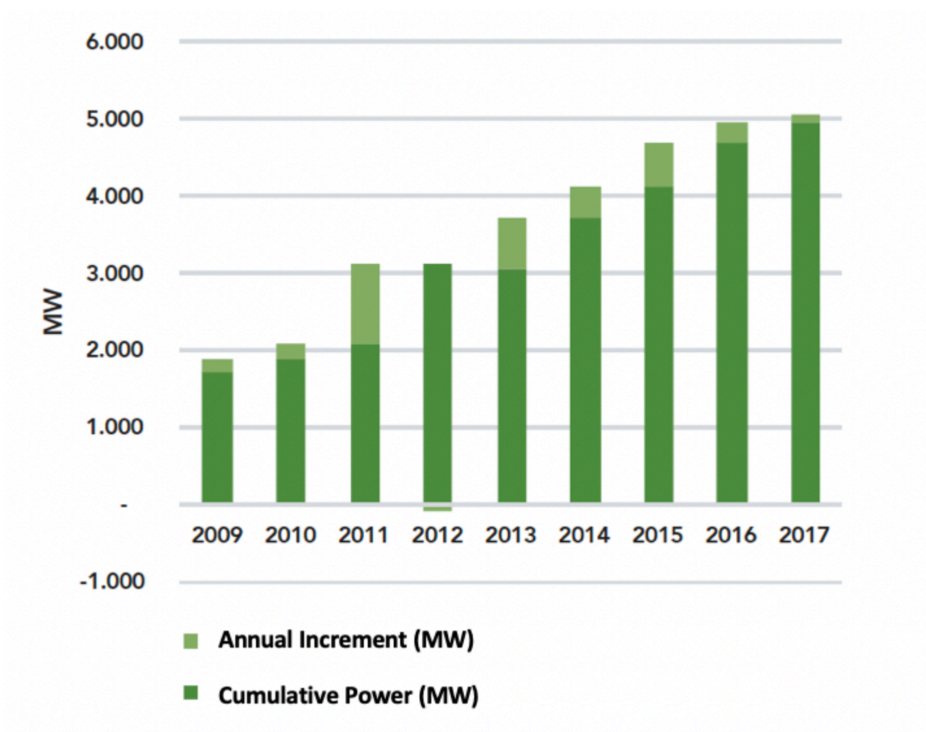


Table 3.37 Installed Capacity in UK (Biomass) – Source: Energy Strategy Group 2018, Politecnico di Milano



3.5.2 Regulatory Framework

The generation of electricity from renewable sources is supported through a combination of **a feed-in tariff system**, **Contracts for Difference system**, a **quota system** in terms of a quota obligation and a certificate system and a **tax mechanism**. Under the feed-in tariff, accredited producers whose plants have a capacity of less than 5 MW can sell their electricity at fixed tariff rates established by the Gas and Electricity Market Authority (Ofgem). The scheme is applicable to England, Wales and Scotland only.
Under the quota system, UK electricity suppliers of more than 5 MW of capacity are obliged under the Renewables Obligation Orders to supply a certain proportion of electricity from renewable sources ("quota") to their customers. Furthermore, in Great Britain commercial and industrial users of traditional energy sources are subject to Carbon Price Floor (CPF), a tax on fossil fuels used for electricity generation. Electricity from renewable sources is exempt from this tax.
Let us sum up briefly the key policy instruments aimed at promoting RES in the United Kingdom:

Table 3.38 Brief description of key policy instruments aimed at promoting RES in UK

Instrument	Description
Feed-In tarif	Eligible renewable energy plants with a capacity of up to 5MW must generally undergo an accreditation process, which may differ according to plant size and energy source. Once this process is completed and the plant has been accredited, the electricity exported to the grid by the plant is bought by a FiT licensee, i.e. an electricity supplier, at rates fixed by the FTO 2012 and corrected yearly by the Gas and Electricity Markets Authority (Ofgem). This system only applies in Great Britain, i.e. Scotland, England and Wales. The Order is not applicable in Northern Ireland.

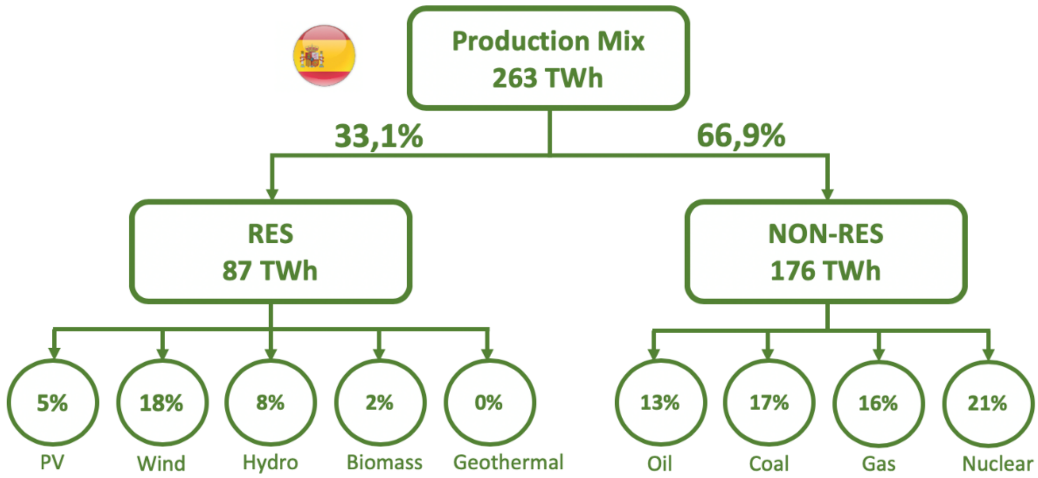
Contracts for Difference (CfD)	A Contract for Difference (CfD) is a private law contract between a RES-E generator and the CfD Counterparty – Low Carbon Contracts Company (LCCC), wholly owned by the UK Government. The scheme is based on a difference between the market price and an agreed "strike price". Where a "strike price" is higher than a market price, the CfD Counterparty must pay the RES-E generator the difference between the "strike price" and the market price. Where market price is higher than the "strike price", RES-E generator must pay back the CfD Counterparty the difference between the market price and the "strike price". An operator of eligible RES-E technology, willing to secure a Contract for Difference, has to take part in an allocation round. The CfD scheme is currently in place in Great Britain and Northern Ireland.
Quota system Renewables Obligation	In the United Kingdom, electricity generated from renewable sources is also promoted through a quota system in terms of a quota obligation and a certificate system. The Renewables Obligation Orders impose on electricity suppliers the obligation to prove that a certain proportion of electricity supplied was generated from renewable sources. To this end, they shall present Renewables Obligation Certificates to responsible regulatory authorities - Ofgem (in charge in England, Scotland and Wales) or the Northern Ireland Authority for Utility Regulation (NIAUR). The quota system supports plants above 5 MW, although plants between 50 kW and 5 MW are also entitled to choose between the feed-in tariff system and the Renewables Obligation.
Tax regulation	From April 2013, Carbon Price Floor was introduced in Great Britain. The tax applies to fossil fuels used for

mechanism	electricity generation. Renewable electricity is exempt from paying this tax.
Biofuel quota	A quota system for biofuels is in place in the United Kingdom since 2007. Fuel suppliers for transport are obliged to satisfy a specified quota amount of biofuels in the total supplied fuel. There is a certificate system for providing proof of compliance.

UK policy framework can be considered in general much simpler than the German and French ones. They rely upon the three tools that we have listed before.

3.6 Spain

Table 3.39 Spanish Production Mix– Source: Energy Strategy Group 2018, Politecnico di Milano



With a production of **263 TWh**, Spain is the fifth country in EU for energy produced. Nuclear energy and wind power are the main sources of production. 2017 has confirmed the trend of the last years, in particular after 2013. New installations and policy schemes are in a serious **deadlock**. Installations of wind and PV systems, that should be the "*war horses*" for Spain, are in the order of few hundreds of MW, while other sources are almost stopped. This stalemate is consequence of retroactive cut to incentives made by governments after 2013.

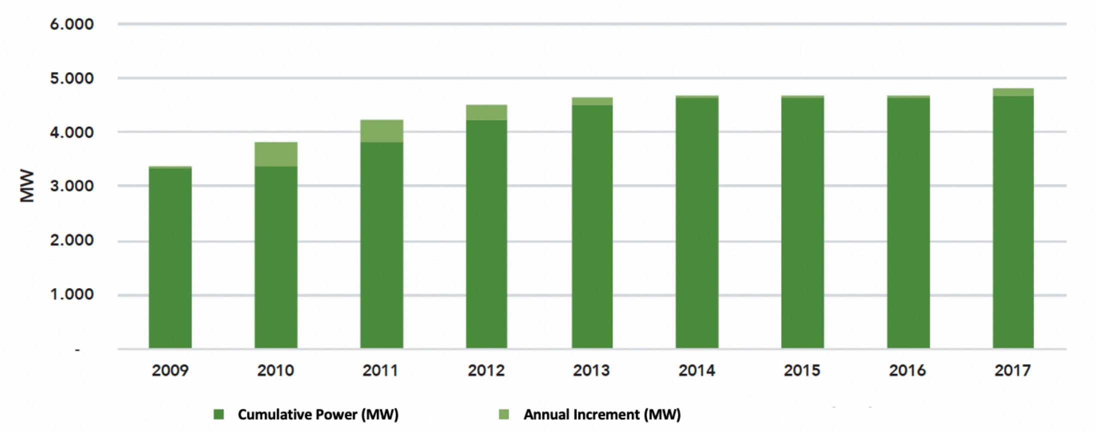
Signs of very important recovery however seem to emerge. The last tenders in 2017 has assigned nearly **3,9 GW** of photovoltaics and **4,1 GW** of wind plants installation starting from 2020.

3.6.1 Installed Capacity & Plant Size

Photovoltaics Systems

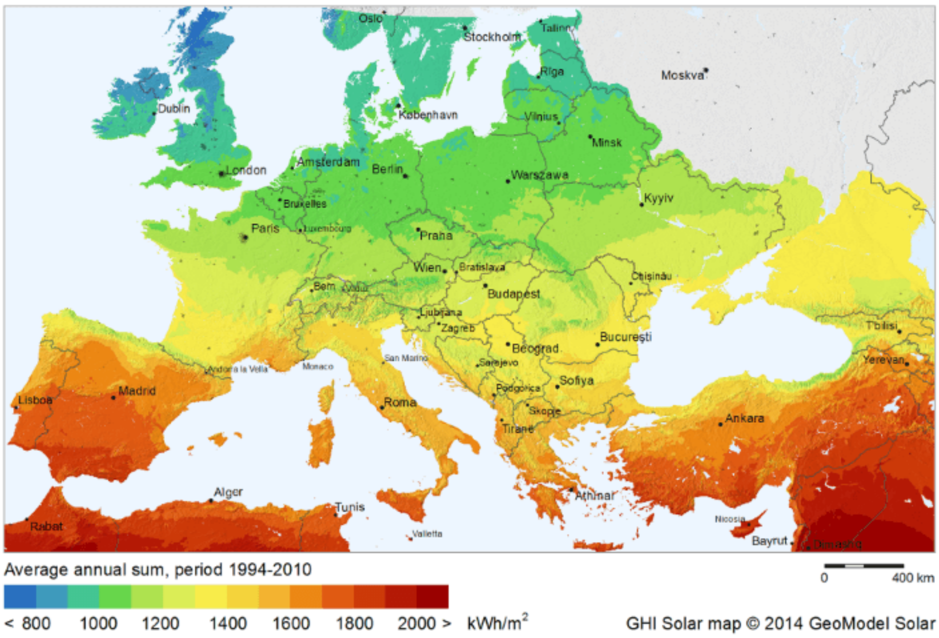
Spain has reached at the end of 2017 an overall volume of capacity of **4,6 GW**, with new installed capacity of **135 GW**, a third of Italy. In the graph below, we can see how the increase in volume is virtually frozen since 5 years.

Table 3.40 Installed Capacity in Spain (PV) – Source: Energy Strategy Group 2018, Politecnico di Milano



The situation in Spain could be considered dramatic. In a country where the average irradiation level is much higher than the European one, PV System should provide much more energy than what is actually doing.

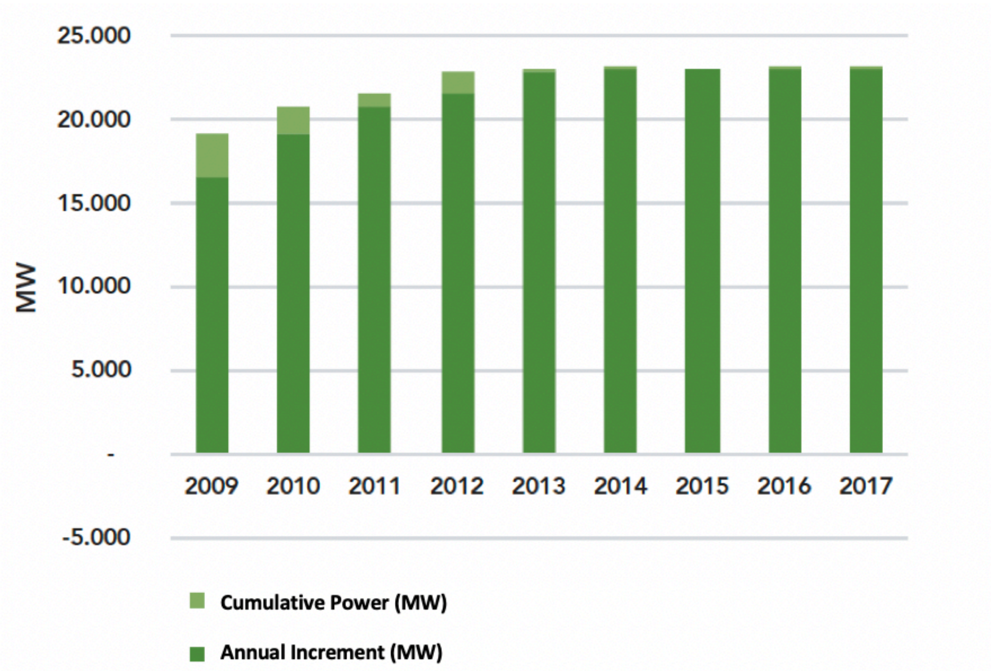
Table 3.41 Global Horizantal Irradiation (GHI) in Europe – Source: GeoModel



Wind Power

At the end of 2017, Spain had a total installed capacity of **23 GW**. A significant amount one can say; the problem, as we saw with other sources in this country, is that the level of installation is stopped at 2013 level (see table 3.42). In the last five years, the net installations were very few. If in 2013 the wind installations made Spain one of the most developed country in this sector, the political stagnation has erased completely all the past success. As we said however, Spain is waiting for good news from the new tender auction policy that promises to revive the market. **4 GW** are ready to be installed in the next years.

Table 3.42 Installed Capacity in Spain (Wind) – Source: Energy Strategy Group 2018, Politecnico di Milano



Hydropower

Hydropower sector in Spain, with its **20,4 GW**, is almost entirely made by big size plants. Except for the 2013-2015 period where some pump plants were installed, the technology is generally stationary, with few MW of new capacity per year.

Table 3.43 Installed Capacity in Spain (Hydropower) – Source: Energy Strategy Group 2018, Politecnico di Milano

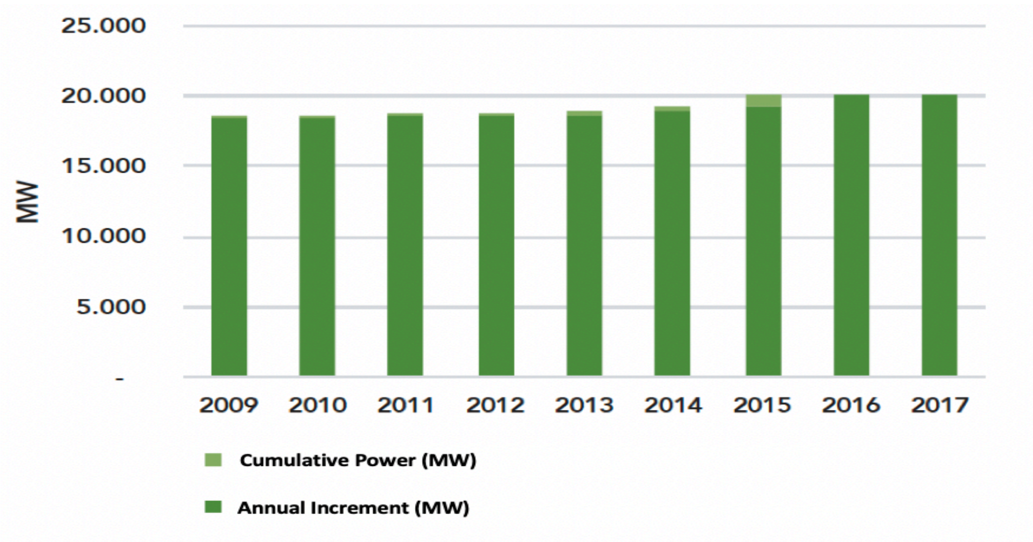
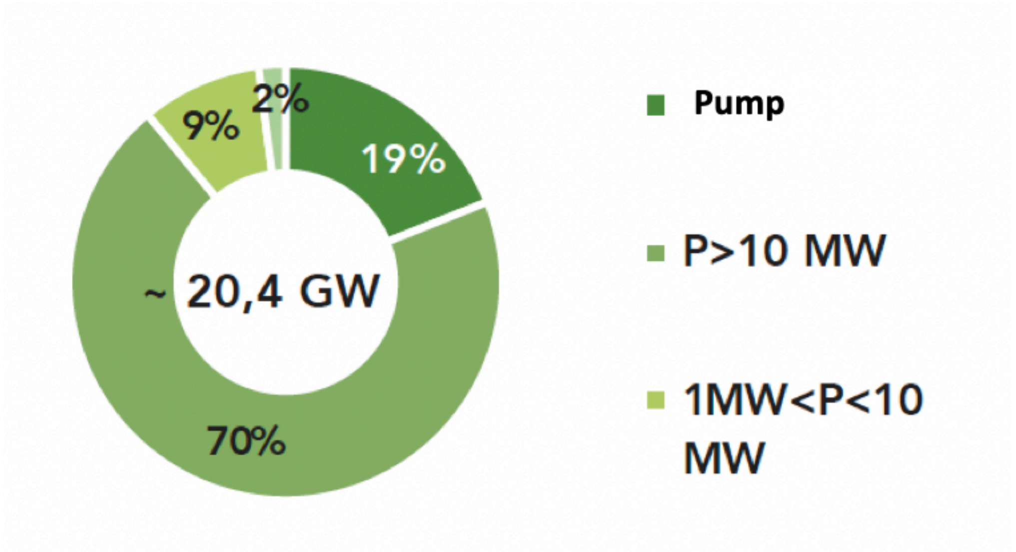


Table 3.44 Installed Capacity in Spain by size (Hydropower) – Source: Energy Strategy Group 2018, Politecnico di Milano



3.6.2 Regulatory Framework

Spanish case on policy framework deserves a deeper analysis, since its example is very significant on the importance of a good regulatory legislation.
Spanish energy policy in the first decade of the 2000s has in fact moved from strong economic support for new facilities based on their environmental benefits, and clear compensation criteria and regulatory guarantees, to a less

ambitious policy following the economic crisis. This later policy is characterized by reduced remuneration for both existing and new facilities and no guarantee of mid-term regulatory stability.
The first change to Spanish policy framework for RES was in July 2013 with an important reform to the so-called tariff deficit. The rules of the game changed and led to numerous **small private investors** being **bankrupted**.
Furthermore, in October 2015, new legislation was passed and imposed additional fees to discourage the use of batteries or other storage systems by households and small companies that produced their own electricity and were connected to the national power grid. This new legislation was seen as threatening renewable energy developments and energy independence in Spain. This kind of legislation on sustainable sources of energy has changed the socio-technical scenario dramatically. They have resulted in less ambitious policy during the economic crisis, characterized by increased hardships for small investors in PV, and lack of guarantees of mid-term regulatory stability.
Let us see in detail the main tools:

Table 3.45 Brief description of key policy instruments aimed at promoting RES in Spain

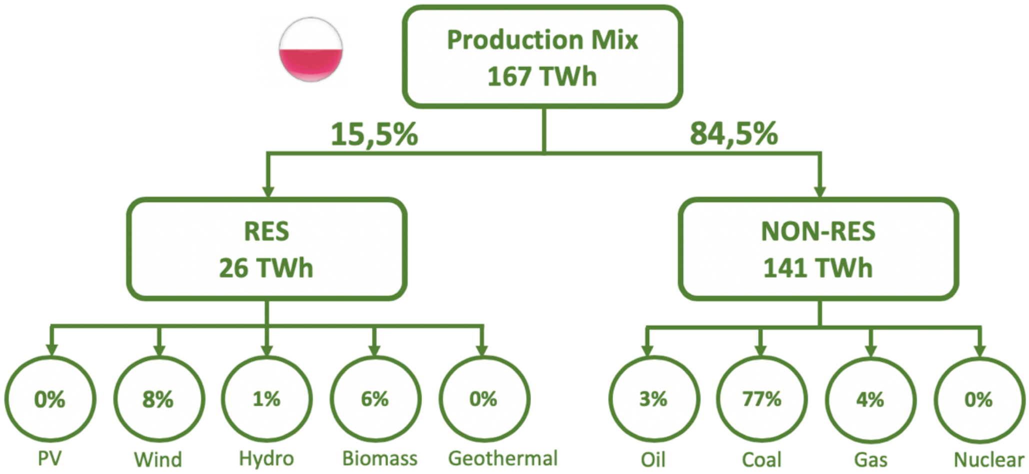
Instrument	Description
Premium tariff (Régimen Retributivo Específico)	The premium tariff or “specific remuneration regime” is not technically defined as a support scheme, but as a complementary retribution to allow renewable technologies to compete with traditional technologies in the energy market. The Real Decreto 947/2015 was approved to regulate the premium tariff (“Régimen Retributivo Específico”), aiming at supporting new biomass plants located in the mainland electricity system and existing or new wind energy plants. The selected procedure to allocate the premium tariff is a call for tenders regulated through Order IET/2212/2015. The latter also approved the value of the different

	compensation parameters for the reference RES plants under the new remuneration regime or premium tariff. In 2015, Real Decreto 900/2015 was approved, establishing charges on existing and new self-consumption RES plants, both on capacity and generation levels. According to RD 900/2015, these are not taxes or compensation for utility losses, but contributions to overall system costs. Self-consumption installations under 10 kW and plants located not on the Spanish mainland will be spared the generation charge but will still be subject to a fixed charge per kW of capacity.

Fortunately, something is changing, and the policy framework is slowly being revised and modified to better answer the problem of the market. Following the positive examples of Germany, UK, and in part Italy, Spain is developing a tendering process to incentivise the production of clean energy. The technologies involved in the auctions are the two main sources of power: **PV Systems** and **Wind Power**. So far Spain has seen being assigned **3,9 GW** for PV and **4,1 GW** for wind power, increasing the faith in a more prosperous future for RES in the country.

3.7 Poland

Table 3.46 Polish Production Mix– Source: Energy Strategy Group 2018, Politecnico di Milano



Poland is one of most representative country of East Europe. Its total production reached at the end of 2017 the amount of **167 TWh,** with almost **200 MW** of new installations. Inside this report, we decided to include the example of Poland also as a clear proof of the heterogeneity of Europe market. Poland, in fact, has a predominant share of energy produced from **coal (77%)**, and Polish intentions are clearly not to reduce this number. This data cannot be considered aligned with the European framework and its will of reducing noxious emissions. Even if the renewable market in this country has started to produce some results after 2014, the situation is still dramatic. The average dependence from RES is far lower than the average of EU and coal represents a technology too much important for the country.

3.7.1 Installed Capacity & Plant Size

PV Systems

At the end of 2017 Poland reached **0,3 GW** of total installed capacity, thanks to **100 MW** installed in 2017 (+27% compared to 2016) and a constant growth since 2014. We can notice in Poland a strong propensity for the **small/residential plants**.

Table 3.47 Installed Capacity in Poland (PV Systems) – Source: Energy Strategy Group 2018, Politecnico di Milano

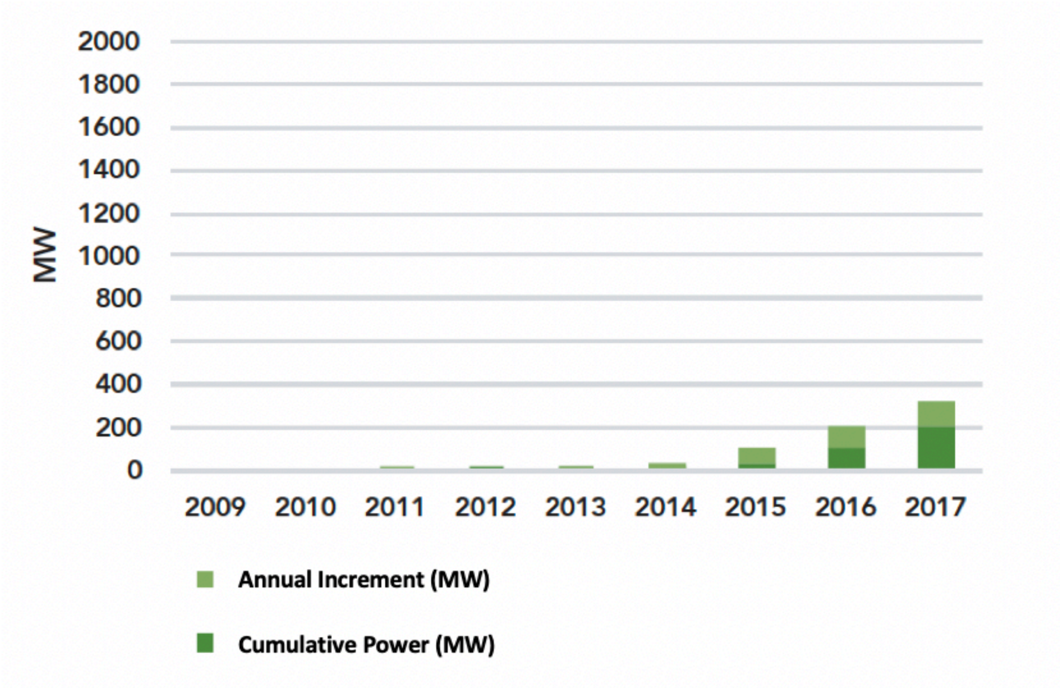
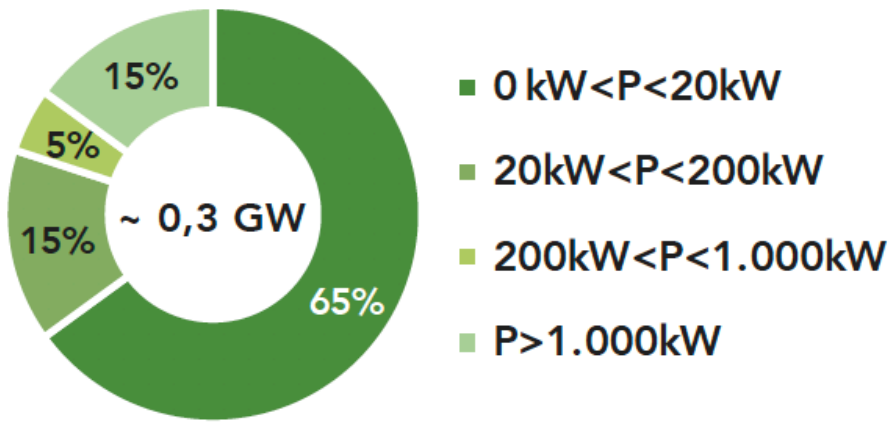


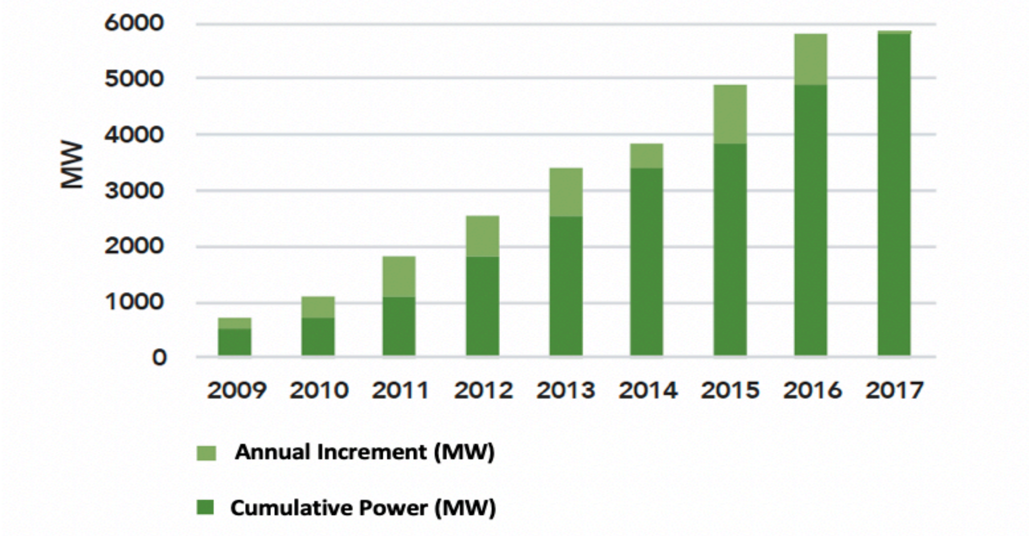
Table 3.48 Installed Capacity in Poland by size (PV Systems) – Source: Energy Strategy Group 2018, Politecnico di Milano



Wind Power

Wind Power in Poland at the end of 2017 reached the total amount of **6 GW**, making it the most developed RES in the country. However, new installations in 2017 were practically zero. After the ''jump'' of 2015 and 2016, new projects stopped. This was due mainly for **restrictions** on potential sites for the construction of new turbines and the **lack** of a suitable **policy scheme.**

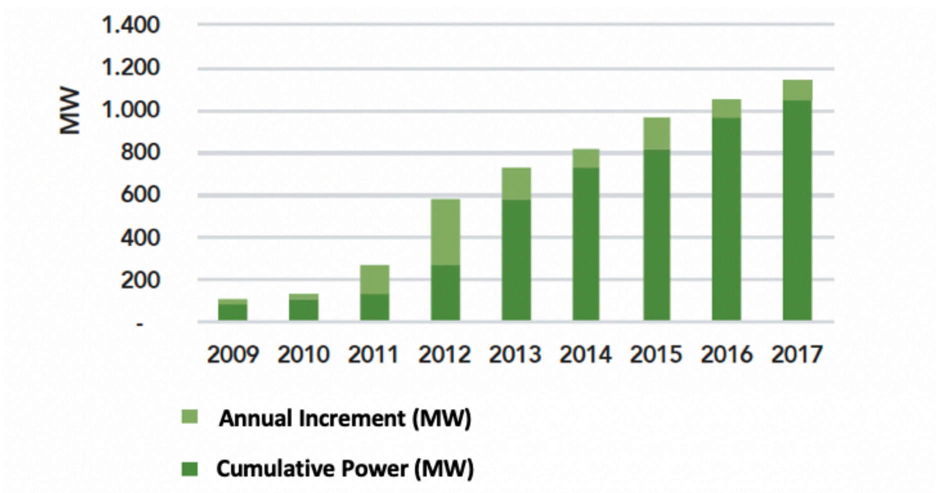
Table 3.49 Installed Capacity in Poland (Wind Power) – Source: Energy Strategy Group 2018, Politecnico di Milano



Biomass

Biomasses in Poland were among all the renewable sources, one of the most active. Its growth has been constant for years, and in 2012 and 2015 were recorded incredible years. Total capacity is **1,6 GW** and at the end of 2017 were installed **90 MW.**

Table 3.50 Installed Capacity in Poland (Biomass) – Source: Energy Strategy Group 2018, Politecnico di Milano



3.7.2 Regulatory Framework

In Poland, support to electricity from renewable energy sources is in a state of uncertainty. At the end of 2016, the Polish certificates-backed renewable electricity quota scheme was replaced for new installations by a **feed-in tariff** or **premium scheme**. In 2017 the government tried also to introduce **tenders** but failed and auctions were blocked in November 2017 due to some ''update in the legal European framework''. In general, polish policy scheme is divided as follow:

Table 3.51 Brief description of key policy instruments aimed at promoting RES in Poland

Instrument	Description
Feed-in tariffs or Premium tariff	Guaranteed electricity price or premium on top of the revenues from electricity sold, during the support contract period. The level is determined (pay-as-bid) by way of tenders. Open to operators of pre-existing RES-E installations opting for this scheme and to operators of new RES-E installations.
Renewable quota scheme, certificates-based	Obligation upon electricity suppliers to surrender on the settlement day of the current year a number of certificates corresponding to a pre-set minimum share of their annual sales volume last year. Open to operators of pre-existing RES-E installations, opting to remain a beneficiary of this "old" scheme that will be gradually phased out completely.
Net metering	Prosumers with micro RES-E installations can sell electricity supplied to the grid up to a certain maximum at pre-specified, favourable terms.

At the end of this thorough analysis is now possible to draw some considerations regarding the different results achieved and the different ways to support development in the energy market from each country.

CAPITOLO 4
DISCUSSION ABOUT THE FINDINGS

What are the outputs of the analysis? Which are the most virtuous country for each renewable energy source? What is the result of the benchmark?

In this section of the report, the study will try to give a holistic view of the achievements of each nation previously analysed.

4.1 Highlights

Only three countries of the six we have analysed have a percentage of energy produced by RES higher than the EU average of 30%: **Italy, Germany** and **Spain**. Furthermore, some countries, like Germany, UK and Spain, has focused their efforts on those renewable energy sources that are abundant on their national sole, like Wind and solar systems. Other countries like Italy instead, have adopted a more heterogeneous approach, focusing with a transversal logic, carrying on the development of every technology with more balance. It is however clear how the achievement of the national targets depends on those technologies that actually are more **scalable**: Wind and PV Systems. Together they represented more than **90%** of new installations in 2017 for RES. (see figure 4.1)

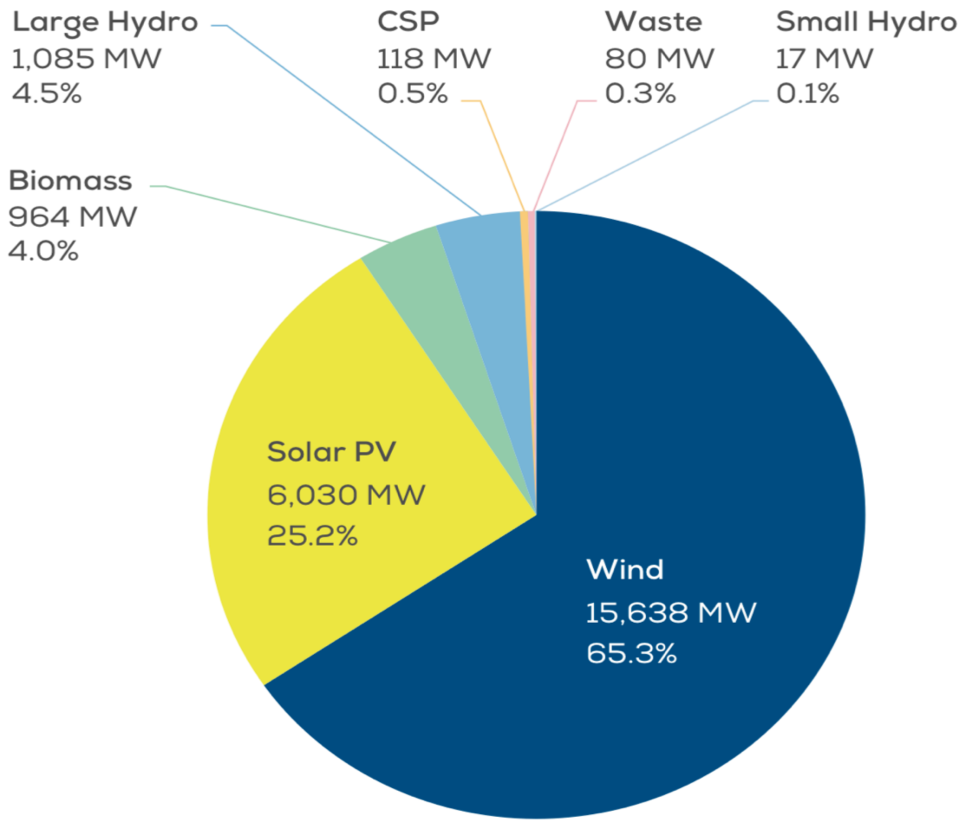


Figure 4.1 Share of new installed capacity in Europe by RES – *WindEurope*

If hydropower remains a strong component of the energy mix for every country, thanks mostly to historical installations, biomass and geothermal plants are going through a phase of uncertainty. The former is suffering for increasing critics and difficulties in convincing authorities on the effective of reducing pollution emissions, while the former is struggling in finding solution to decrease the costs of installations and operations and diminishing its environmental impact. Only Italy in fact is able to produce a significant amount of energy from this technology, even if minimal and restricted to historic site of geothermal energy presence.

Giving a look to the shares of installed capacity in Europe in 2005 and 2017 (see figure 4.2), we can realize what we have explained before. It is clear how hydropower was already a strong presence a decade ago, while wind and PV system were still very small actors (they moved respectively from 6% in 2005 to 18% and from 0,3% to 11,5%).

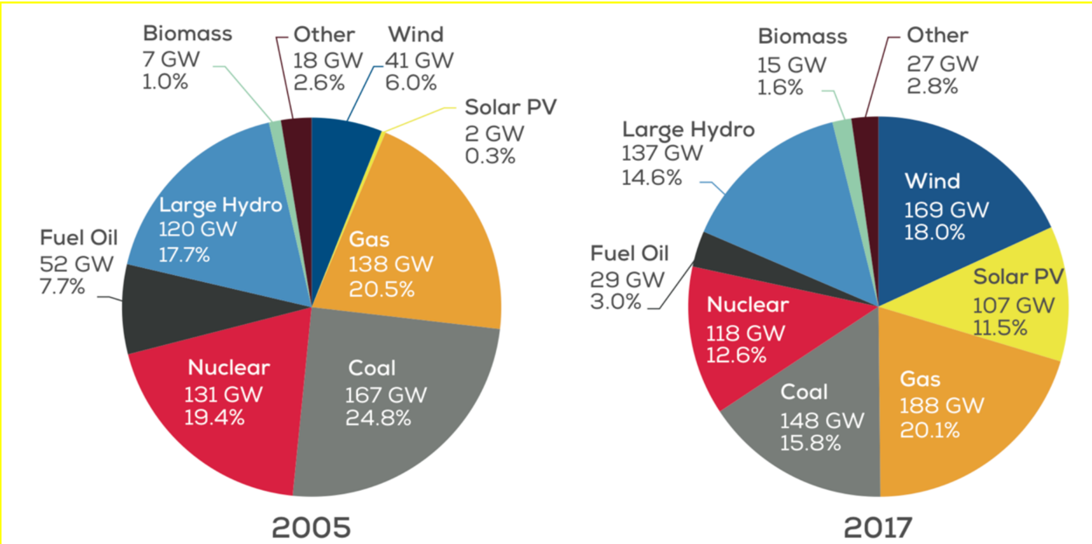


Figure 4.2 Shares in Installed Capacity in Europe in 2005 and 2017 – Source: *WindEurope*

In the following tables of the report it will be summarised the results of the analysis according to **energy mix** and **cumulative capacity installed.**

Table 4.1 Summary Energy Mix– Source: Energy Strategy Group 2018, Politecnico di Milano

Country	PV	WIND	HYDRO	BIO	GEO		OIL	COAL	GAS	NUCLEAR
	9%	6%	14%	6%	2%	37%	6%	12%	45%	0%
	6%	10%	3%	8%	0%	33%	4%	37%	13%	12%
	5%	18%	8%	2%	0%	33%	13%	17%	16%	21%
	4%	11%	9%	5%	0%	30%	2%	23%	20%	25%
	3%	15%	3%	8%	0%	29%	1%	7%	41%	21%
	2%	5%	10%	2%	0%	19%	1%	1%	7%	72%
	0%	8%	1%	6%	0%	15%	3%	77%	5%	0%

Table 4.2 Summary Cumulative Capacity– Source: Energy Strategy Group 2018, Politecnico di Milano

Country	PV SYSTEM	WIND	HYDROPOWER	BIOMASS	GEOTHERMAL	
	110 GW	169 GW	223 GW	37 GW	1,5 GW	540,5 GW
	43 GW	56 GW	11,3 GW	7,5 GW	40MW	118 GW
	19,7 GW	9,8 GW	18,7 GW	8,6 GW	824 MW	57,6 GW
	7 GW*	23 GW	20,4 GW	1 GW	–	51,4 GW
	7,7 GW	13,8 GW	25,5 GW	2 GW	–	49 GW
	12,6	18,9 GW	4,5 GW	5	–	41 GW
	0,3 GW	6 GW	2,4 GW	1,6 GW	–	10,3 GW

From these tables it's possible to draw some results:

- **German** and **Italian** installations in PV Systems account together for more than **50%** in Europe;
- **German** and **Spanish** installation in wind technology account for about **40%,** and if also UK is included, the share rises to **60%**. Here it is important not to forget the impact of **offshore installations**, especially in Germany, UK and France, where they are becoming more and more relevant. (see figure 4.3)

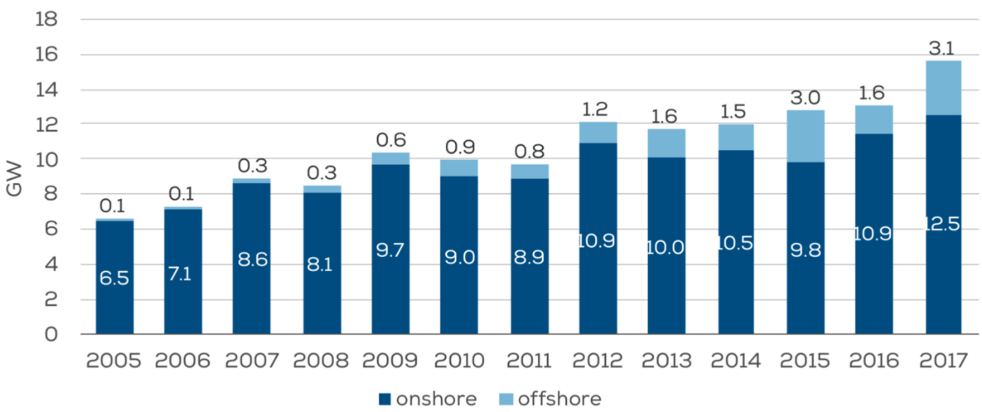


Figure 4.3 Annual Onshore and Offshore wind installations in EU – Source: *WindEurope*

The report has so far shown the results *by country*. To have a more holistic view of the situation is necessary also to pursue a transversal analysis *by technology*. The study will be divided in three subgroups:

1) **Wind Energy**
2) **PV Systems**
3) **Hydro, Biomass and Geothermal Power**

4.2 Wind Energy

Wind power installed more than any other form of power generation in Europe in 2017. Europe installed almost **16 GW** of new wind power capacity during 2017, an increase of 25% compared to 2016 annual installations. **12,5 GW** were onshore, and **3,5 GW** were offshore.
Germany installed the most wind power capacity in 2017, with 42% of the total EU new installations. It remains the EU country with the largest installed wind power capacity, followed by Spain, the UK and France (see table 4.3). This type of technology is well spread among EU countries: 16 EU countries have in fact more than 1 GW of wind power installed and 9 of these have more than 5 GW installed. Germany and UK have to be considered the most virtuous countries: they not only strengthen their onshore installations, but they also made huge progress with offshore ones (see figure 4.4).

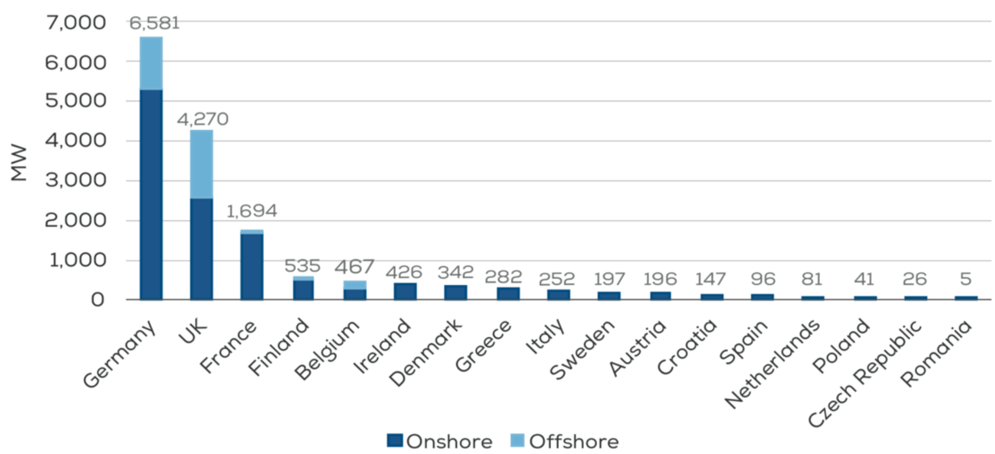


Figure 4.4 installed wind energy capacity onshore and offshore – Source: *WindEurope*

France and Italy made instead good progress only in onshore turbines, even if France is moving towards the new technology peremptorily. The report has already discussed the motivations that make Italy reluctant to invest in offshore projects (tourism, environmental impact etc.).
The difference in the results of installations has to be given to the fact that Italian peninsula is clearly less windy and much more mountainous than France soil.
Spain and Poland on the other hand obtained very negative results in 2017. Political stagnation and bad policy framework have completely stopped their investments.
In the following lines, we sum up energy mix and new installations for the six countries analysed in detail.

Table 4.3 Cumulative Capacity Wind Power

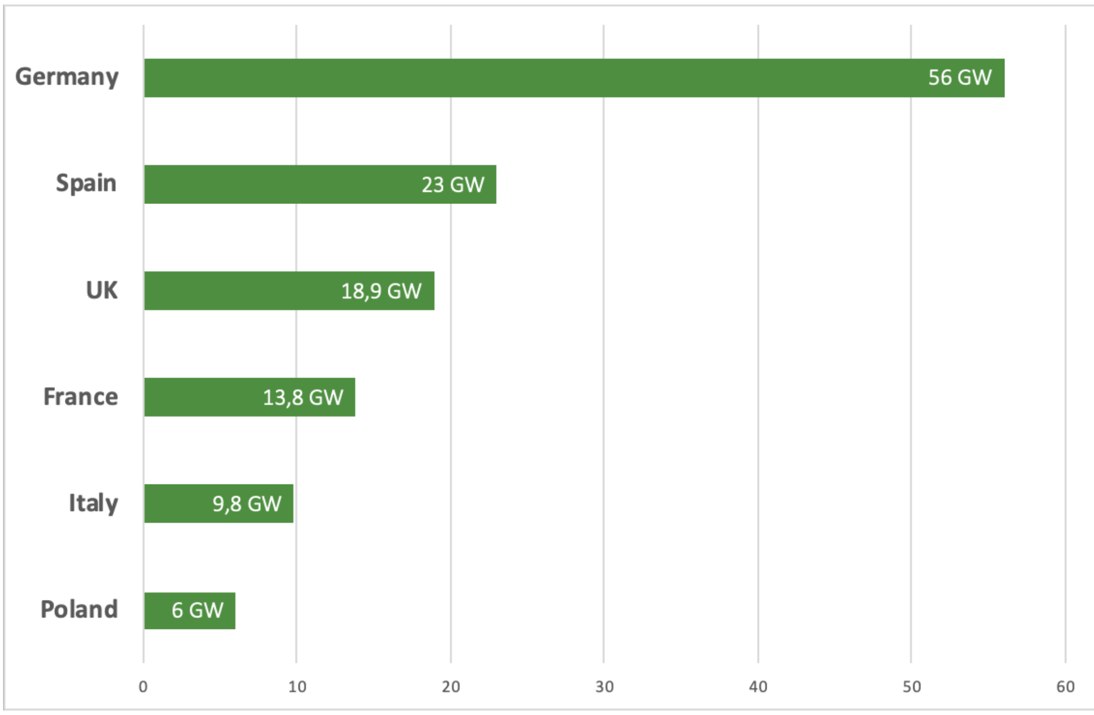
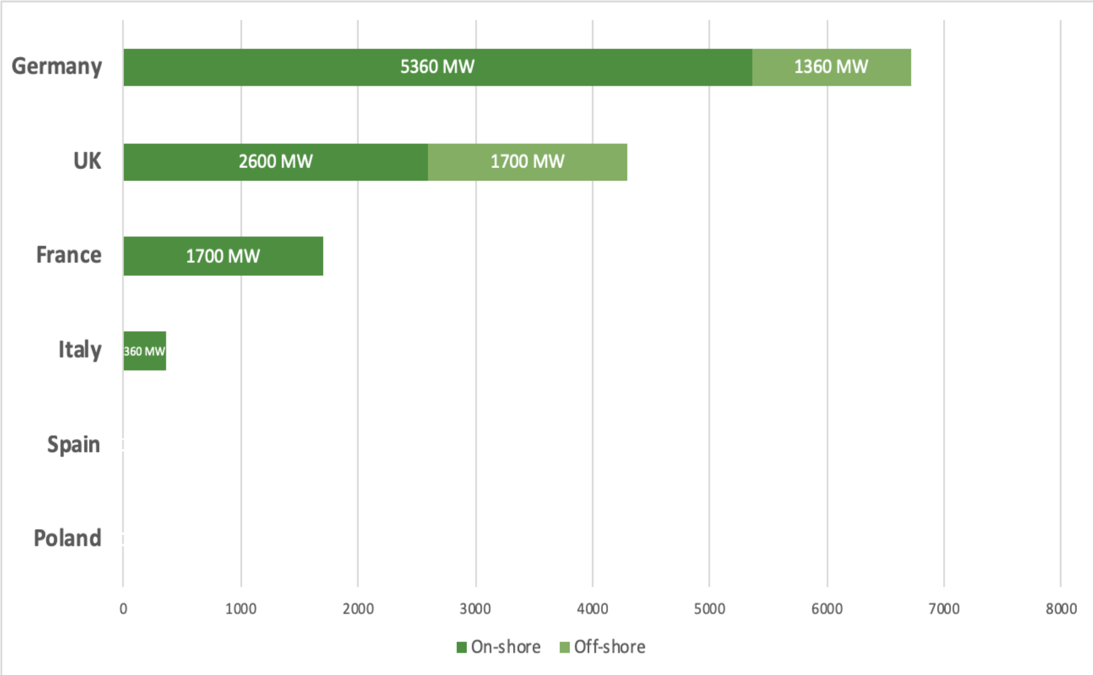


Table 4.4 New Installed Capacity for Wind Power in 2017



4.3 PV Systems

With wind power, PV is without any doubt the technology that can be developed the most and by far the most scalable. Germany in this market is the absolute leader, despite the average level of **irradiation** is much less than those of Spain or South Italy. An efficient policy framework, combined with strong investments (covering all the typology of PV Systems and not focusing only on a particular sector), have allowed the Teutonic country to overcome the barrier of 40 GW of capacity installed. This incredible result is reflected also on new installations (1750 MW), 5 times those of Italy. On the other hand, Italy is still the second ''economy'' in this market, even if UK is catching up. We only have to look on new installations (900 MW vs 410MW) to realize the different speed of installation. Also France is about to conquer its relevant market share, despite a ''late start''. Finally, Spain and Poland. The former in 2008 was one of the most developed country for solar energy. Its global irradiation level is one of highest in the world and the country seemed on the verge to conquer the market. As we deeply explained before, some bad political choices have severely blocked the evolution. Poland instead is going through a ‘’come back’’ to coal, still cheaper and easier to fulfil in this actual moment.

In the following lines we sum up graphically, the status of the technology in each country analysed.

Table 4.5 Cumulative Capacity PV Systems

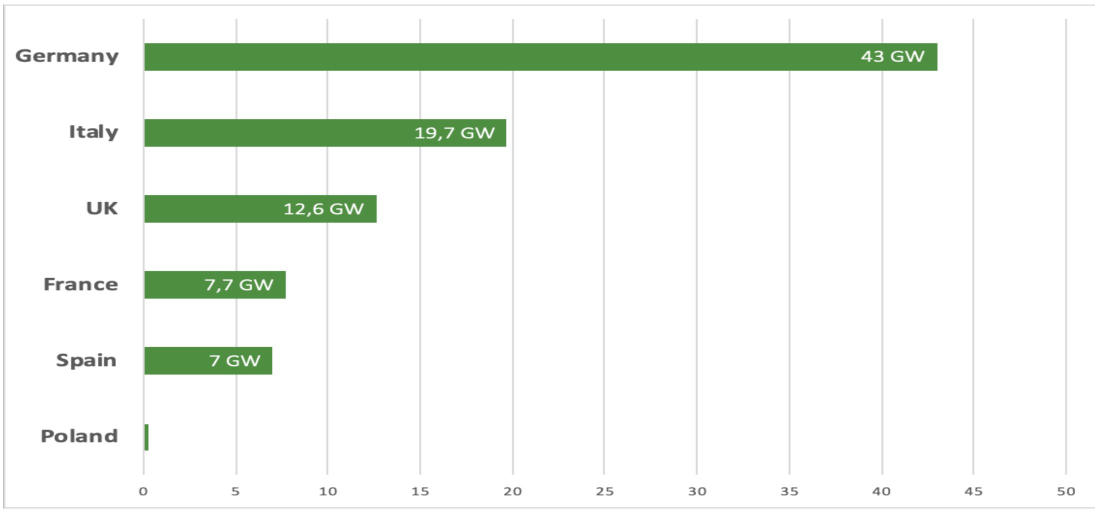
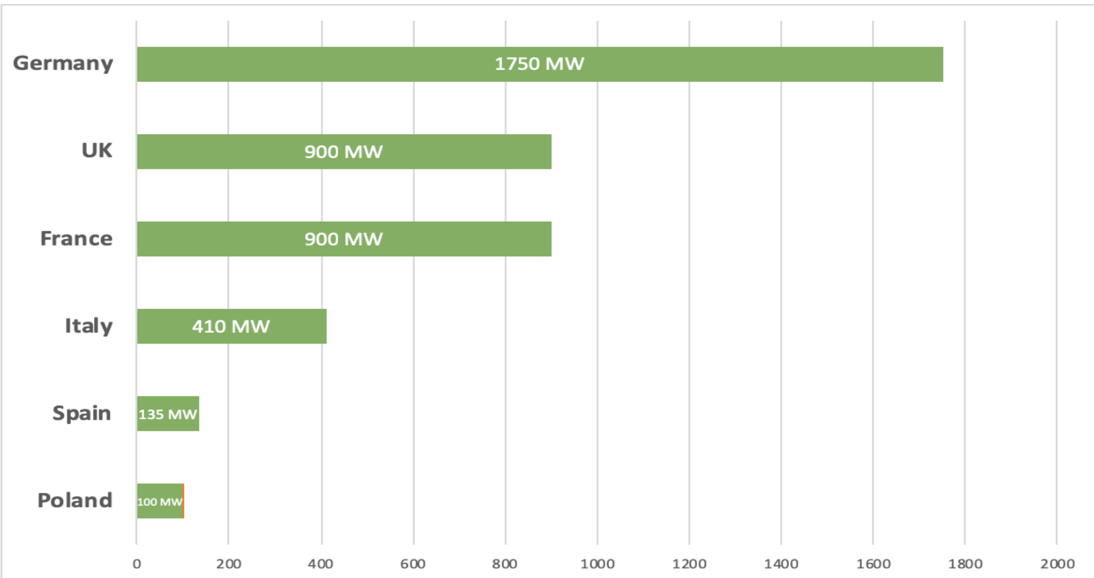


Table 4.6 New Installed Capacity in 2017 PV Systems

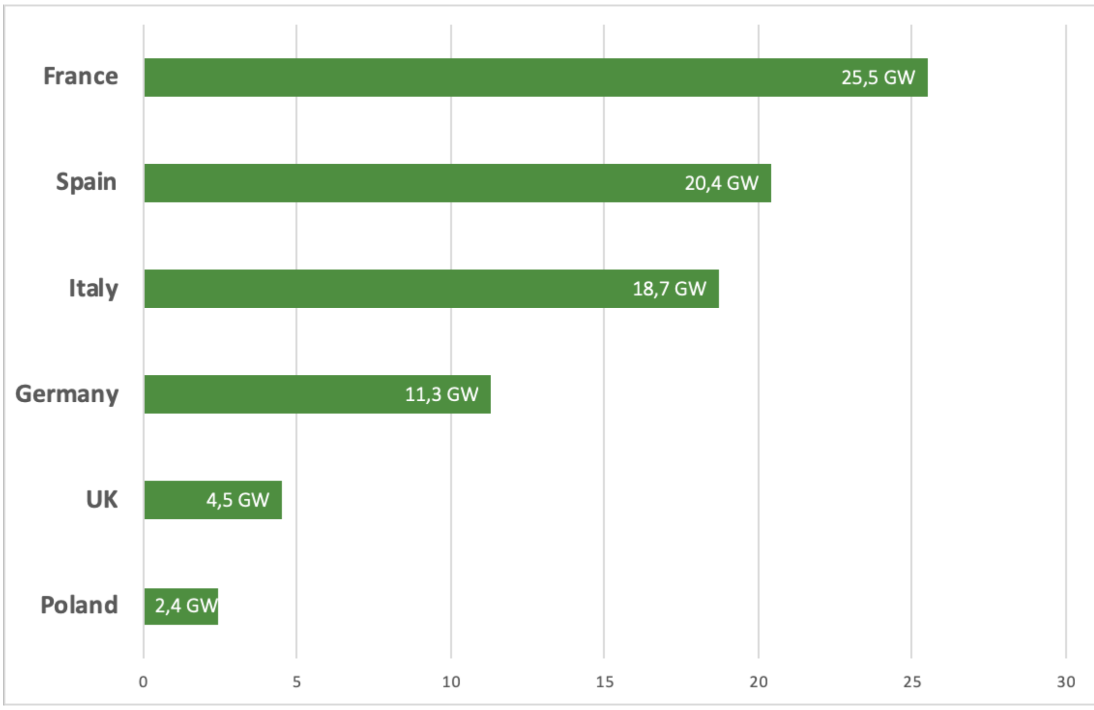


4.4 HydroPower

The wider European region, including non-EU countries, added **2.3 GW** of installed capacity in 2017, bringing the total installed hydropower capacity in the region to **249 GW**. Despite adverse climate condition throughout most of the continent, hydropower generated an estimated 600 TWh of clean electricity in 2017. It remains the **single largest source of renewable electricity in Europe**.

Hydropower has a long tradition in the old continent, with many countries adding significant hydropower capacity after the second half of the 20^{th} century. All the countries that have been analysed in the report in fact, are considered to be **mature hydropower markets** with at least more than 2 GW of cumulative capacity (see table 4.7). Therefore, capacity additions have come from **upgrades** and **smaller-scale projects**. This is the reason why new installations in this technology remained very low compared to wind and solar ones. Most of the remaining potential for hydropower development is in Eastern Europe, especially in the ex-Yugoslavia region.

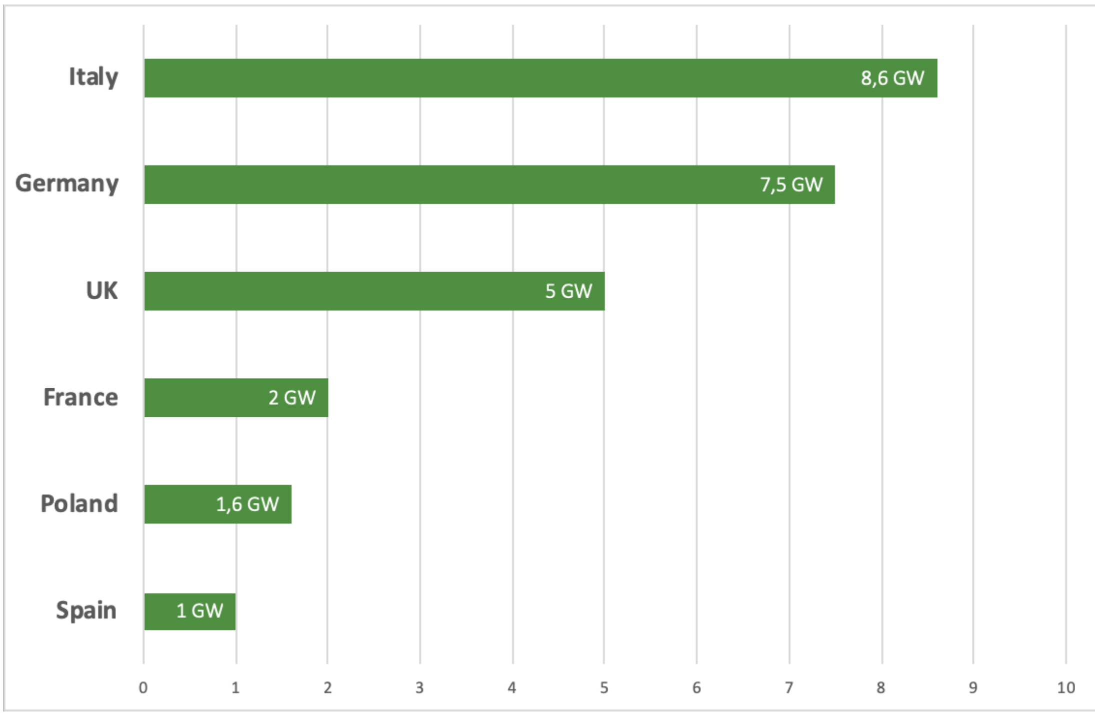
Table 4.7 Cumulative Installed Capacity for Hydropower



4.5 Biomass

The EU's approach towards biomass energy can be considered contradictable. The role of bioenergy, and therefore its potential impacts, has been dramatically under-addressed in public discussion. Solar and wind improvements and developments have obscured biomasses in the last years.
Many concerns have risen recently about a possible negative impact on land use, livelihoods, food security, climate, biodiversity and water for energy production. Bioenergy has by far the largest **land footprint** of all renewable energy forms, and large-scale consumption could lead to increased GHGE.
This is the reason why in 2017 new investments and installations regarding this technology have basically null for every country. The market is waiting for more clarification and a renewed legislation that could revive this sector. In the following table is shown the cumulative installed capacity of the six countries analysed.

Table 4.8 Cumulative Installed Capacity for Biomass



4.6 Geothermal Power

Iceland and Italy are by far the largest European players for geothermal. Both these countries mainly use "traditional geothermal" generation, from very high temperature fields.

Geothermal projects for electricity are being developed across the EU, carried by positive regulatory framework and financial support. France and Germany are among the main countries where this technology is being developed.

The geothermal sector however remains small and quite fragmented. Its projects are defined by long development times and uncertainty regarding resource availability in the early phases of investment. It requires many authorisations, and procedures are usually slow.

The geothermal market in Europe is undergoing a **transition process**. New investments, the development of new markets and the impact of innovative technologies supporting the growth of the sector and a change in the business models are all the ingredients that are characterizing this technology in this energy era.

CAPITOLO 5
CONCLUSIONS

What are the future challenges for the European Union? What are the next steps to achieve the targets? Are these targets achievable?

To conclude the analysis the report will try to draw the next actions and forecast whether will be possible to reach the objective fixed by the governments. The analysis will be conducted mainly on the Italian case, since it is the country with the clearest and most definite national strategy.

5.1 Future Prospects

Europe seems to have raised the bar once more. It has ridden the wave of enthusiasm for renewable sources and has exploited a favourable political and technological trend. We have seen in section 3.1.1 how the need for a change in the energy market has driven to the creation of a ''package'' of laws and targets, the so-called **Winter Package**. With this proposal, EU aims to be more competitive in the challenging task of energy transition. We saw along this study that the future target has even been corrected towards a more ambitious goal of **32%** of dependence from RES in 2030. EU's countries have been ''invited'' to define a strong and effective **long-term strategy** to achieve this result. The Italian SEN is exactly the result of this proposal. Italy was one of the first countries to define a national action plan, but in the last month, also Germany and France have started to work on something similar. Before diving into the precise analysis of the Italian case, the report will briefly show what the aforementioned countries have done so far to be aligned with European directives.

5.2 Energy Strategy in Germany

Germany is developing a national strategy to reach the future European objectives. Even if a document like the SEN has not yet been published, some long-term objectives have already been set:

- **Reduction of emissions of 55% by 2030 and of 85/90% by 2050.**
- **30% of energy consumption will have to be from RES by 2030 and 60% by 2050.**

The first step of this strategy will be the set of new **auctions** for the new installations of renewables. Inside the EEG document, the reported estimates for the short-term are about **33GW**, divided as follow:

Table 5.1 Energy Strategy in Germany Energy Strategy Group 2018, Politecnico di Milano

Renewable Source	Net annual installations [MW] (from 2018 to 2020)	Net annual installations [MW] (from 2020 to 2023)
Wind Onshore	2800	2900
Wind Offshore	1550	800
PV Systems	600	600
Biomass	150	200

5.3 Energy Strategy in France

Also France is working on a **multiannual energy plan**. The French government has set the following target for the future:

- **32% of energy consumption from RES by 2030.**
- **40 % of Electricity production from RES by 2030.**
- **38% of heat production from RES by 2030.**
- **15% of fuel will have a renewables origin by 2030.**
- **10% of gas will have a renewable origin by 2030.**

In the following table will be summed up the main target for French economy of middle term:

Table 5.2 French Energy Strategy – Source: Energy Strategy Group 2018, Politecnico di Milano

Renewable Source	AS IS [GW]	To Be (2023) [GW]	
		conservative scenario	optimistic scenario
Wind	13,8	24,8	32
PV Systems	7,7	18,2	20,2
Hydro	25,5	25,8	26,1
Biomass	2	1	1,3
TOT	**49**	**69,8**	**79,8**

With the conservative scenario the final cumulative installation would account for almost **70 GW** (+42%), while with a more optimistic one, French installations would be almost **80 GW** (+62%). The power would be quite uniformly distributed between wind power, solar systems and hydropower, even if wind and PV would increase much more than the other technologies.

5.4 SEN: A detailed study

In section 3.2.1, this report has discussed in general what the Italian government has produced to boost the energy transition in Italy. Coherently with EU's will, SEN draws future targets towards 2030 in terms of:

- **RES**
- **Energetic Efficiency**
- **Phase out from coal**
- **Energetic safety**
- **Competitiveness of the market**

Regarding the last point, Italy is lagging compared to France and Germany, where a strong and efficient **auctions system** is already in place. Having said that however, this report will try to focus on the first and third point: **RES** and **phase out from coal**.
About this point, Italy is surely more virtuous than other countries. Germany still relies upon coal for more than 40% of its energy production for example (compared to 15% in Italy). Anyway, in Italy still exists today **8 GW** of electricity generation from coal plants.
After COP 21 in Paris in 2015, the phase out from coal dependence has become a dominant topic. Inside the SEN document has been assumed two possible scenarios were analysed:

1) **Base Scenario**: incremental phase out from coal and energetic consumption from RES of 38%.
2) **SEN Scenario**: radical phase out from coal and energetic consumption from RES of 55%.

Here below, the two scenarios are shown in detail and broken down for each energy sources and the journey towards 2030.

Table 5.3 Base Scenario – Source: Energy Strategy Group 2018, Politecnico di Milano

BASE (Mtoe)	2015	2025	2030	Δ (2015-2030)
Import	4	3	2,8	-30%
Gas	55	54	56	+1%
Coal	13	10	10	-23%
Oil	57	54	51	-11%
RES	26	31	31	+19%
Tot	**156**	**152**	**151**	**-3%**

The main results of the Base Scenario are:

- **Reduction of primary consumption of 5 Mtoe**
- **38% of electricity produced by RES**
- **Cumulative installed capacity of RES of 60 GW** (actually 52 GW), equivalent to 129 TWh

This scenario is clearly encouraging but is not sufficient to meet the target for 2030. Let's see what the details for the SEN Scenario are:

Table 5.4 SEN Scenario – Source: Energy Strategy Group 2018, Politecnico di Milano

BASE (Mtoe)	2015	2025	2030	Δ (2015-2030)
Import	4	2,8	2,5	-38%
Gas	55	55	50	-9%
Coal	13	4	4	-69%
Oil	57	47	43	-25%
RES	26	33	37	+42%
Tot	**156**	**142**	**136**	**-13%**

The main results of the Sen Scenario are:

- **Reduction of primary consumption of 20 Mtoe**, driven mainly by the reduction in consumption of fossil fuels (coal and oil)
- **55% of electricity produced by RES**

- **Cumulative installed capacity of RES capable of 184 TWh**

To reach these objectives, further investments are definitely needed. The analysis of the two scenarios has made the experts more incline towards the second one. Therefore, from now on the report will try to assess the impact of this scenario on the future renewable market.

5.4.1 Necessary Actions and new Energy Mix

As said before, new investments will be necessary to reach the ambitious goal of total independence from coal and 55% of electricity generation from RES. New investments will have to be translated in actions. The most important will be:

- **Strengthening of electric network**
- **Installation of 3 GW of hydro pump** to be installed mainly in the centre/southern regions
- **Installation of 2,5 GW of capacity of gas generation by 2030**
- **New power line from Sardinia to continent**

Inside the new SEN 2017 is also shown a possible evolution of the energy mix by 2030. From the figure below (5.1) is clear how coal and oil are becoming less and less important soon after 2025. They will be substituted by gas and mainly RES. It is interesting to see how gas production will raise until 2025 and then they will come back to as-is levels, while RES will increase their share of 70%.

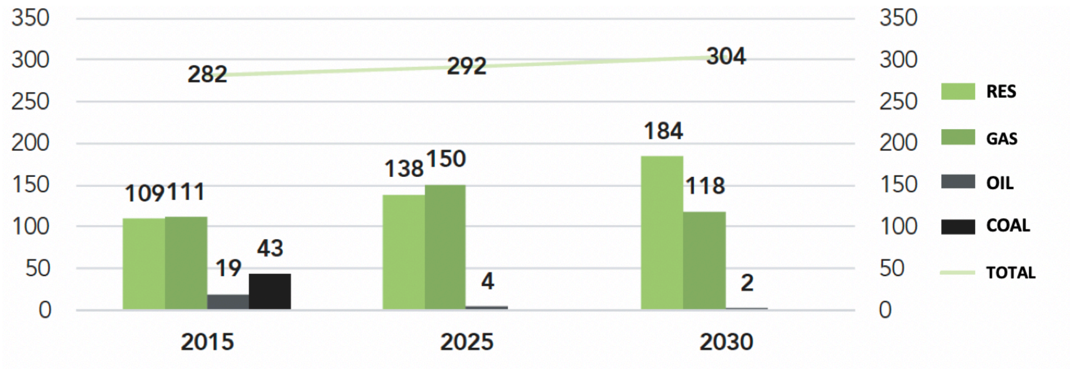


Figure 5.1 Electricity Generation by source (TWh) – Source: Energy Strategy Group 2018, Politecnico di Milano

Inside the various renewable sources, however there are many differences in terms of future development and improvement. **PV Systems** and **Wind power** are expected to grow **massively** (x2,5 and x3 respectively), hydropower and geothermal power will remain constant and biomass will even lower their 2015 level (see figure 5.2).

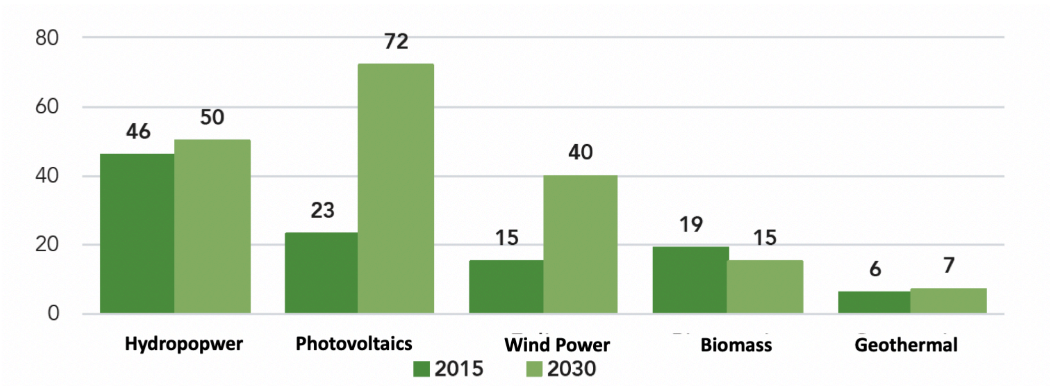


Figure 5.2 Evolution of RES electricity generation (TWh) – Source: Energy Strategy Group 2018, Politecnico di Milano

5.4.2 Production Target

Looking at figure 5.2 it is clear that technologies like wind and photovoltaics will be the most developed, while biomass and geothermal power will remain the same. Hydropower on the other hand, will be affected by a slight increase compared to 2015 level. However, the target level of 50 TWh does not seem so easy to reach. If we look at the past, this value has been overcome many times, but in the last years, the production of electricity by hydropower has reached **the lowest level** of the last decade. After the peak of 2014 with of almost 60 TWh, there have been accounted 44,7 TWh in 2015, 42,3 TWh in 2016 and an even lower 37,5 TWh in 2017. This drastic decrease is the main reason in the reduction of energy produced by RES in the last years. Given this data, is clear why the experts are sceptics about the possibility to reach the target level of 50 TWh by 2030.

The reason of this decrease has to be found firstly in **natural cause**. 2017 has been the drier year of the last 200 years, with a reduction of **precipitation** of 30%. At the same time however, the **uncertainty** about the **renewal of the concessions**, has brought the attention on **maintenance** activities rather than **investments of middle/long term**. If climate change is an independent variable and no one can manipulate it, much more can be made by the governments to assure more clarity about the concessions and meet the 2030 target.

Regarding PV Systems and Wind Power instead, the increase in electricity by these two sources is clearly significant. The former is expected to rise from 23 TWh in 2015 to **72 TWh**, while the latter from 15 TWh in 2015 to **40 TWh**.

5.4.3 Installed capacity: PV systems

The official document of SEN 2017 limited its target to the production of electricity. In the report we tried to estimate also the new installations (GW) needed to reach this target. A hypothesis has been necessary to compute this study: *the rhythm of the actual installations will remain the same along all the years until 2030*. However, all the computations have been made starting from 2015, since the SEN based its target using that year as starting point. In this way we were able to keep two years as ''buffer''.

According to the document, by 2030 will be needed an addition of 10 TWh of **self-consumption**. Considering a rate of self-consumption of 40% and excluding co-generation plants[1], it will be needed an increase of **25TWh**. This increase will be added in the form of **small residential plants** (<1 MW), therefore the other **24 TWh** will be added as **utility scale** (>1MW)**.**

Assuming also an average irradiation level for small plants of **1100 hours** per year, given the fact that they are not able to catch all the sun available and the fact that they are mainly located in the North of Italy, the capacity to be installed will be of **23GW**. For utility scale plants instead, the average irradiation level is computed as **1800 hours** per year (thanks to the mono-axial tracker and their location in Southern Italy), thus it will be needed an increase in installations of **13 GW**.

Globally the new capacity to be added will have to be around **36GW**, two times the actual level. This also means an increase per year of **2,8GW** (seven times the actual rate of installation!), divided in 1GW of utility scale and 1,8GW for smaller plants. The detail mix of plant size is shown below.

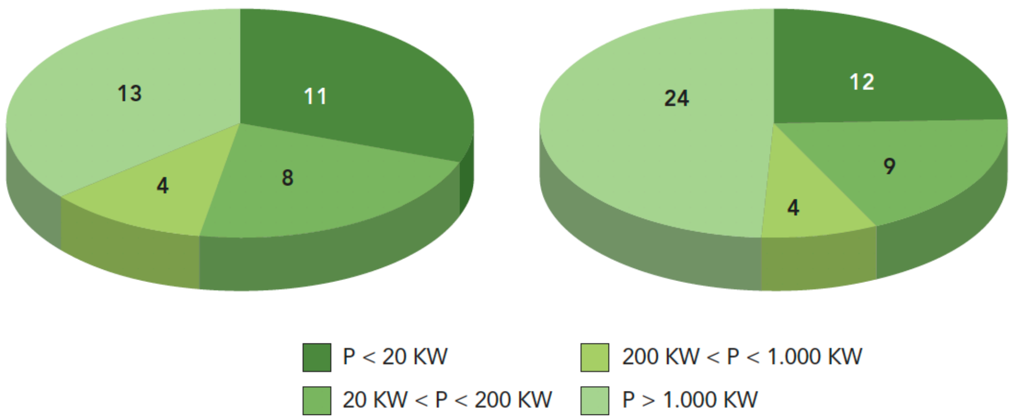


Figure 5.3 New installed capacity from 2018 to 2030 (GW) and added production (TWh)

[1] The hypothesis regarding self-consumption considers that all the 10 TWh to be added must come from small photovoltaic plants for a simplicity reason. To be coherent with the actual situation, where 25TWh of 30 are made by co-generation, [28] we should have considered that only 2TWh of the 10 forecasted will have origin from new PV installations. If we consider a self-consumption rate of 40% and 1100 hours of average irradiation level, we obtain 5 TWh of production from small PV plants and therefore **4,5 GW** of new capacity added.

5.4.4 Installed capacity: Wind Power

Regarding Wind Power instead, situation is a little bit different. Due to technical reasons, wind power is less scalable than PV and it finds its major application in plants of big size and it is also much more ''*site specific*''. Considering an average hour of wind blow of 2500 per year and 25TWh of production needed to meet the target, new installations should account for approximately **10GW**. To reach this objective will be necessary to install about **770 MW** per year, more than double respect to actual standard.

5.4.5 Installed capacity: A global view

With the absence of proper support scheme, it appears very unlikely to meet the target fixed with the SEN 2017 for what concern PV systems and wind power. For the former, cumulative installation should triplicate, from 20GW right now to 56 GW in 2030, and annual installations should become seven times higher. For the latter, both cumulative installations and annual addition should double. A new legislation is about to be enacted[2], and this is for sure a positive news, but still, if Italy wants to meet their ambitious target of 2030 a supportive scheme could not be enough.

5.5 Conclusions

This report set the ambitious goal to evaluate the actual status of the energy market in Europe with a strong focus on renewable energies and Italy as a reference country. Furthermore, it has also tried to evaluate whether this

[2] The draft of the new legislation that is about to be enacted and will influence the period between 2018 and 2020 provides mainly three new aspects:

1) **Competitive auctions** for plants with capacity more than 1 MW for wind and PV
2) **Support to PV** through tariffs once more
3) **Elimination of direct access and tariffs reduction** for small plants.

country will be able in the future to fulfil its duties and achieve its targets set firstly at European level with the Winter Package and later with the SEN. The conclusion, after the analysis performed, is that there still exists a **significative gap** between the actual framework and the desired one. This gap can only be filled firstly by a **strong political commitment** and secondly by the operators and the energy community. Tools to ''change gear'' are not ready, even if are well known. The new legislation is stuck between the intricate swamps of Italian government, and the market is not ready to operate without supportive tools. It is therefore essential to not lower the guard and implement corrective actions not to squander all the achievements of the past years. We should look at examples like Germany and UK and imitate them, and at the same time look at other countries, for instance Spain, and try to avoid their errors. The step required for the next years is one of the most ambitious steps for the entire Union. In times of Euroscepticism, nationalism and populism, those in favour of a united Europe might find in Renewable Energies a strategy to save more than one decisive problem.

CAPITOLO 6
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