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Empirical analysis of support schemes for wind power.

Comparison of France, Germany, Italy, Spain, Denmark and the UK's wind energy policies

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Abstract

Empirical analysis of support schemes in force for wind power

Comparison of France, Germany, Italy, Spain, Denmark and the UK's policies for wind energy deployment"

European member states are cooperating to integrate large quantities of renewable capacity in their electricity generation mix. However, renewable energy sources (RES) have different costs and operations methods depending on technologies. Supports schemes adopted for wind power deployment have not succeed to decrease wind electricity costs in all EU countries. The aim of this study is to determine the keys design parameters member states should care about in order to create successful RES policies. To this end, the research question is as follow: "How wind policies adopted by Italy, Germany, France, the UK, Denmark and Spain allow these countries to have the 6 largest European fleets of wind turbines." In this context are described the support schemes actually in force for wind power with a deepening on the design parameters playing major role on the policy's effectiveness.

The research question takes places through an analysis of the different schemes in force in their respective countries. The outcome is that in 2016, auctions became the main allocation method for RES financial support. Feed-in systems, especially feed-in premiums are the most used payment mechanism for compensating the costs of RES operators in regards to power prices. Quota uses have declined over the last 5 years in the EU; however, the UK still operates its "Renewable Obligation" scheme.

When using auctions to allocate support on wind power capacities, policy makers should especially care about the capacities they are announcing. In 2016, French and German wind auctions have been unsuccessful because announced capacities were to important compared to industry capabilities. Finally, renewable energy auctions seem to be the key to success in Spain while most countries have started the same processes. Generally, offshore auctions have been more successful when leaded on a project scale.

On this basis, it is recommendable that policy makers should care about creating schedules for updating support schemes. Often, the effectiveness of support has decreased as wind power markets were rapidly increasing. Further research on the responsibilities of regulatory authorities regarding support for wind electricity operations would give more precisions on existing and new design parameter playing a role in the effectiveness of policies.

Table of contents

Table of figures

1 Introduction

According to the "National Aeronautics and Space Administration", the planet's average surface temperature has risen by 0.9 degrees Celsius since the late 19th century. Since over 20 years, EU member states have shown their awareness regarding the increasing threats of natural catastrophes, rising sea levels and other Ice melting due to climate changes. To copy with such danger, countries have agreed on an EU scale energy policy, which would increase the uses of renewable against fossil-based energies and decrease the EU dependency on energy imports.

Long-term sustainability views combined with a constant EU dependency on conventional energy resources have resulted in the creation of a complex energy policy. Member states manage the deployment of RES-E under control of the EU. This thesis gives emphasis on the policy adopted for wind power deployment by the six EU countries having the largest wind turbines fleets: France, Germany, the UK, Spain, Italy and Denmark.

Since 2016, onshore wind power became competitive against fossil-based energy sources in Germany. However, the exploitation of the full electricity generation potential that wind power could provide to Europe requires much more than competitiveness in term of levelized costs of electricity (LCOE). While making wind and solar the main sources of electricity, energy transition stakeholders have struggled to secure the exposure that wind power generators have on the power market prices.

Moreover, countries like France or Italy, which started renewable energy sources policy among the first, are now struggling to adapt their policies to new market conditions and decreasing costs of wind power. The EU electricity market reforms that occurred in the last 10 years have led to the creation of a free access unbundled EU market offering to the power sector new challenges and opportunities. The unbundling means that generators, transmission and distribution operators as well as retailers of electricity are working separately to avoid market distortion and facilitate an EU scale competition among energy providers. Several EU countries like Germany or Denmark have in addition agreed to shift away from coal or nuclear uses. While such actions seem to show a green lantern to wind power deployment, the shares of wind power in electricity generation mixes have not been increasing equally in all countries. The offshore sector especially has been developing very unequally in the EU proving differences in the effectiveness of policies. To find out why certain policies main turn successful or not, the thesis contains an empirical analysis of the adopted support schemes for wind power deployment in the six selected countries, which aims to answer at the following:

What motivates member states to cooperate for RES development?

What power is the EU exercising on member states energy policy?

What are the tools used by EU member states to support the deployment of wind power?

What are the parameters allowing the creation of a successful energy policy?

Most of the data used in this thesis comes from “Bloomberg New Energy Finance”. The American energy dataset has been the main information source for the empirical analysis. The first section of this report justifies what motivates EU policy makers to work on the diminution of our environmental footprint. It explains the nature of climate changes and the challenges that they imply on the sustainability of our economies. The second chapter gives explanations on the way the EU energy policy is organized. It lists the challenges that the energy union has decided to take on through the last support scheme reform. An explanation of the different support schemes existing for wind power deployment is also given. The third chapter is an evolution of the second; it describes the methodology adopted for the empirical analysis. A description of policies adopted by the six selected countries for wind power takes part in that section.

Finally, the last chapter describes the methodology I have used to determine which policies are or are not successful. This part covers the key design parameters that policy makers have to focus on when designing support schemes. It states my personal point of view on the support schemes, their key design parameter and the points to watch out when making policy decisions.

2 Chapter 1

To understand the importance of the European Energy policy, this section gives an overview of how climate changes are affecting Europe in environmental, social and economic aspects.

A climate change results in a change of global climate patterns. Such changes have been mostly apparent in the beginning of the 20^{th} century largely due to the increased levels of atmospheric carbon dioxide produced using fossil fuels. Through the history, Humans have always had an impact on the behavior of the climates they were exposed to. Early Human history has never affected the climate more importantly than in a local and regional scale.

In the 18^{th} century, when the industrial revolution started, the Human kind made a shift from predominantly agrarian and rural societies in Europe and America to powered factories and massive industrial production (mainly iron and textile). The first booming in the sector of transportation, communication and banking has resulted in a remarkable increase in fossil-based energies. Fossil fuel uses cause changes in the atmosphere's composition, which thereby affect the earth's climate on a global scale. Greenhouse-Gases are the major driver of climate changes. Other aspects of human activities such agriculture, land uses and the damming of rivers and lakes also affect the climate system. The effect of human activities is estimated to be 10 times larger than any natural factor (IPCC, 2007).

2.1 Effect of global warming

Global warming consequences are mainly affecting human health, biodiversity and ecosystems which results in degradation of social and economic sectors such as agriculture, tourism and energy production. Global warming will enhance high-extreme temperatures such as extremely unexpected hot days and heat waves. The distribution and abundance of plants and animal species (firstly birds and insects) is expected to be heavily deteriorated. This phenomenon could lead to a change in the biodiversity's behavior due to a loss of control of the number of pests and invasive species, which would make our ecosystem unable to provide services and goods such as natural reservoirs, natural erosion control, and agriculture. Desertification phenomenon should to occur in southern areas of Europe causing high risks of droughts and energy security of supplies for urban areas.

2.2 Effects on water availability

The melting of the Alps Mountain glaciers (40% of Europe's fresh water) may lead to water shortages all the way across Europe affecting one of the main sources of energy in Europe: Hydroelectric Power. Changes in water availability and quality will cause direct damages on several economic sectors like agriculture, industry, energy, and transport.

2.3 Effect on sea-level rise and coastal areas

Thermal expansions of the ocean and melting ices have been accelerating the phenomenon of sea level rising in the last few years. European coasts will become more vulnerable to flooding and erosion as results of the global temperature rise. Approximately, a third of the European population living 50km close from coasts are being threatened by the sea-level rising. This represents 30% of the EU's total GDP (ISSN 1725-9177 2012). As the coasts are likely to be degraded by sea intrusions, there are increasing chances that salt water would mix with freshwater habitats affecting biodiversity and the services and goods that coastal areas provide. As a result, the habitat of many unique bird and plant species might be deleted.

2.4 Floods, droughts, landslides and other effects

As it is already happening in the Mediterranean regions and expected to expand, rising temperature combined with less precipitations will lead to intense summer droughts. Researchers Flörke, Wimmer and Cornelius have estimated the impacts of 100 year of flood events based on the climate changes forecasted by "EC Europa" for the "economy first" scenario. The results are showing that the Western Europe will be affected diminution of Gross Added Value between 2.5 and 10 billion dollars by 2050. Droughts and water shortages are going to increase the risk and severity of large fires increasing directly the risk of large areas desertification. River floods and storms are likely to increase in frequency and importance causing flashfloods and pluvial floods.

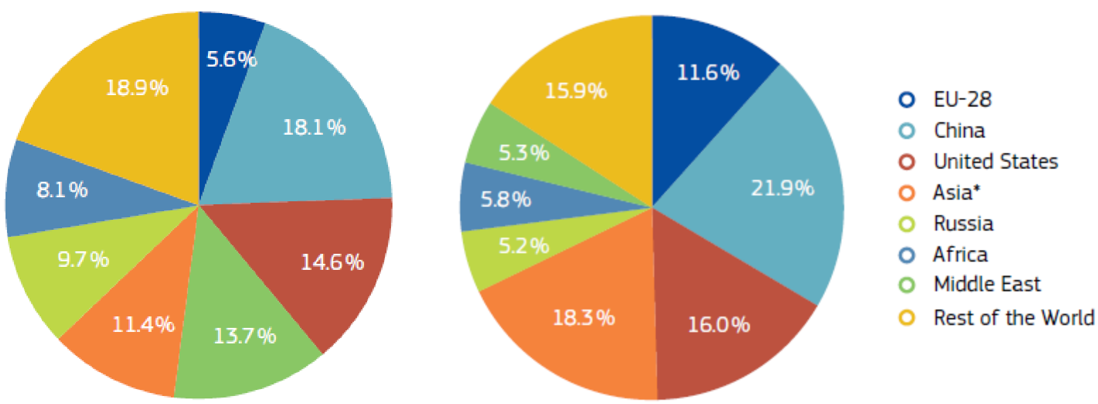
3 Chapter 2

3.1 Why having an EU scale energy policy?

3.1.1 The European Union energy situation

The European Union is the smallest producer of energy in the world, holding 5.6% of the global production (13 790 Mtoe 2015). Europe shows a negative energy balance and occupies the place of fourth biggest consumer in the world (figure below). In 2015, the global consumption of energy represented 13 647 Mtoe while 1626.2 Mtoe were consumed by the EU28 member states.

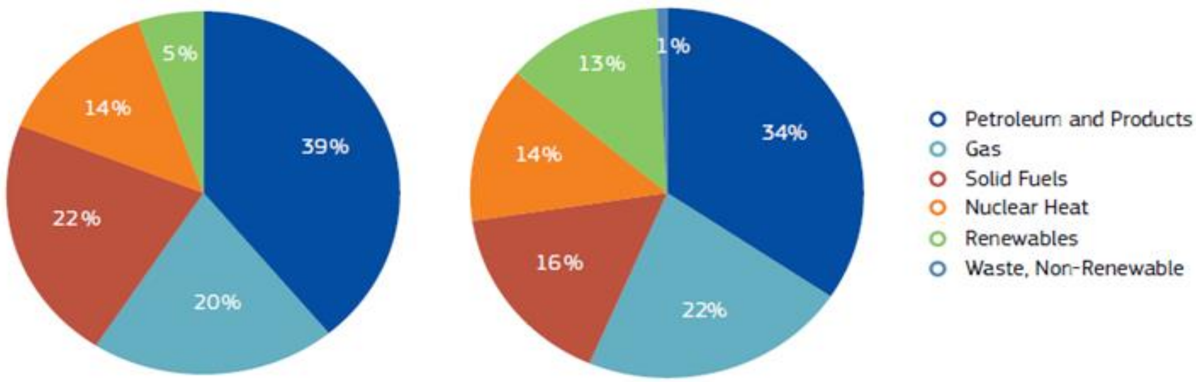
Figure 1: World Energy Production (left) and Gross Inland Consumption (right) by Region



Source: eurostat 2017

EU efforts on reducing energy consumptions and Co2 emissions have driven the total gross inland consumption of the year 2015 to a lower level than in 2005. By comparing the energy mix of the year 1995 and 2015, an increase in the share of renewable is remarkable. This increase generated a decrease in fossil uses making the 2015 EU-28 energy mix more environmentally friendly than in 1995 in term of Co2 emissions.

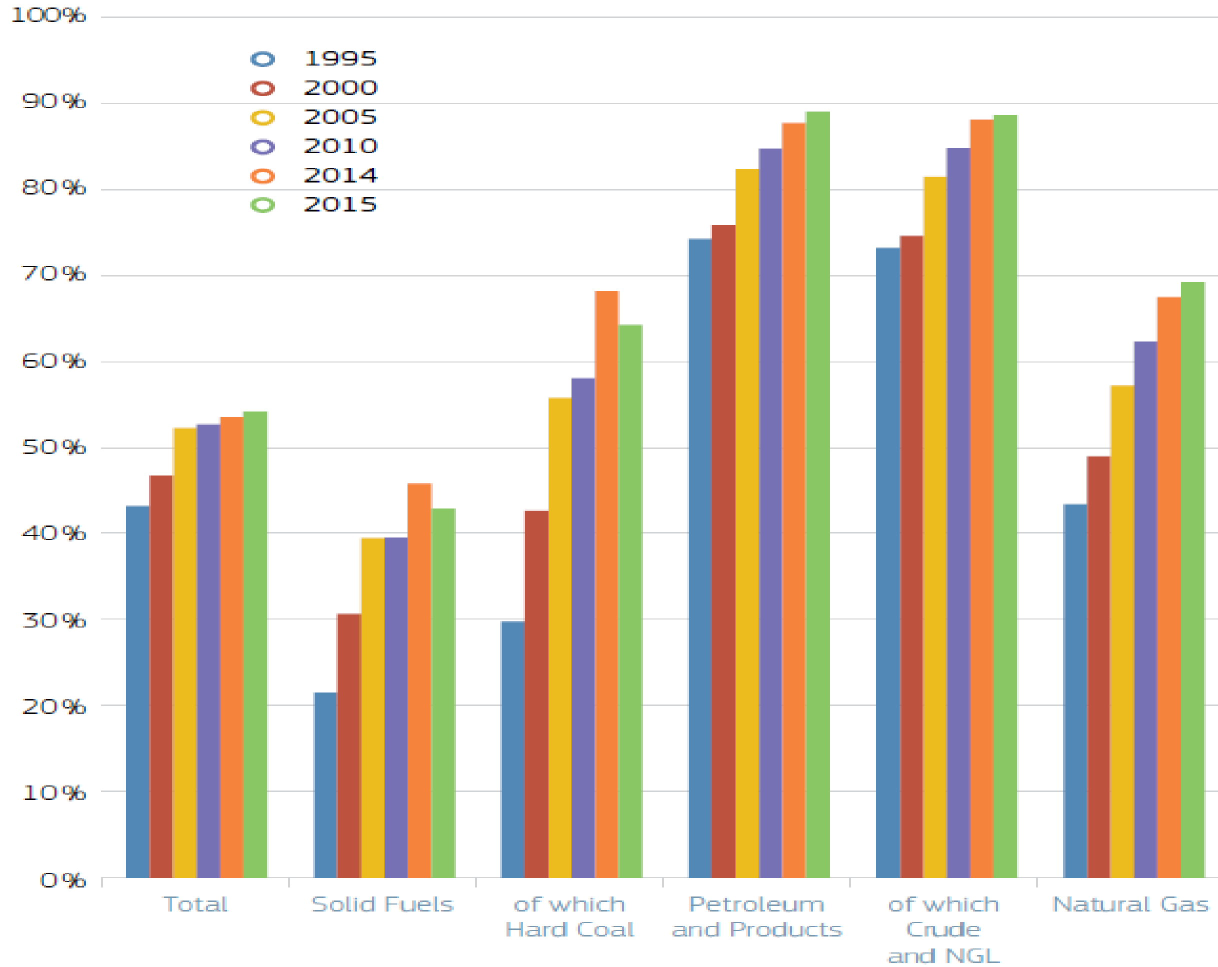
FIGURE 2: EU-28 GROSS INLAND CONSUMPTION ENERGY MIX 1995 (LEFT) 2015 (RIGHT)



Source: eurostat 2017

By increasing its share of renewable into the energy mix, the EU aims to overtake two challenges, decrease the Co2 emissions and lower the EU dependency on foreign energy imports. Since 2000, 50% of the total energy consumptions were imported from abroad. The imports are solid fuels (including hard coal, lignite and peat), petroleum products (crude oil, natural gas liquids, feed-stocks and other hydrocarbons) and gas. The figure number 3 shows that the total energy import dependency in the EU from 1995 until 2015 has meet a slow but constant increase going from 43.1% in 1995 up to 54% in 2015.

FIGURE 3: *EU-28 ENERGY IMPORT DEPENDENCY BY FUEL – (% 1995-2015)*



Source: Eurostat, May 2017

EU imports of natural gas are significantly coming from Russia (37%) and Norway (32.5%). Russia occupies the place of first EU energy provider for 2 other sources: crude oil (29.1%) and solid fuels (29%). Norway (12%) and Nigeria (8.4%) were respectively the 2015 second and third crude oil suppliers. Colombia (24%) and the USA (15.8%) were the second and third solid fuels suppliers (Eurostat, May 2017).

Because we cannot keep the economy growing without energy, the management of renewable energy sources is a strategic sector that the EU has to deal with. The diversity of the EU energy portfolio called energy "mix" is relatively important. In fact, none of Europe's countries is alike in term of energy needs, production and sources. France contains large nuclear power plants, Poland has vast coalmines, and Austria is the first hydropower producer. Finally, Denmark and the Netherlands have large gas fields. Such diversity combined with environmental and economic challenges makes energy management in the EU a very important and complex topic. Thus, the importance of a European energy policy containing strong and active pillars is a necessary requirement for achieving the followings:

- Securing Europe’s energy supplies
- Ensuring that energy prices do not make Europe less competitive
- Protecting the environment and in particular combating climate change
- Improving energy grids
- Decrease the EU energy dependency.

3.1.2 The Energy union

Cooperation has always been the heart of the European energy policy since the creation in 1952 of the European Coal and Steel Community and the European Atomic Energy Community (EURATOM). At that time, was adopted series of three market liberalization packages (adopted in 1990, 2003 and 2009) establishing an internal market for electricity and gas. The internal market was made with the ambition to reinforce energy trades inside the EU. These liberalization packages had for focus, the separation of energy production and supply from energy-transmission networks (unbundling) as well as the access for a third –party to gas storage facilities and the reinforcement of consumer protection with a strengthening of regulatory surveillance.

To answer at a rising energy demand and growing environmental challenges, the European commission has launched in February 2015 a new strategy resulting in the creation of the Energy Union for enhancing cooperation with a forward-looking strategy. Such strategy aimed to offer EU consumers, a secure, sustainable, competitive and affordable energy. To do so, five interrelated and mutually reinforcing dimensions are composing the pillars of the current energy union:

TABLE 4: *THE FIVE PILLARS OF THE EUROPEAN ENERGY UNION*

Energy security, solidarity and trust

- Diversifying Europe's sources of energy and making better, more efficient use of energy produced within the EU.

A fully-integrated internal energy market

- Using interconnectors which enable energy to flow freely across the EU - without any technical or regulatory barriers. Only then can energy providers freely compete and provide the best energy prices.

Energy efficiency contributing to moderation of demand

- Consuming less energy in order to reduce pollution and preserve domestic energy sources. This will reduce the EU's need for energy imports.

Decarbonising the economy

- Pushing for a global deal for climate change and encouraging private investment in new infrastructure and technologies.

Research, innovation and competitiveness

- Supporting breakthroughs in low-carbon technologies by coordinating research and helping to finance projects in partnership with the private sector.

Source: AC EUROPA

This plan supports the development of free flows of energy across the EU member states developed and allowed by infrastructure, technology and efficiency improvements. The Energy Union has accelerated the movement in 2013 by reforming its support system and adopting guidance for the design of renewables support schemes. Support schemes are defining the strategies adopted by member states in order to develop the use of financial instruments, which will boost the development of RES.

In October 2014, the EU adopted a new framework for climate and energy. It included policy strategies for reaching the RES-E integration targets. Based upon economic analysis, (figure next page) these target goals measure how to decrease GHG emissions to an adopted level by 2050 in a cost effective way. A road map has been designed for every EU member states (EMS) guiding them on the achievement of the respective target goals.

Figure 5: EU energy targets

2020 targets:	•Reducing greenhouse gases by at least **20%** compared to 1990 levels •**20%** of energy from renewable sources •**20%** energy efficiency improvement
2030 targets:	•**40%** reduction in greenhouse gas emissions •At least **27%** EU energy from renewables •Increase energy efficiency by **27-30%** •**15%** electricity interconnection (i.e. 15% of electricity generated in the EU can be transported to other EU countries)
2050 targets	•An **80-95%** cut in greenhouse gases compared with 1990 levels. The Energy Roadmap 2050 shows how we could do this

Source: Europa.eu

3.2 The previous RES support scheme

Until 2017, the energy market alone could not furnish the desired increase of renewable deployment since renewable energies were much more expensive those fossil-based energies. Thus, the European commission through its directives had elaborated guidance systems for member states to develop renewable energy support schemes. In 2001, the EU directive 2001/77/EC started the boom of RES deployment and was enforced by the directive 2003/54/EC. The table below resumes the objectives of both directives:

FIGURE 6: DIRECTIVES 2003/54/EC AND 2001/77/EC CHARACTERISTICS

Directive 2003/54/EC	Directive 2001/77/EC
• Ensure competition and effectiveness of the market	• Promote an increase in RES deployment
• Deal with congested capacity	• Member states should elaborate objectives in RES deployment and show transparency in the process of achieving those objectives
• Show transparency on grid usage, capacity allocation and interconnectors information	• Reduce the regulatory and non-regulatory barriers Promote especially RES-E for security and diversification of energy supply
• Make an "unbundling" of generation, transmission, distribution and wholesale sectors	• Limit costs to the consumer
• Show clearance on the costs and benefits of RES deployment	• Reduce the need of public support
• Member states shall create effective support schemes for RES deployment to insure control and transparency of support budgets	

Source: EC Europa

Both directives allowed the use of the following support schemes:

• The Feed-in tariffs (FIT) consist in fixed electricity prices paid to RES producers for each unit of energy they are producing and injecting into the grid. Guaranteed for a period, FIT payments are linked to the economic lifetime of the different RES projects. Most of the time, FITs are paid via electricity grid and system or market operators regarding their purchasing power agreements (PPA). The importance of the FIT payment is calculated upon the levelized cost of electricity (LCOE) sp that RES producers can recover from their costs.

- Renewable energy quotas are a minimum share of renewable energy production that power utilities, electricity suppliers or large electricity consumers must have in their energy mix. Defined by national, regional or local governments, these quotas are increasing over the time to support the development of RES. In some cases, such requirements are using green certificates.

- Green certificates are tradable assets proving that electricity was generated thanks to a renewable energy source. They are used as an alternative to other policy mechanisms. GC are created and traded because governmental policies require suppliers to integrate certain percentages of renewable into their energy mix.

- Investment aids are simple funds raised to the payment of RES projects. They are fixed by the regulatory authorities in a regional or national scale. Their payments take place in the form of grants, preferential loans and tax exemptions or reductions.

- Contract-for-differences are strike price based for each technology. When wholesale electricity prices are falling below the strike prices level, producers receive a compensation payment. In addition, when electricity prices overcome the strike price, generators pay money back.

- Tax exemptions are excise duties for renewable energy producer regarding the quantities of energy they produce. They are most of the time a calculated upon a percentage of the quantity produced.

Feed-in-tariffs and Green certificates were the main schemes adopted by almost all European member states until the renewable directive 2009/28/EC. This reform came to enforce the RES policy established through directives 2003/54/EC and 2001/77/EC. It installed a common framework for the promotion of energy from renewable sources. Mandatory targets of renewable integration were calculated for every member state for the shares of RES in final energy consumption and transport. The directive also promoted the following directives:

- National RES action plans, calculation of the share of energy from RES
- Provisions for the guarantees of origin of electricity
- Heating and cooling produced from RES
- Free access and operation to the grids
- Installment of criteria for bio-fuels and bio-liquids, etc.

3.3 Why new EU support scheme?

The October 2014 reform of the EU guidance aims to avoid the phenomenon that the EMS would answer at their energy mandatory targets by increasing the costs of energy for households and businesses since this could lead to a degradation of the European economy. The new member states guidance suggests that they are free to design their energy development strategies. The EU commission is in charge of approving member states' support schemes. The 2013 guidance suggested the followings:

- Financial supports for renewable energies development must not exceed what is necessary nor deteriorate the market's competitiveness.
- As technology decreases the production costs, schemes will be gradually deleted.
- Changes in the schemes are announced in advance to maintain the investor's confidence for future investments.
- Countries must show cooperation trough exchanges of energy depending on their potential to keep the costs as low as possible.
- The compensation of RES producers must shift from the actual subsided status to a competitive one.

In the EU, the global economic and financial downturn observed in the late years has led to a freezing of support for renewable sources as well as long-term uncertainties in some EMS. This always generates a notable drop in investor confidence turning their focus on other sectors. As reform is necessary to adapt at falling production costs and enhance the renewable energy integration, the EU focuses on designing a scheme attractive for investors with proper public consultations, transparency, long-term support schemes and avoiding unexpected announcements.

3.3.1 Choice and design of support instruments

Depending on the market technology, scale, timeframe and location, the EU uses different support methods. The commission keeps calling for more market exposure from the EU energy market so that the competition could drive the energy production and investment decisions more efficiently and cost effectively. Lately, the commission has asked for more support for the early stage of development technologies to enter the market. The new support elements used by EMS are the followings:

- The feed-in premiums (FIP) are support schemes where the selling of RES electricity takes place with a price based upon the electricity spot market. FIP producer receive a payment called premium regarding the market price of their electricity production.

- Tenders and auctions are bidding processes based on competitiveness and the market having aiming to help identifying the most appropriate projects to be built and allocate accurate payment methods to these projects. Typically, certain amounts of power (MW) or energy (MWh) are proposed for bidding. Bidders enter then in competition for producing the proposed volumes based on their support levels. The lowest support levels are winning the auctions and offered support payments for their projects on a given period. The main difference between tendering and auction activities is that in auctions, the price is the only evaluated criteria. However, tenders may include other criteria (project lifetime, environmental footprint, ecosystem degradation, employment generation…) Tenders and auctions have the advantage of increasing competition and driving indirectly RES costs down. They also permit a better allocation of RES support.

3.3.2 Keeping costs low

To facilitate the low-cost movement, the competitive allocation mechanisms aims to force market operators to reveal their real production costs so that schemes payments can be adjusted on time. The cost allocation mechanism states that market operators must calculate and provide their revenues in advance for member-states to adjust their support level to the differences between the agreed and expected revenues. To avoid market operators from making extra profit out of the EU subsidies, regulatory authorities verify and approve the company's production costs and define levels of excessive growth in budgetary terms. According to the "renewable power generation costs in 2017" report made by the International Renewable Energy Agency (IRENA), the key drivers to cost reductions are the following:

- Economy of scale in manufacturing activities
- Manufacturing process improvements optimizing capital uses
- Capacity factor enhancement thanks to technological improvements
- Minimized risk in project development
- O&M reduction thanks to the use of real-time data (improved predictive maintenance).
- Lower barriers to market access
- Falling cost of capital

4 Chapter 3

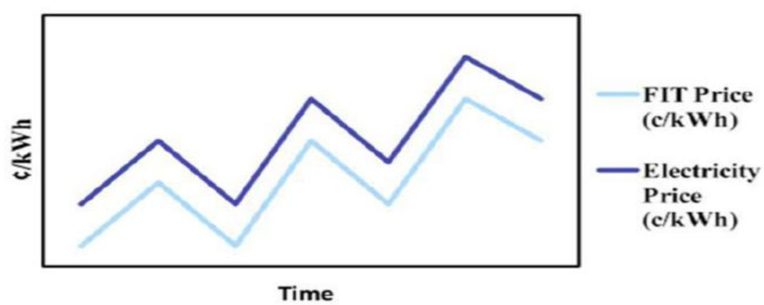
In this section are compared the three main support schemes having been used by member states in the history, the auctions, the feed-in-tariffs and the feed-in-premiums.

4.1 Comparison of the main schemes

In this section are described the organization of three main support schemes having been used by member states in the history, the auctions, the feed-in-tariffs and the feed-in-premiums. In the EU, two different mechanisms allow the FIT payment calculation. The first one consists in adjusting the support level based on the levelized cost of electricity.

The second one refers to adjusting the support level upon the results of an auction or bidding. This method became popular after the last support schemes reform. Feed-in-tariffs have the advantage of offering a safe and stable market to investors. They only cost money to member states if the projects operate. They enhance market access for all investors and participants since they distribute equally development benefits across all geographic areas. There are two different kind of FIT payment structures; the first one provides RES producers a payment, which is a percentage of the retail price of electricity (figure below).

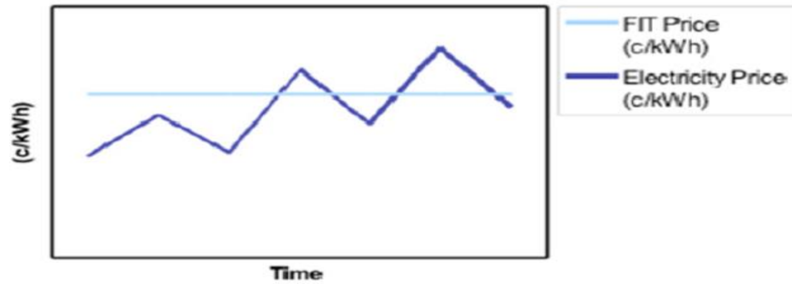
FIGURE 7: *PERCENTAGE OF RETAIL-PRICE FIT MODEL*



Source: NREL

The main used payment method is however independent of the electricity retail prices. It consists in a fixed price approach payment where support level offers a pre-determined payment for a period of time (figure below).

Figure 8: *Fixed-price FIT model*



Source: NREL

In general, fixed-price FITs are preferred because they have demonstrated more cost-efficiency with lower risks of overcompensation and market distortion.

The Feed-in-premiums

The premium price option differs from FIT because it offers a payment (called premium) on top of the spot price of electricity. This allows a better approximation of RE generation costs and permits to consider the environmental and societal benefits of renewable sources. This model is market dependent; it rewards RES producers if market prices are low and penalizes them when they drop down (figure below).

FIGURE 9: *SLIDING FIP MODEL*

Source: Journal of Physics Conference Series

Premium prices may have two different formats, "sliding or constant". The constant premium model remains unresponsive to market price changes over the time, it compensate producers even when market prices are increasing (often-called "fixed premium" model). The sliding premium varies in line with market prices with limits. The "caps" sets limits under which market prices cannot fall, while the "floor" sets the limits over which market prices are not allowed to jump.

Constant premium prices are interesting in a way that they motivate to generate RES electricity especially when demand and market prices are high. However, this model shows some financial risks for RES producers if high market prices are suddenly dropping down. It can cause high upfront capital projects to struggle covering production costs because of insufficient revenues if "caps" and "floor" are not correctly adjusted. These are predetermined maximum and minimum limits that support levels can't exceed.

The table below summarizes the "pros" and "cons" of constant FIT and sliding premiums, which projects developers and policy makers are checking before taking incentives:

FIGURE 10: *EVALUATION OF FIXED-PRICE FIT VS. SLIDING FIP POLICIES*

Fixed-Price FIT Policy characteristics	**Sliding FIP Policy characteristics**
Advantages	
1: Higher degree of cost efficiency (this leads to lower per-kWh payments for renewable energy) 2: Give better view of project costs 3: Reduce market risks 4: Hedge against electricity prices volatility *5:* Support immature technologies	1: More "market-oriented" 2: Allow more efficient grid management 3: More compatibility to disoriented markets (allow both renewable and conventional to be sold on the spot market) 4: Encourage competition between new generation of conventional and renewable sources
Disadvantages	
1: Unresponsive to market prices 2: Distort electricity market (Can motivate producer to increase/decrease their production regarding market prices) 3: Higher long-term cost to society 4: Doesn't optimize project creation in high demand locations (only in high financial efficiency locations*)*	*1:* Higher average payments per kWh 2: Gives seasonal RES productions the same power in the market as non-seasonal RES

Source: NREL

4.2 The Auctions

Between 2005 and 2015, the number of countries using RES auctions has been rising from 6 to 60 in the world. Auctions have particularly proven their effectiveness at deploying large quantities of RES generation capacities in a cost-effective way after the last EU support scheme reform. They have the ability to gather different RES technologies and market sizes in competition together. They permit to discover the real prices of energy projects and give certainty about capacities and allocated quantities. However, auctions may show disadvantages as well. For small-scale producers, administrative procedures required to participate in an auction sometimes represents significant costs and influences their ability to take part. Competition during auction rounds can also generate aggressive biddings that market players are not ready to follow. As a result, there are sometimes delays in project constructions.

There are two rules allowing an auction round to be successful. At first, allocations must enforce competition among market players to drive down the costs. Secondly, market player must get access to the bid only if they can realize their projects with respect to the agreed timeframe and prices agreements.

Auctions are price-based. It means that the only criteria determining if the bid is awarded or not is its support level. Tenders differ from auctions since they include other selection criteria. The outcome of an auction represents the level of support that producers will receive. Most of the time, this level of support corresponds to the reference value for the FIT or FIP.

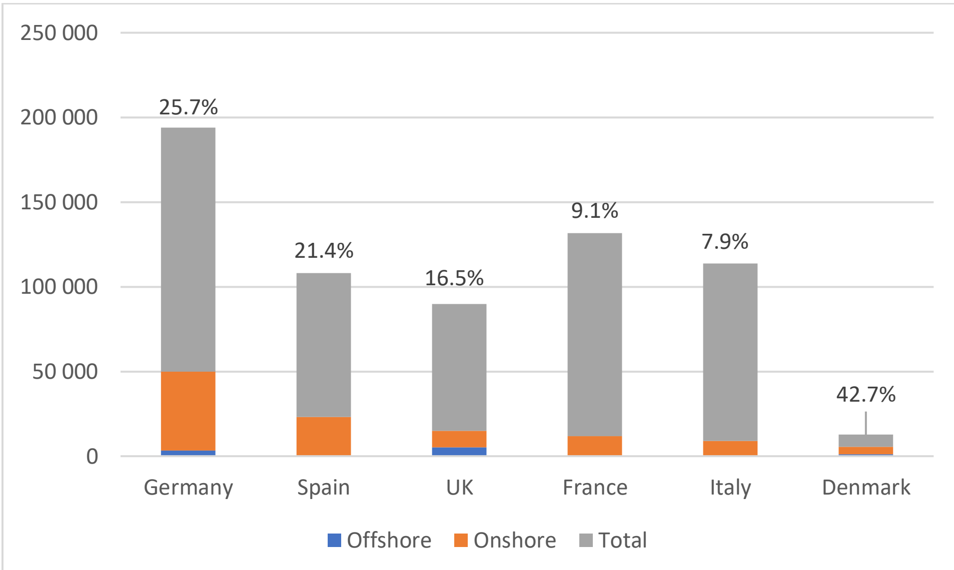
In the EU, auctions take place in two different natures; Spain for example uses technology neutral auctions, meaning that auctions are available to all kind of RES. Some countries have separated their auctions schedules per RES technologies (technology specific auctions).

- Technology specific auctions have the advantage of being very simple since they generate a strict division of electricity sources. However, they enhance competition only inside a single technology market.
- Technology neutral auctions are more complicate in their design since they require rules to compare different technology competing for the same bid. However, they put all RES in competition together and allow massive deployments of the most cost-effective RES.

5 Analysis of the new implemented support schemes by selected countries

The following section gives emphasis on the energy situation and support schemes adopted for wind power development of a group of selected countries. The selected countries are the top six biggest wind power capacities existing in the EU. The graph below describes the wind power deployment of the selected countries in comparison to their total generation capacities.

FIGURE 11: *TOP 6 EU WIND POWER CAPACITY (MW) AND SHARE IN TOTAL GENERATION CAPACITY (%)*



Source: BNEF

5.1 Data limitation

The analysis of support schemes adopted for wind power deployment by countries takes the following shape, in a first time, an overview of the country's energy mix and energy situation is given. This overview contains the 2016 capacity mix of the concerned country, its investments in the wind power sector between 2012 and the first quarter of 2017 and the country's distance toward its 2020 target for electricity generation (RES-E). To continue, a comparison of the levelized cost of electricity (LCOE) between the wind power sector and the LCOE available of technologies competing with wind in term of shares in the capacity mix (renewable and fossil-based electricity sources) for the period 2013-2018 is given. The last part of the country description contains a graph summarizing the different support schemes adopted for wind power development from 2000 until today.

5.2 UK

In the United Kingdom, Gas is the main resource for electricity generation. Coal is the second most important resource. However, Wind and Solar PV together account for 29% of the UK capacity. The main barrier observed to wind power deployment in the UK is the freezing of the support schemes that is to happen on March 31.2019.

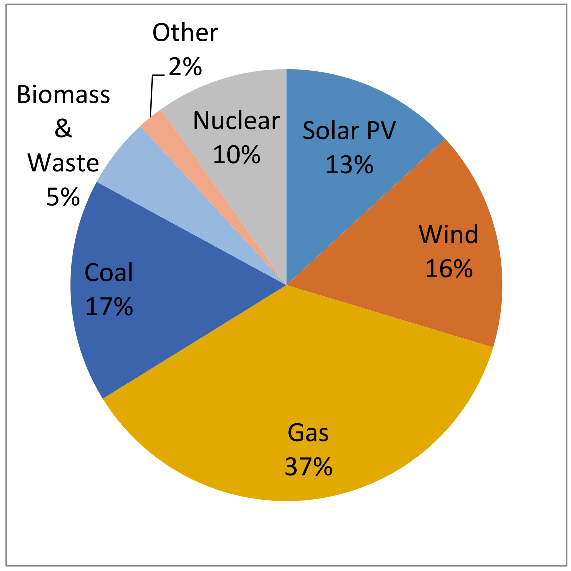


FIGURE 12: UK 2016 CAPACITY MIX

The UK government has transformed its energy policy landscape after its supporters called for less overspend on consumer-funded incentives. As a result, the renewable development program (Renewable Obligation certificate) and the feed in tariff incentive were blocked between 2016 and 2017, stopping existing support for wind and solar power and all other technologies with support projects under development. The only support instrument left available for RES development in the UK is the contract for difference auction scheme. However, this system only operates for large offshore wind projects. Despite its exit from the EU, the UK has reached the agreed 31% integration of RES electricity generation in its capacity mix.

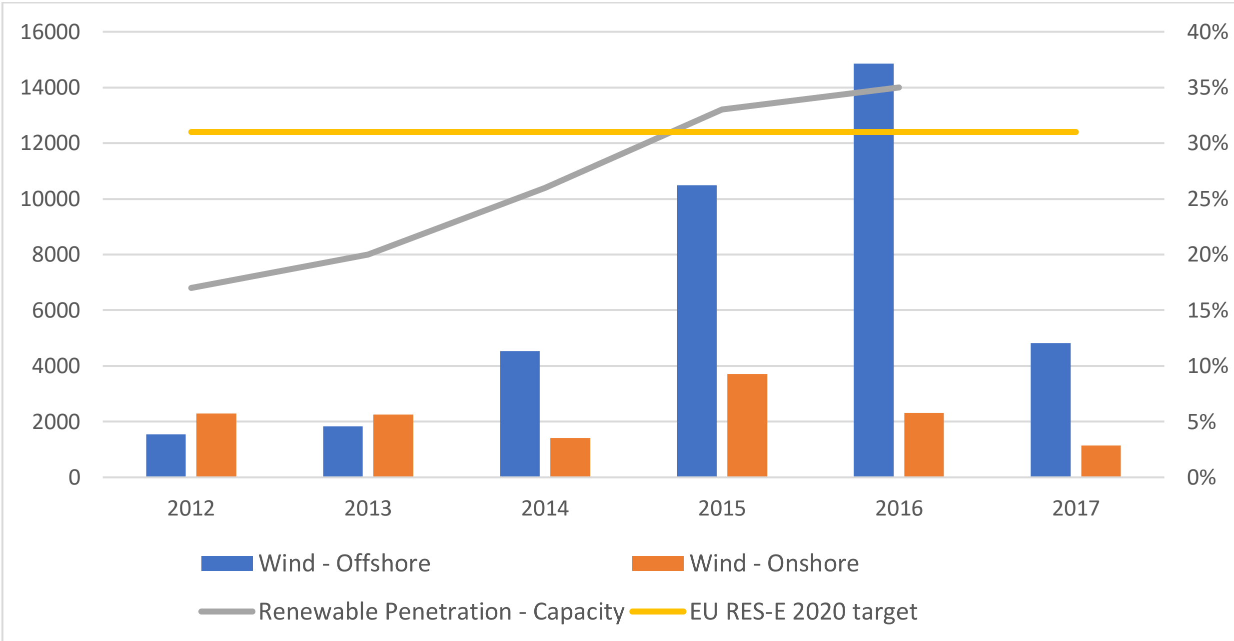


FIGURE 13: UK WIND POWER SECTOR INVESTMENTS ($M) AND COUNTRY DISTANCE TO RES-E 2020 TARGET (%)

In 2017, global investment in RES felt to its lower level for a decade totaling 10.3b$. As especially, offshore wind investment has dropped from over 14 billion dollars in 2016 to less than 6 billion dollars in 2017. BNEF 2050 forecast have estimated than by mid-century, half of UK's power generation should be provided by wind farms and a third by solar power. Focusing mainly on offshore wind, the UK owes a part of the most important potential sources in the world. Even if investments are at decline, the installation of minimum 10GW of offshore electricity production is to be secured by 2020.

Even if the Brexit of the UK leaves uncertainties regarding the energy policy landscape, the country is not famous for making retroactive changes in its support schemes (BNEF country assessment 2017). Thus, the UK is expected to respect is long-term commitments regarding RES policy.

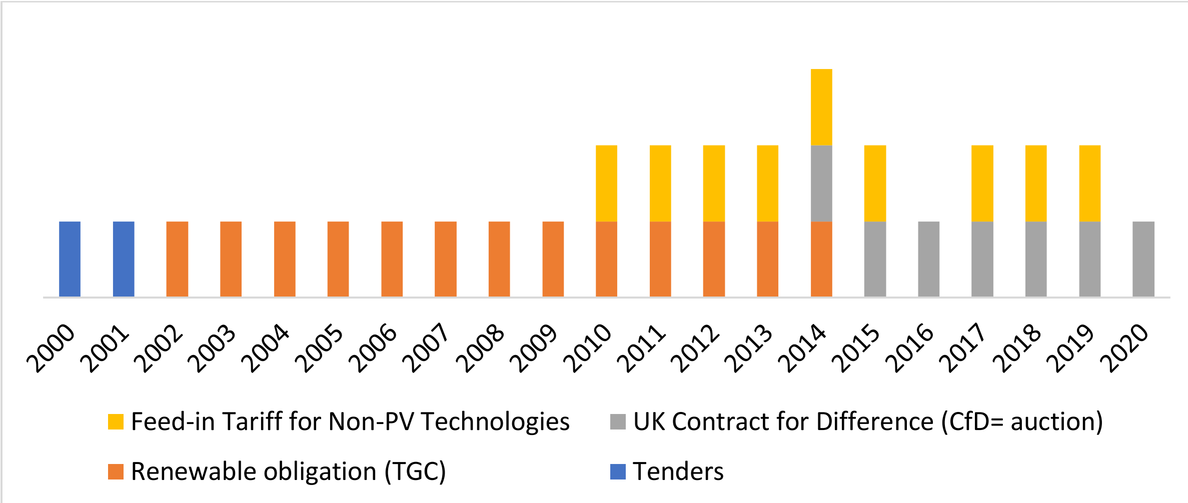


FIGURE 14: UK WIND POWER SUPPORT SCHEMES EVOLUTION

Slowly replacing the renewables obligation system where concerned parties had to integrate specified amount of RES production in their portfolios under threats of penalties, the contract for difference (CfD) operation period have been extended to March 31, 2026. The government has planned the CfD schemes in 3 pots, the first one gathering mature technologies (onshore wind, solar PV) and the second one gathering all other immature technologies (offshore wind, advanced conversion technologies, energy from waste with combined heat and power). LCOE values are available for the two main operating renewable sources in the UK. While the wind offshore technology seems to be in a slow stagnation compared to the Netherlands or Denmark. Wind onshore as it is the general trend is most northern European countries, is the cheapest renewable technology in the UK.

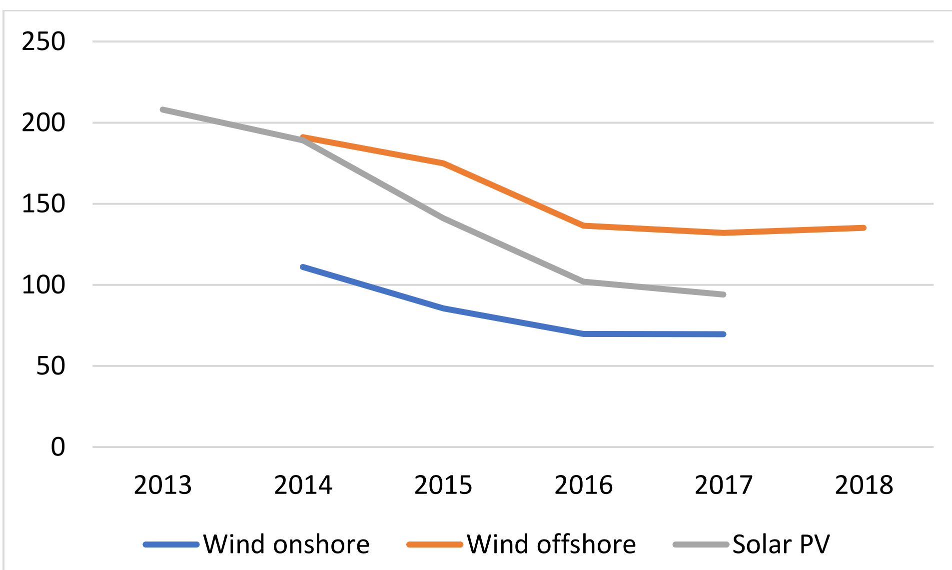


FIGURE 15: UK LCOE EVOLUTION ($/MWH)

5.3 Spain

Gas accounts for 31% of the Spanish electricity mix. With respectively 22% and 21% of the shares, hydropower and wind are the second and third most important electricity generation capacities. RES are thus occupying the biggest part of the capacity mix.

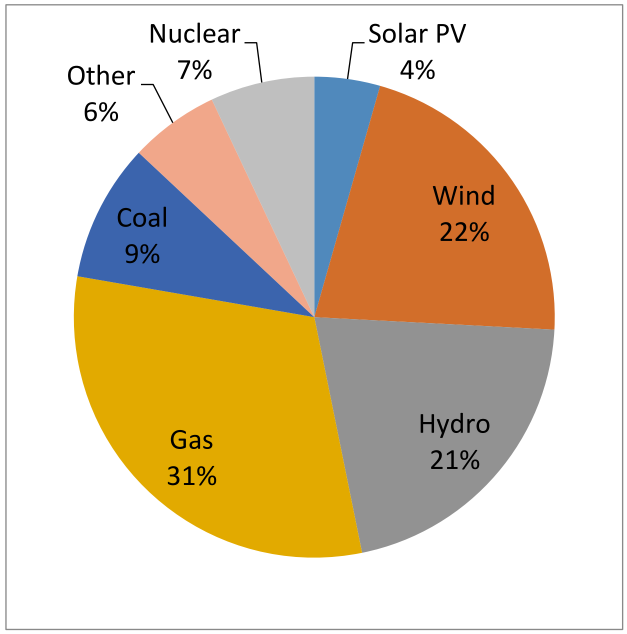


FIGURE 16: SPANISH 2016 CAPACITY MIX

Currently at 36.6% of RES integration, Spain needs to grow by 0.85 per year to reach its 2020 target. However, according to BNEF analysis, it is very unlikely to happen since investments have been decreased by more than 15 times compared to 2007. Spain voluntarily decreased its RES development in general because of an overcapacity and a deficit in support for RES-E accounts. The installed return on investment (ROI) supposed to secure a reasonable profitability seemed to be the core barrier for reaching 2020 targets. Spanish RES sector, which accounted over $46 billion of investment between 2007 and 2008, has decreased to only $100 million in 2015 because of the economic recession and the retroactive subsidy cuts for RES-E. Beside the ROI, Spain supports RES-E via auctions. The auction system proposes participants the option to bid a percent reduction off Spain's regulated investment return policy. The policy provides a minimum return level of around 7.5% for a 10 years period. In 2017, over 4GW of onshore wind capacity and 3.9GW of solar capacity were awarded with highly subscribed auction rounds. A series of damaging retroactive policy changes has weakened the attraction for investors making Spain the highest risk market with Portugal and Italy. The Spanish generating capacity is expected to keep growing steadily until 2030 (BNEF forecast), showing opportunities for investors. Currently, Spanish wind and solar technologies are competing head to head. Bloomberg New Energy Finance expects the Spanish auction market to be risky but highly competitive over the next 5 year.

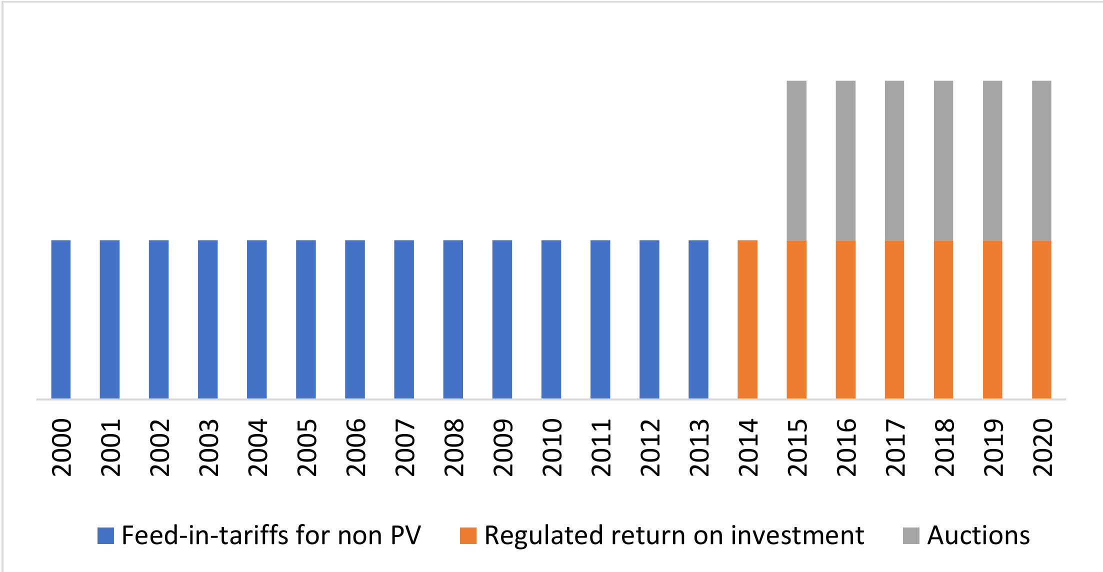


FIGURE 17: SPANISH WIND POWER SUPPORT SCHEMES EVOLUTION

In 2012, investments in wind power accounted for almost 700 million dollars. However, in 2013 and 2014, investments were completely stopped. They only started to be relevant again in 2016 with 191 million dollars. 2017 has been a motivating year since investments were raised up to 793 million dollars.

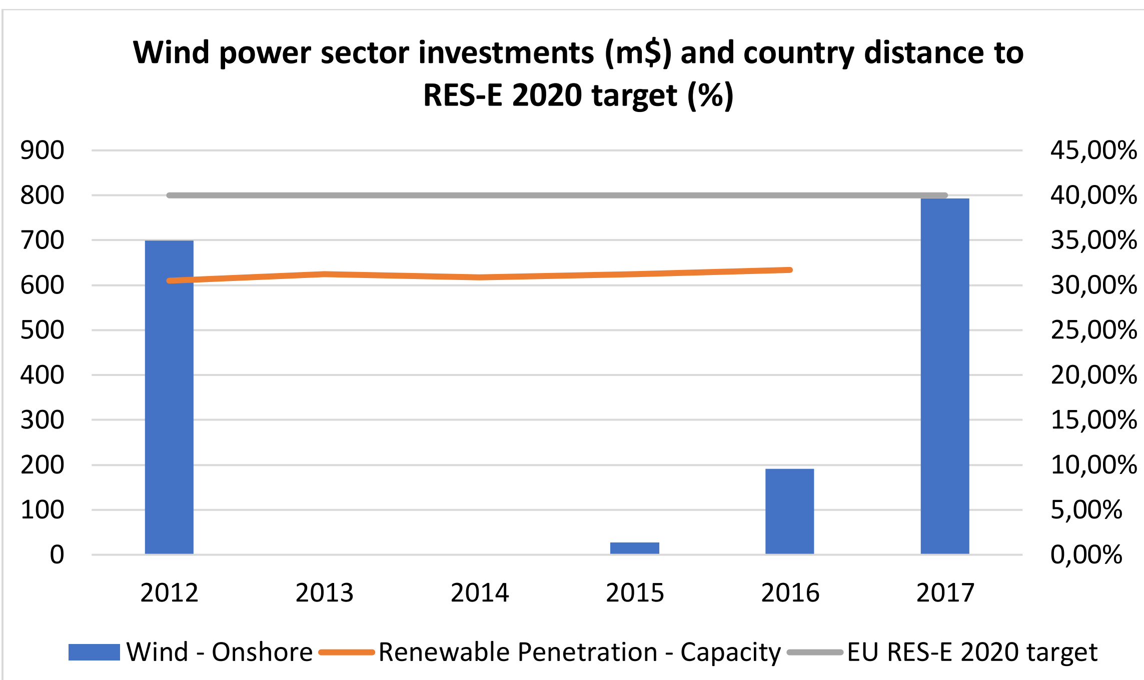


FIGURE 18: SPAIN WIND POWER SECTOR INVESTMENTS (M$) AND COUNTRY DISTANCE TO RES-E 2020 TARGET (%)

Regarding the levelized costs of electricity, data is only available for wind onshore and Solar PV. The wind onshore technology in Spain is the cheapest of the group: 59$/MWh in 2018. In 2015, the LCOE of solar PV was of 148$/MWh, compared to 88.5$/MWh in Germany and 86$/MWh in Italy in the same year, this can be qualified as an expensive technology. Even if Spain has one of the biggest potentials for Solar PV in Europe, the wind technology remains far more available.

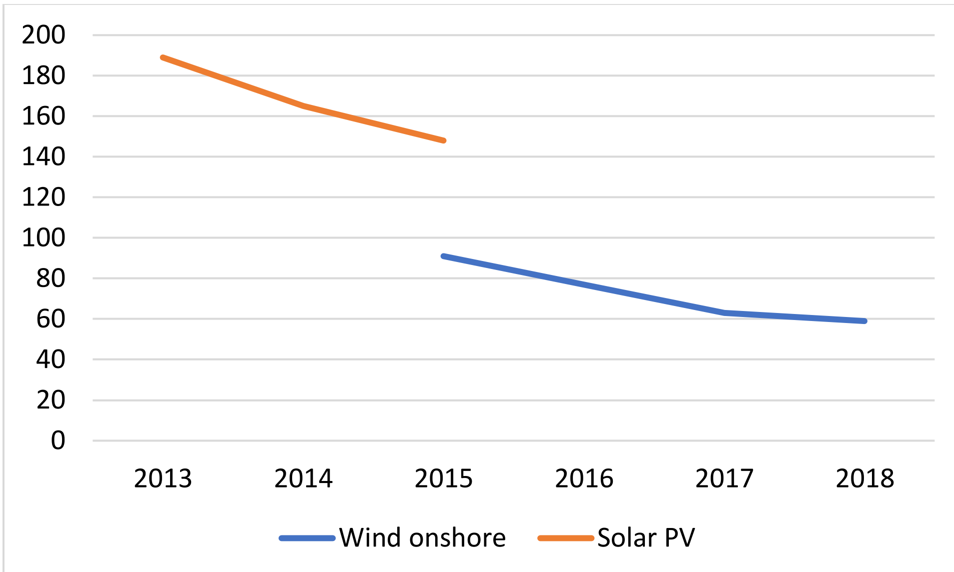


FIGURE 19: SPAIN LCOE EVOLUTION ($/MWH)

5.4 France

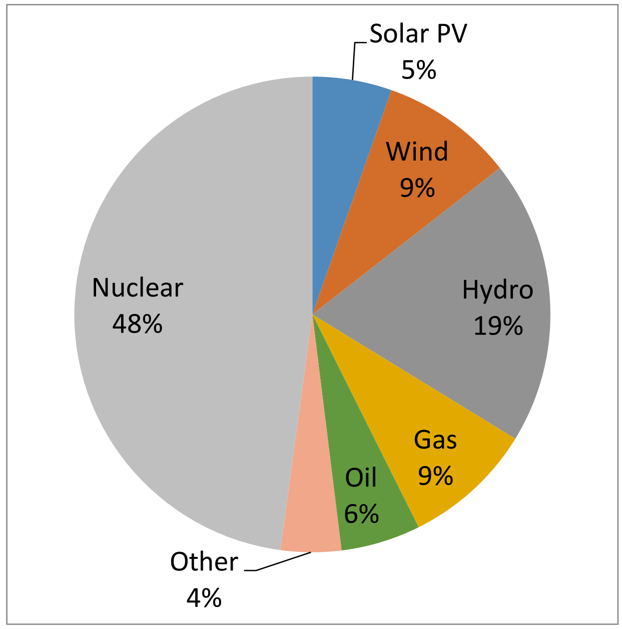


FIGURE 20: FRENCH 2016 CAPACITY MIX

France's nuclear power plant fleet is the most important in the EU and accounts for more than 48% of the country's capacity mix. While wind and solar power accounted together for around 14% of the capacity mix shares in 2016, hydropower was the biggest operating renewable in the capacity mix with 19% of the remaining shares.

France has committed a very audacious set of targets for 2020 and 2030 including 32 % of RES integration by 2030 and a cut by 50% of the nuclear generation by 2035. In line with the Netherlands, the French support schemes strategy adopted gathers tax incentives, net metering, feed-in tariffs, premiums and tenders/auctions. Two core barriers to RES deployment were identified. France's nuclear power, which allowed the country to have the cheaper electricity and be the biggest exporter since the turn of the century became a constraint since the decrease in nuclear electricity generation compels the country to adapt its electricity network. Another noticeable constraint in the French electricity market landscape is the dominance of the former monopolistic company EDF. The retail market liberalization in 2010 and the increased competition in the generation segment has succeed to decrease the state-owned company's market share to 70% in the generation and retail of electricity but its subsidiary "Réseau de Transport d'Électricité" still holds the monopoly over transmission.

With a very positive political landscape for sustainable development, France needs to increase its renewable investments hovering $5-7 billion since 2006 to reach its targets. Investments in the wind power sector have remained relatively stable since 2012 and did not fall under 1000 million dollars. 2017 has been a record year with over 2500 million dollars invested in the onshore sector. The offshore wind sector doesn't benefit from the same motivation. A few projects along the Atlantic coast have been cancelled for rural opposition keeping the investments to zero until today. In 2017, France installed a record amount of 1.7 GW of new onshore wind capacity and is expected to beat its PV historical installation record in 2018. Absorbed by efficiency improvements, the non-growing electricity demand is not supposed to affect the capacity mix development. Supporting energy transition, French president Emmanuel Macron has made official the government's ambitions to preserve a stable environment policy and increase renewable challenges during his 2017-21 tenure.

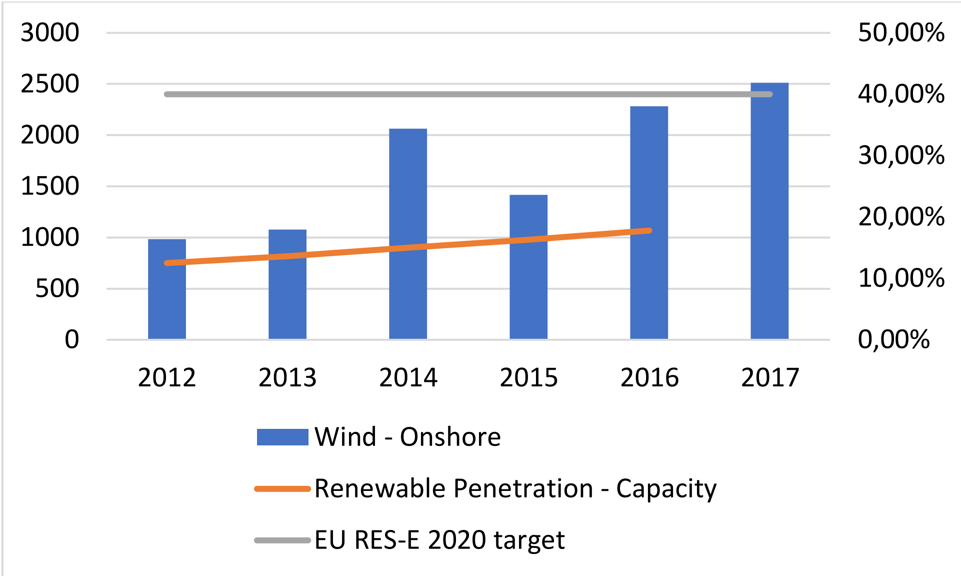


FIGURE 21: FRANCE WIND POWER SECTOR INVESTMENTS ($M) AND COUNTRY DISTANCE TO RES-E 2020 TARGET (%)

The LCOE of wind onshore in France considered as relatively high compared to 59$/MWh in Spain is off 72$/MWh. However, by comparing it to the LCOE of nuclear power, it is simple to assume that the wind power sector is to play a major role in the capacity mix of the 20 coming years.

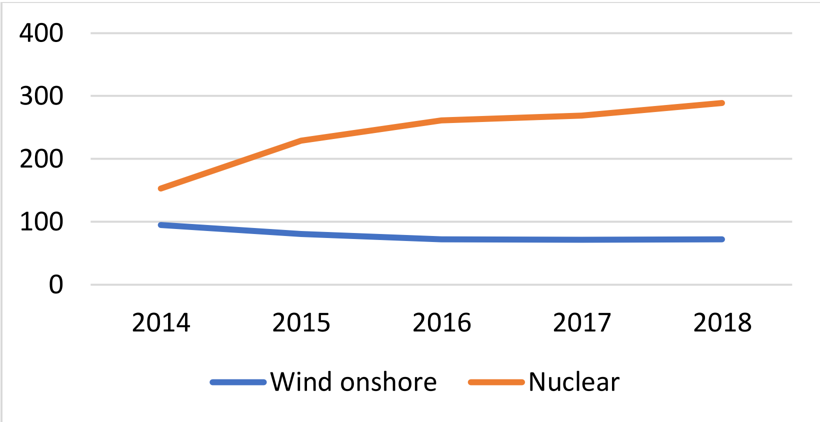


FIGURE 22: FRENCH LCOE EVOLUTION ($/MWH)

The volumes of paper work required for their implementation often curb French renewable energy projects. Moreover, local resistance movements have also increased the project development time. Project development times in France are among the longest for any similar markets.

French support for wind power deployment is organized via offshore tenders, tenders for all RES, onshore auctions and feed-in-tariffs. Except in 2003 and 2004 where the introduction of tenders was a failure, French renewable policy has always remained stable.

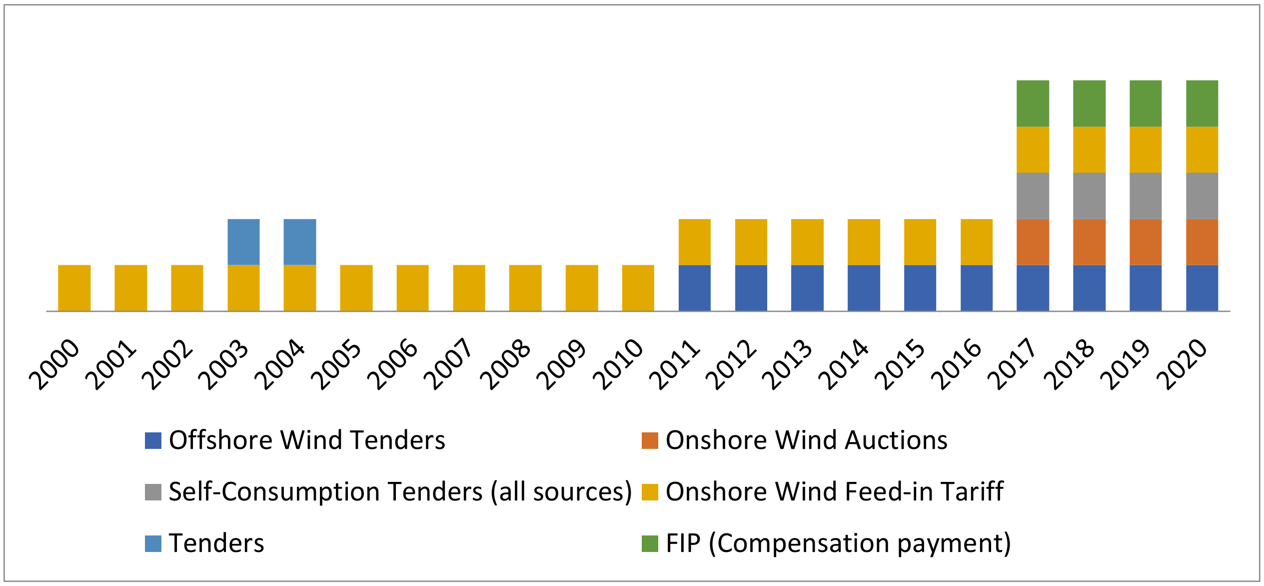


FIGURE 23: WIND POWER SUPPORT SCHEME EVOLUTION

Having started in December 2017, the onshore wind tenders are organized in six rounds with an allocation of 500MW in each until mid-2020. Successful bids are awarded the right to start the realization of projects where the bid prices are representative to the amount of FIP; producers are going to be paid. The first French offshore wind tender was created for 3GW in 2011, around 2000MW were contracted.

5.5 Italy

Similarly, to Spain, Gas is the main source of electricity in Italy. Solar PV combined with wind and hydropower account for 41% of the Italian power capacity. By targeting 27% of RES-E shares in the global energy mix, Italy foresees a coal generation ban after 2025. After several year of RES public support freezing, several incentives were implemented by the Italian government since 2015, offering four kinds of support scheme instruments to RES deployment. Even if the landscape seems better now, several political barriers are still causing problems. Those mainly concern the solar PV sector. However, green certificates for wind were phased out between 2012 and 2014 without replacement by another support scheme. Reopened in November 2014, subsidies were restructured down. This decree was created to diminish the government expenditure on RES at a level of EUR 5.4b/years. The core technical barrier impacting Italian RES deployment remains the abilities of the transmission sector to manage flux variations into the grid. Because the Italian RES-E integration was 34% in 2016, with a 2020 target of 33.5%, the challenge of reaching 27% of renewable energy share for all sectors in 2020 does not involve the RES-E sector anymore. Regarding investments in the wind power sector, 2012 was a record year with over 1000 million dollars collected.

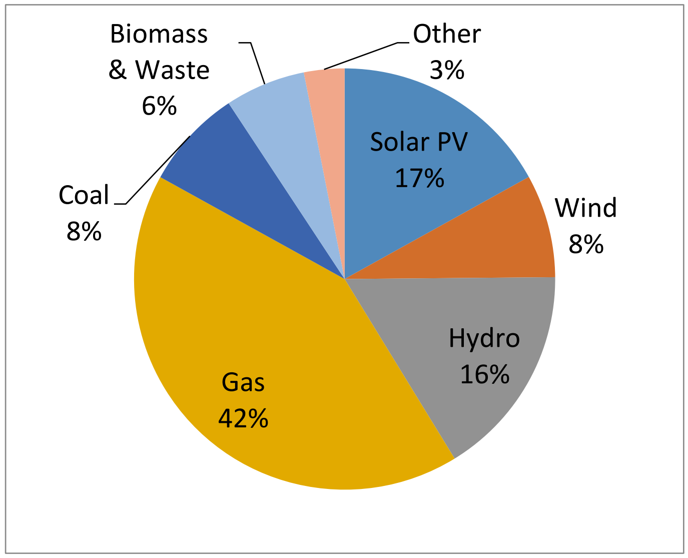


FIGURE 24: ITALIAN 2016 CAPACITY MIX (MW)

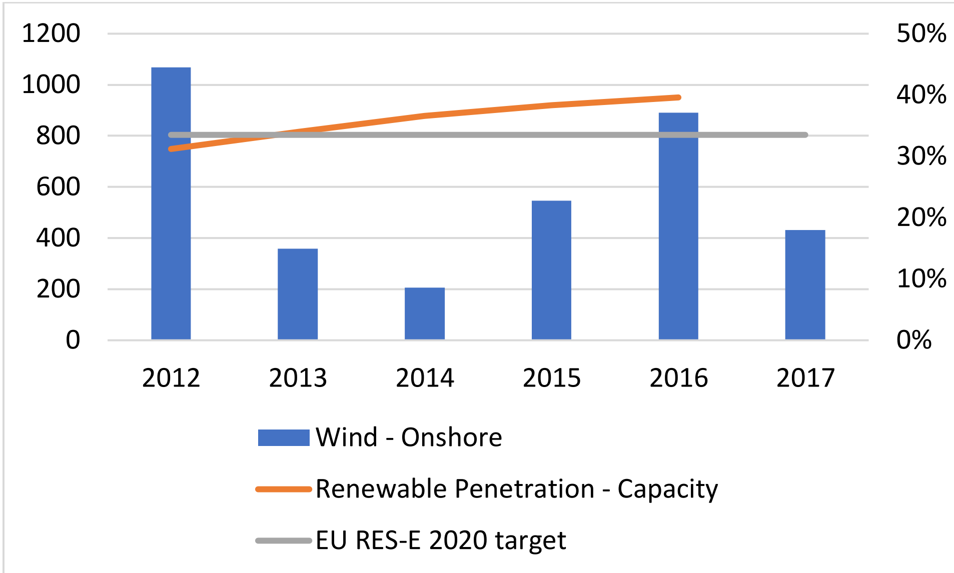


FIGURE 25: ITALY WIND POWER SECTOR INVESTMENTS ($M) AND COUNTRY DISTANCE TO RES-E 2020 TARGET (%)

In Italy, since 2016, the wind and the solar PV sector are competing head to head. In 2017, the LCOE of wind power was off 62.5$/MWh. The onshore wind sector meets problems concerning the repowering of old production sites since they are considered the same way as new projects and are imposed the same bureaucracy. Being the cheapest sources of new renewable source, wind and solar PV are the upcoming dominant technologies in Italy. However, the hydropower sector shows an interesting deployment with low operating costs totalizing 16% of the RES-E shares. As a net importer, Italy shows higher wholesale electricity prices than the neighboring EU countries and faces new constraints regarding the adaptation of its grid to imported French nuclear energy and local-seasonal RES productions.

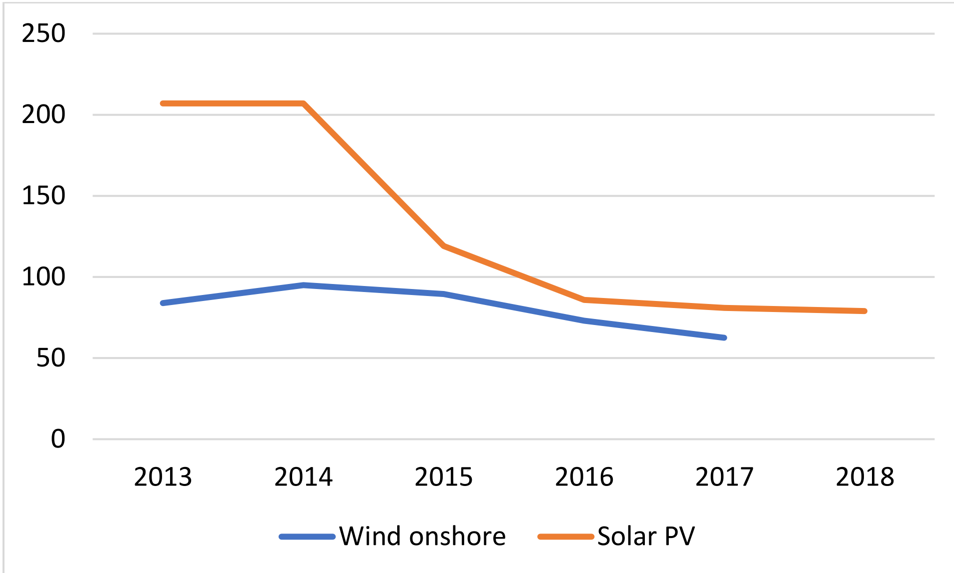


FIGURE 26: ITALIAN LCOE EVOLUTION ($/MWH)

In 2015, the Italian government made a shift from using tradable green certificates to support RES-E to the use of feed-in premiums for all non-PV projects having a capacity smaller than 5MW. In 2013 and 2014, nearly 2000MW of onshore wind were auctioned as well as 30MW of wind offshore. No auctions were observed in the wind power sector since then. However, the auction market is expected to close its first renewable energy auction rounds in 2019.

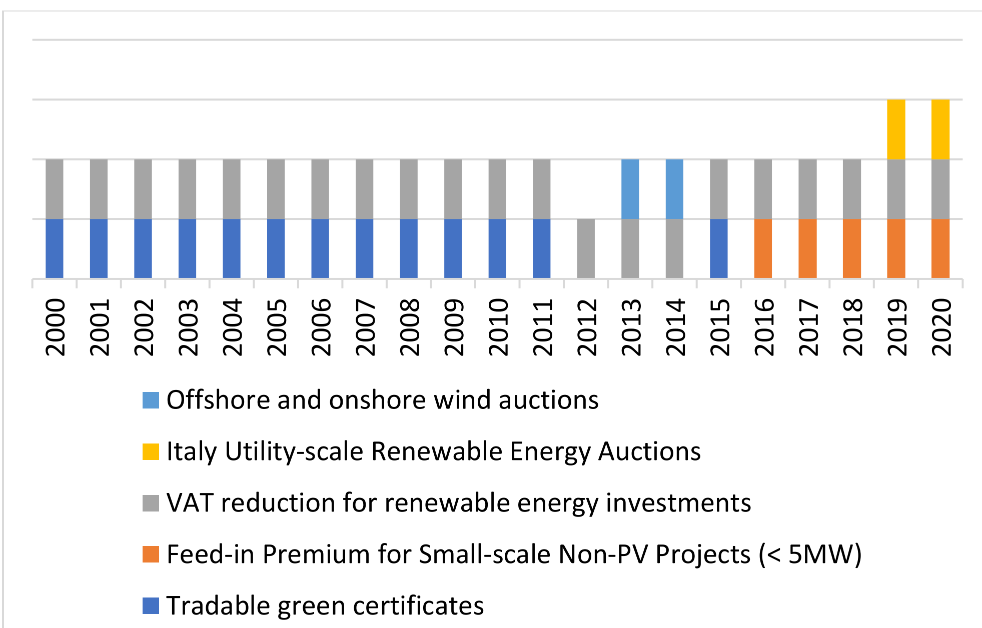


FIGURE 27: ITALY WIND POWER SUPPORT SCHEMES EVOLUTION

Even if the Oil-based electricity generation has gone from 20GW in 2008 to 3GW today, fossil-fuel generation still accounts for 64% of the Italian power-mix because most was replaced by Gas plants. Power prices are not sufficient to allow a sustainable maintenance of the existing capacity, especially in regions having severe grid adaptation constraints. To fix this difficulty, Italy has created a new capacity mechanism, which was approved in 2018 by the European Commission. Regarding the wholesale market, the main stakeholder remains former monopolistic company “ENEL” holding 24% of the share. The rest of the market is relatively fragmented and open to competition enhancements. Driven by a steadily decreasing GDP, the power demand has been declining since 2011. However, economic recovery should allow a 16% jump until 2040 (BNEF analysis). ENEL, motivated by the new policies supposed to reduce financing barriers (New Energy Strategy) has announced its ambition to automate 90% of its generation fleet by 2020 with 60% enabled thanks to internet of things connectivity. This might play a big role on operation and maintenance costs and in power prices competitiveness.

Less severe compared to Spain, retroactive changes in RES support have still had relevant impacts on investor’s motivations. Yet, the new policy landscape combined to an economic recovery appears to be positive for the future.

5.6 Germany

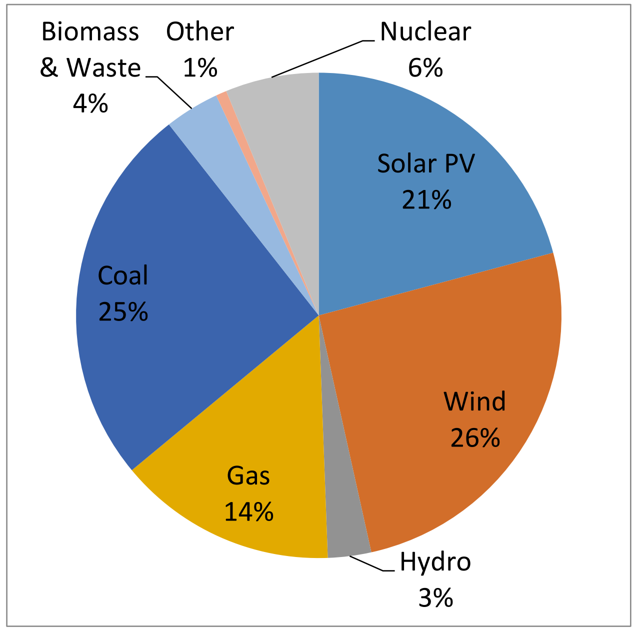


FIGURE 28: GERMAN 2016 CAPACITY MIX

Historically, Germany has always been the leader of the energy transition. Aiming to achieve 18% of renewable energy consumption by 2020, the German government spends over $24 billion in RES subsidies per year to reach this target. Subsidies are given mainly via auction for feed-in premium and feed-in tariffs. Because of its high urbanization, Germany faces constraints regarding finding available spaces to exploit its wind potential. Since 2017, Wind and Solar PV together became the main source of electricity generation. In 2016, wind power accounted for 25% of the electricity generation capacity while coal accounted for 26%. The government has announced its ambitious plan to decrease greenhouse gas emissions (GHG) by 40% by 2020 and 95% in 2050. Nuclear is to be retreated by the coming 10 years. The main challenge faced by German policy makers remains shifting away from the coal-based power generation. Abundance of production and low electricity prices allows Germany to be one of the largest exporters of the EU.

With 34.1% of renewable electricity production in 2016, the country is expected to reach its 2020 renewable energy target. Contrary to other EU countries, RES investments have remained relatively high and stable over the years. In 2017, offshore wind attracted most investments and was closely followed by onshore sector. The government has made clear its wish to facilitate renewable investments. The electricity market is relatively well shared with many large corporation stakeholders (RWE, Uniper, STEAG, RWE…). Energy efficiency measures are expected to block the demand growth for the next 10 years. Auctions and demand for self-consumption are the main aspects increasing opportunities for RES projects.

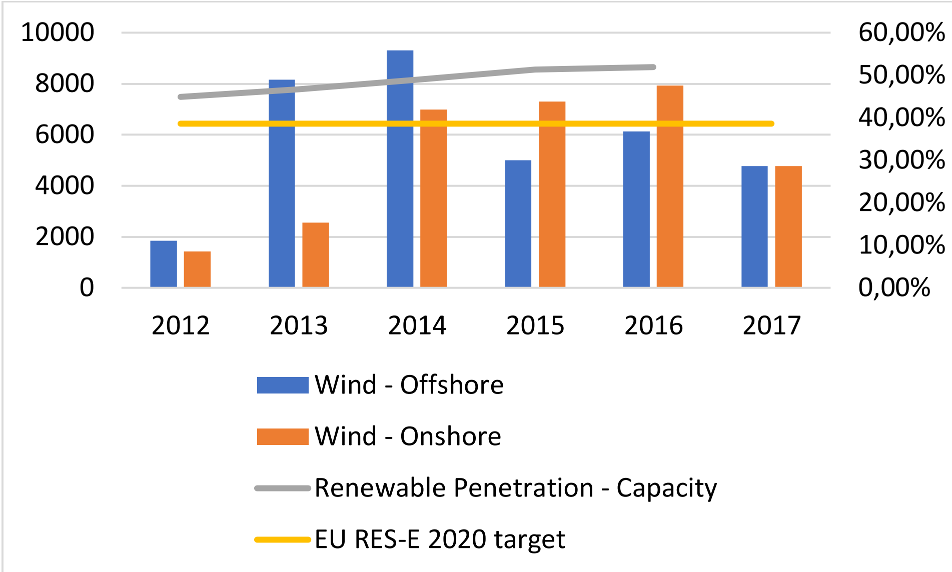


FIGURE 29: GERMAN WIND POWER SECTOR INVESTMENTS ($M) AND COUNTRY DISTANCE TO RES-E 2020 TARGET (%)

Germany benefits from having two renewable sources cheaper than Coal. In 2017, the cost of wind onshore was off 63$/MWh, the cost of solar PV was 77.6$/MWh while coal had a value of over 84$/MWh.

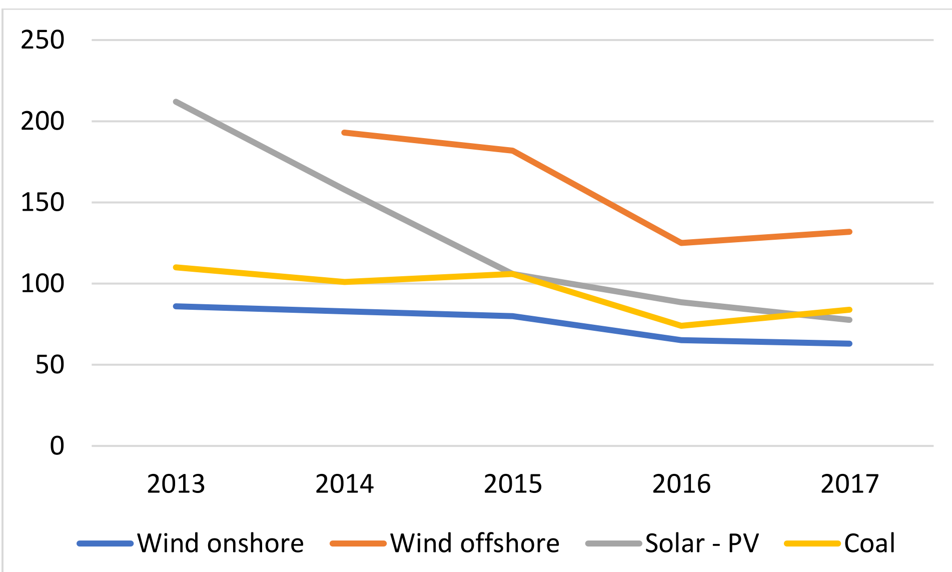


FIGURE 30: GERMAN LCOE EVOLUTION ($/MWH)

Since 2017, 5 different financial instruments are composing the German support schemes. Germany supports wind offshore essentially via feed-in-tariffs and both feed-in tariffs and premiums for the onshore sector. The auction market is also separating the onshore sector from the offshore one but a new technology neutral tender scheme has been designed and is in a try-out phase.

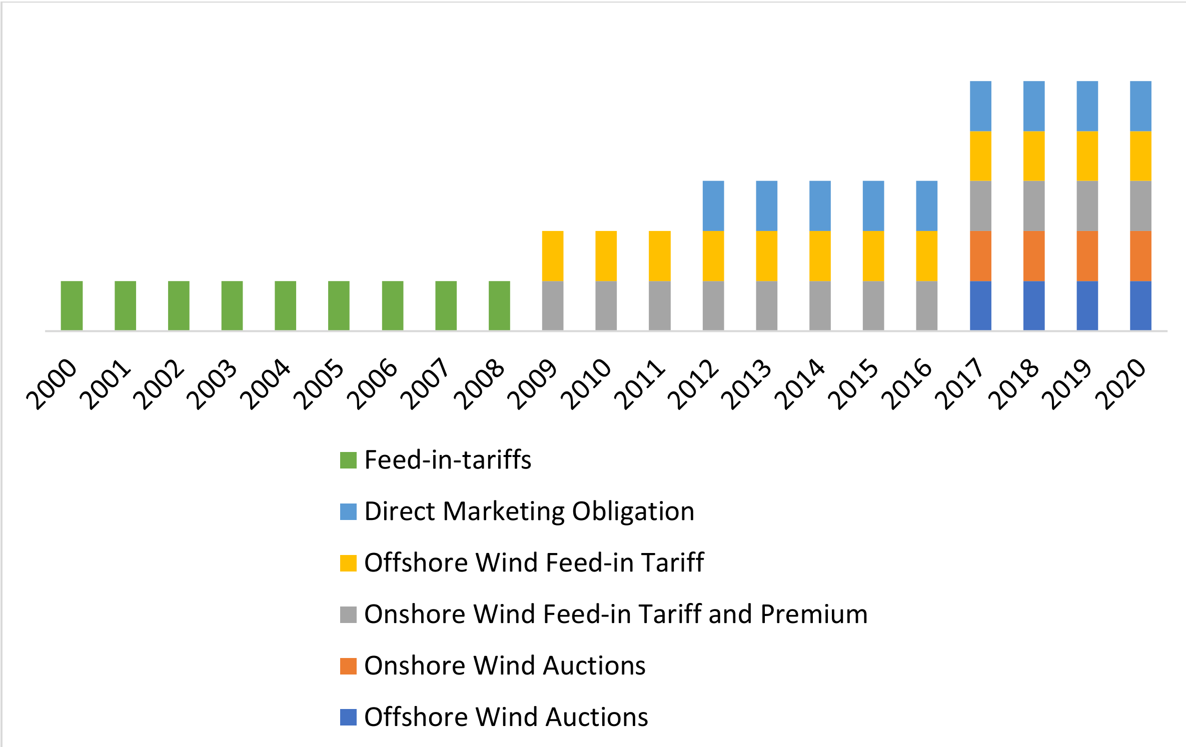


FIGURE 31: GERMAN WIND POWER SUPPORT SCHEMES EVOLUTION

5.7 Denmark

Denmark holds the record of renewable energy integration for electricity generation. The wind power sector occupies a strong place of leader with 43% of the shares in 2016. Non-renewable based energies only accounted for 40% of the shares in 2016. Coal and Gas are the dominant fossil-based sources of electricity shared in an equal way (17%). The country has decided to achieve a general energy consumption including 30% of renewables by 2020 and seems to be in the right way to achieve its goals.

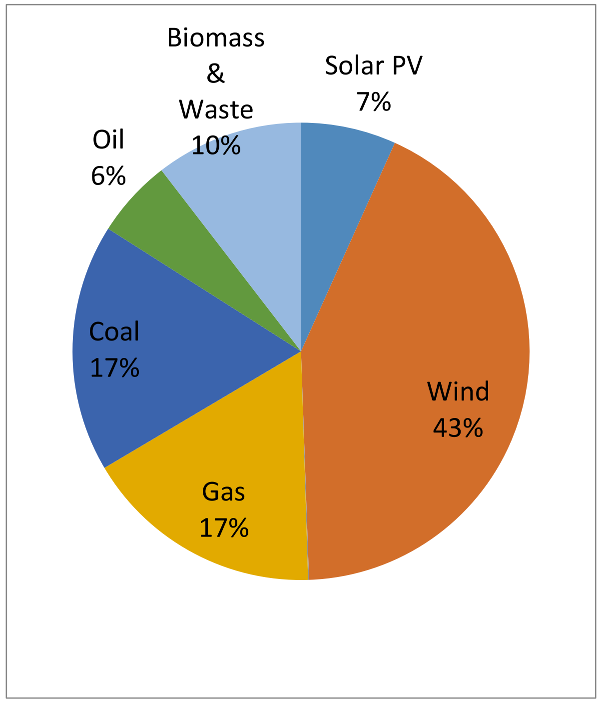


FIGURE 32: DANISH 2016 CAPACITY MIX

Between 2010 and 2017, the renewable energy sector attracted over 14.5 billion dollars. Investments in the onshore wind sector have remained constant over the last 5 years, fluctuating between 485 million dollars in 2013 and 185 million dollars in 2012. The Danish 2020 EU RES-E target has been reached in 2015. Since then, investments in the offshore wind sector have largely overcome the onshore sector. In 2016, 1160 million dollars have been raised for financing offshore projects. 2017 has been a record year of 2872 million dollars invested for wind offshore deployment.

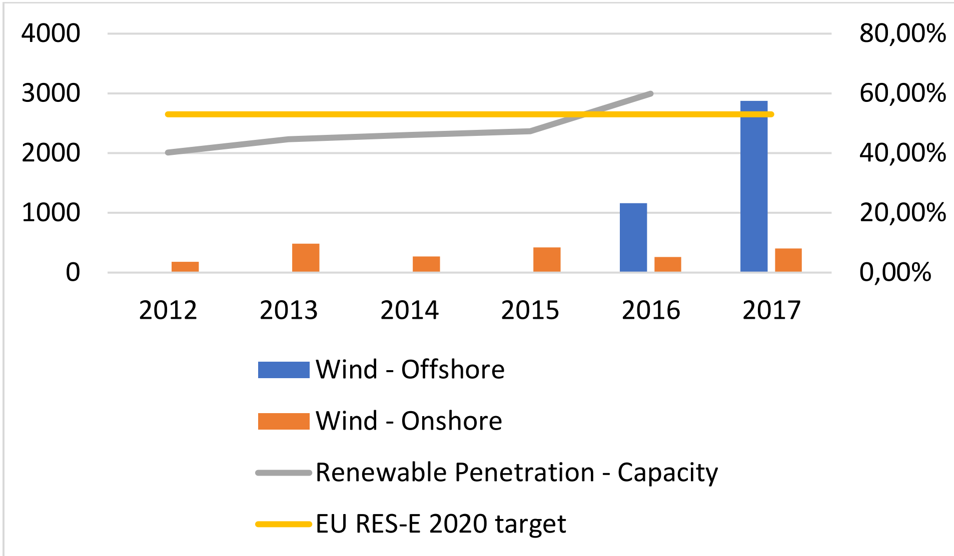


FIGURE 33: DENMARK WIND POWER SECTOR INVESTMENTS ($M) AND COUNTRY DISTANCE TO RES-E 2020 TARGET (%)

Power prices in Denmark are among the lowest of Europe. In 2017, the retail household price of electricity had an average of 303€/MWh. Denmark shares its wholesale power market with Norway, Sweden and Finland, but each country has its own governance and policy. The objective is to achieve 50% of electricity generation by 2020. There is almost no barrier observed to the deployment of wind power in Denmark, many problems of public opposition were solved thanks to an incentive forcing developers to offers local communities a minimum of 20% shares of the onshore wind farms measuring more than 20 meters. Denmark has very ambitious plan regarding renewable sources management and has committed to phase out coal by 2030 and achieve the following on its own:

- Source all heat and power by renewables before 2035
- Make renewables the only source of energy by 2050
- Integrate at least 200,000 electric cars by 2020.

In 2016, the price of offshore wind electricity was 80$/MWh, which is the second cheapest LCOE observed in the EU after the Netherlands.

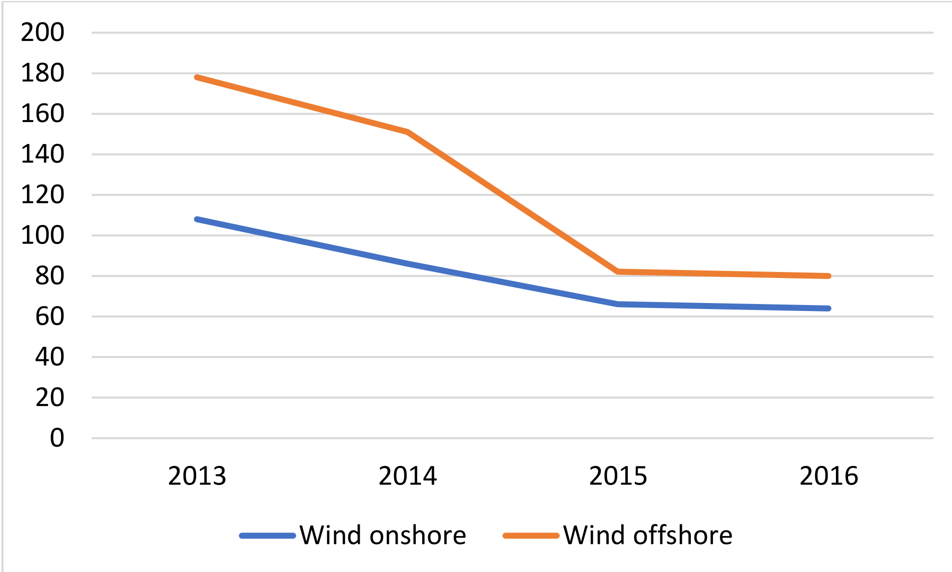


FIGURE 34: DANISH LCOE EVOLUTION ($/MWH)

In 2008, Denmark shifted away from the use of feed-in tariffs toward feed-in premiums to support wind power. 2009 and 2010 have been turning years with the introduction the net metering system. The first Danish offshore wind auctions were observed in 2015 and were directly followed by onshore auctions. This year, the government decided to shift from technology specific auctions to multi-technology auctions introducing the renewable energy auction schemes.

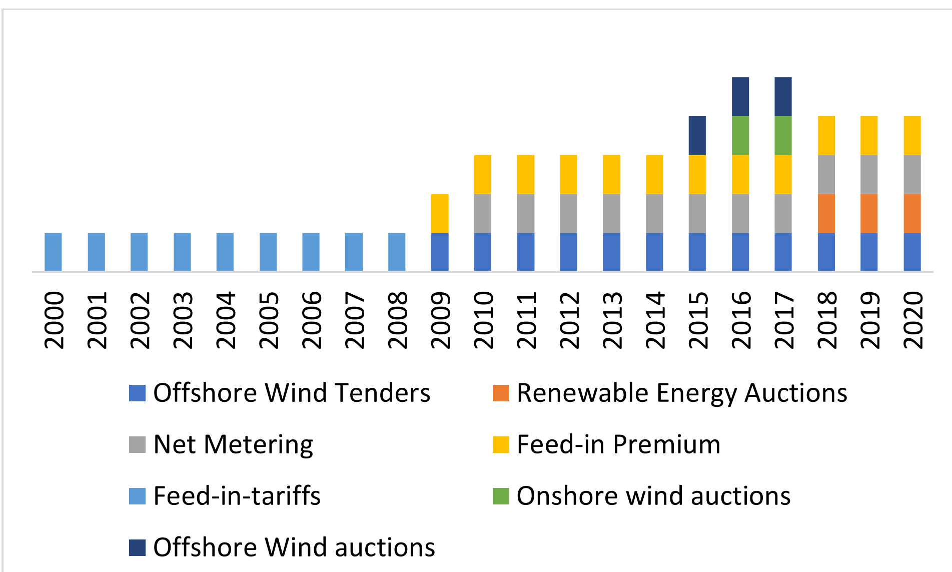


FIGURE 35: DANISH WIND POWER SUPPORT SCHEMES EVOLUTION

6 Chapter 4

6.1 Methodology

The evaluation of the auction and tender efficiency takes place separately from other support schemes since the data collected for these schemes gives information regarding the capacity auctioned and thus, the deployment directly allowed by the auction/tender rounds.

To evaluate the effectiveness of the different support schemes, the growth per year of wind power capacity since 2000 and over the last 3 year is calculated in order to find out, which countries have installed the best long-term policies and which ones are currently being the most efficient.

The Danish net metering system's effectiveness is not being evaluated since it only operates for homeowner of wind power plants having a generation capacity inferior to 25 kW. The Italian VAT reduction isn't being observed either since it just allows wind project developers to benefit from a 10% VAT instead of 20% for equipment and service purchase during the plant construction. The evaluation of support schemes efficiency other than auctions/tenders takes the following steps:

- Based on the country's wind power capacity, a calculation of the percentage of increase per year takes place.
- When they are fluctuations in the percentages of added capacity per years, its means that the efficiency of the support schemes varies over the years. In fact, as the market size increases, support schemes may become less adapted to the support of wind power. Thus, a ranking of the capacity growth per year is done for each country; the growth is calculated in average since 2000 and in the 3 last years of operation (from 2016). These values are used as an indicator of support scheme's effectiveness. However, they do not allow any conclusion regarding which support schemes is more efficient since within countries, energy mixes have different profiles and other impacts can influence the deployment of wind power such as the competitiveness of other technologies. The size of the market at the first year (2000) also influences the observed growth. Countries like Spain, Denmark and Germany already had large fleets of wind turbines in their capacity mixes in 2000 while Italy, France and the UK's fleets of wind turbines were almost inexistent. Therefore, the percentages of growth in wind power capacity are used as an "indicator" of policy effectiveness.

- The results of the mean growth in installed wind power capacity are listed below. They show that in general, over the whole period observed, countries increase by more than 10% per year their generation capacity. France has the highest observed growth per year with 34.5% while the UK and Italy are second and third with respectively 19.9% and 17.3% of growth per year since 2000. Compared to its total installed generation capacity, Denmark has a very high penetration of wind power capacity, which explains why it has a smaller growth per years. Regarding the short-term growth, the 3,5% observed for Denmark is a very good performance since the country has already over 60% of its total generation capacity running from RES. France, Germany and the UK also shows the results of long-term policy efforts neighboring a growth of 10% added wind capacity per years. Lately, Italy and Spain does not seem to benefit from effective policies since growth has almost been inexistent over the last 3 years.

Countries	**Mean Growth (2000/2016)**	**Mean Growth (2013/2016)**
Germany	12.7%	11.7%
France	34.5%	11.5%
Italy	17.3%	2.6%
Spain	12.9%	0.1%
UK	19.9%	9.9%
Denmark	4.8%	3.5%

FIGURE 36: AVERAGE GROWTH IN WIND POWER DEPLOYMENT OBSERVED BETWEEN 2000 AND 2016

- This section contains a summary of the key lessons learnt from the selected countries in designing support schemes for wind power. In the appendix section, are described the support schemes adopted for each country in order to find out the key design parameters which allow an efficient support for wind power deployment.

The analysis of the auction/tender design parameter take similar steps with the other support schemes. At first, auction results are compared for all countries in order to find out which auctions have been successful. Three different categories of auctions/tenders are being evaluated, the onshore auctions, the offshore auctions and the renewable ones. The impact of auction on support levels and wind power costs are compared. To find out the successful auction designs, 3 criteria assess the effectiveness of auction rounds.

The first one is the auctioned capacity; it refers directly to the quantity of wind power permitted to be build thanks to the auction in force. The second one is the realization rate; it refers to the ratio between the capacities being announced with the capacity being auctioned.

The last criterion is the impact of the auction on wind power costs. To reflect this impact as precisely as possible, observable bids prices are compared for France, Germany, Italy and Denmark. Bids prices are directly comparable to each other for these countries because bid values are directly representing the values of FIP and FIT. Bid prices can also be compared for the UK because they reflect the strike price of the auction and the strike price is the agreed price in the power market for which the producer agrees to produce without support. In the case of Spain using a regulated return on investments, comparing bid prices does not allow any possible conclusion regarding the level of support or the impact of auctions on wind power costs. Therefore, a comparison of LCOE is done. The last part of this section contains a summary of the key design parameters allowing the creation of successful tender incentive.

6.1.1 Analysis of support schemes in force except auctions/tenders

The following section summarizes all relevant observations concerning the support schemes adopted for wind power other than auctions and tenders.

***Figure 37:** Summary of all support schemes in forces except auctions/tenders incentives*

Germany	
Support schemes	Eligibility
FIT	• Any wind plant is a capacity inferior to 100kW is eligible.
FIP	• Any projects having won a tender round are eligible.

France	
Support schemes	Eligibility
FIT	• Any offshore plant having won a tender round is eligible. • Onshore plants located in areas with cyclonic risk and equipped with some special devices are eligible.
FIP	• Onshore wind plants with a maximum of 3MW of capacity and 6 generators are eligible.

United-Kingdom	
Support schemes	Eligibility
Renewable Obligation	• All wind power technologies are eligible.
FIT	• Small-scale plants with capacity inferior to 5MW are eligible.

Italy	
Support schemes	Eligibility
FIP	• Any wind power plant with a capacity between 1kW and 5MW is eligible.
FIT	• Any wind power projects having been awarded in a tender are eligible.

Denmark	
Support scheme	Eligibility
FIP	• Any onshore wind plant is eligible. • Offshore plants have to be awarded from a tenders to be eligible.

Spain	
Support scheme	Eligibility
ROE	• No difference between technologies is made; all wind power plants are eligible to the regulated return on equity.

The German direct marketing obligation is in my opinion interesting since it allows adapting the grid to seasonal production of wind electricity thanks to the contribution of energy producers.

Generally, Green certificates used in the UK in the form of “Renewable Obligation” have proven their effectiveness in the past as they allow wind power deployment by constraining entitled parties to integrated RES in their portfolio. However, this scheme shows limitations in term of security of supply and project financing. As large conventional power plants are to close in the coming 5 years in the UK, RES are challenged to alleviate the production losses. Under the RO scheme, generator’s revenues are tied up to power prices and the RO incentive gives no security to generators regarding price risks. Fluctuating power markets threat the fact that RES producers would shut down their productions when returns are not sufficient. Moreover, this scheme provides that RES productions and certificates are traded in an open market; however, generators are not getting accreditation until projects are commissioned which has often limited their access to capital for financing projects.

The last criteria influencing my preference for feed-in systems is the fact that under the RO scheme, market players have often chosen certificates in regards to their costs which indirectly played in the favor of the most available and mature technologies. Other allocation systems such as auctions allow a better support for immature technologies. Finally, quota systems should be limited to the deployment of large-scale power production when countries have no advantages of developing other technologies than wind.

Historically, FIT systems have been useful in deploying large-scale wind power capacities by offering generators a better security of income in regards to low and fluctuating power prices. The FIT incentive has allowed generators to sell their generation in a market were conventional electricity had prices advantages. However, as RES costs are getting closer to conventional generation costs, FIT systems are challenged by FIP offering a better adjustment of support level to fluctuating power prices. Under the FIP, the risk that generators would get subsidies related to power prices higher than required called "overcompensation" is non-existing. This has two main advantages to member states: at first, they avoid non-necessary support costs. Secondly, it ensures that the market is kept low cost driven and undistorted. From the above observation, my personal point of view is that FIT should be used to support immature wind energy markets while FIP are better designed to enforce the position of leading electricity resource that the wind power sector has in most countries.

According to me, FIP systems are the best incentive to support a low-cost and large-scale wind power deployment because they permit the best exemption of generators from power-price risks. FIT systems are simpler to operate and thus should be used to support small-scale "residential" wind plants where the production is too small to distort the electricity market. The main challenge to the use of feed-in systems remains to levelize support levels to falling production costs.

When thinking about the design of their FIP and FIT schemes (appendix), policy maker should especially care about the adjustment method of support level to generation costs and the duration of support. When using both kind of feed-in systems, the calculation of caps and floor (minimum and price references) combined with the use of an appropriate payment method is necessary to provide generators with financial supports perfectly adjusted to market conditions. The most observed payment mechanism is the sliding (floating) feed-in premium. As published by the "Council of European Energy Regulators" in January 26, 2016 in their report called "key support elements of RES in EUROPE", caps and floors are useful to member states to avoid having higher amounts of support than expected. This report also states that FIP have a large acceptance from power generators. Thus, my conclusion regarding feed-in systems is that policy makers should use sliding FIP which have proven themselves to be effective in countries like Germany with the condition that they are combined to fixed schedules containing dates of readjustment of floors and caps and duration of support (most observed value: 20 years).

Additionally, when the wind market is already a leader in the electricity generation sector like in Germany or Denmark, countries should think of tax/investment/net metering incentives in order to increase the focus on small-scale wind power deployment since most of the time, the small-scale wind power potential is harder to exploit for economies of scale reasons.

6.1.2 Analysis of Onshore auctions

The graph below generalizes the auction market as it is up until today. Results are showing that Germany is by far the biggest auction market of the group. Germany has auctioned more than 10GW of wind electricity capacity since 2016, year in which the first onshore wind auctions were announced. Spain started its first auction scheme in 2016 with the creation of both onshore and renewable auctions. It is today the second biggest market of the group with 8.7GW of capacity auctioned. France closely followed by the UK (5.49GW) occupies the third place of the ranking with a total auctioned wind power capacity of over 6GW. All four of these countries have started auctioning wind power capacities in similar periods. In 2016 came the first wave auction for the onshore sector. Wind offshore and renewable auctions came into force respectively in 2017 and 2018 for these countries. Denmark is the smallest market of the group. Italy was the first country to start auctions in 2013. However, the country does not seem to benefit from its experience since only 2.24GW of wind power capacity were auctioned in total and the realization rate is the lowest observed. France and Germany both have average realization rates. This means that they haven't been able to auction the capacity they planned to. Since 2018, all countries of the group have a renewable auction scheme. Denmark is the only country not operating an onshore auction scheme because the biggest part of its onshore potential is already exploited. Therefore, Denmark has opted for other allocation methods to deploy onshore wind power. Spain is the only country of the group, which does not run offshore auctions.

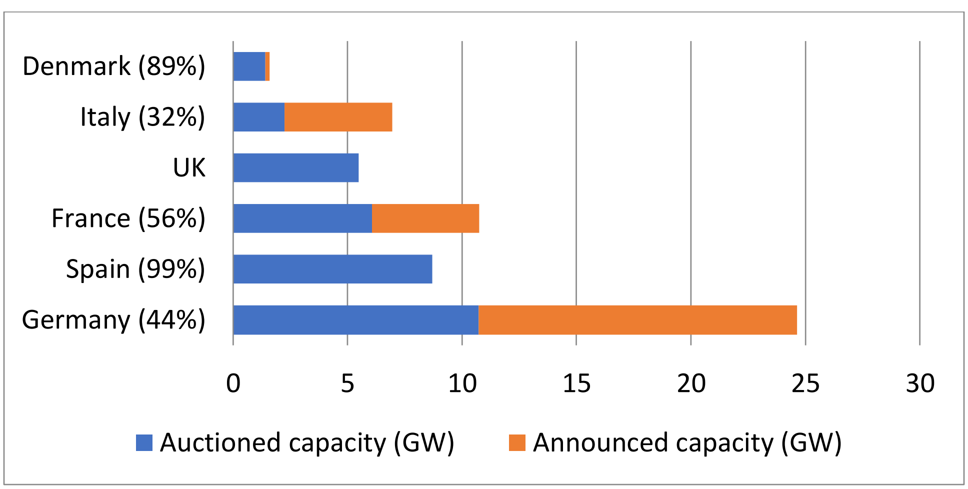


FIGURE 38: TOTAL AUCTIONED CAPACITY RANKING AND REALIZATION RATES (%)

Spain and Denmark are showing very high realization rates in general, which means that the auction rounds have been effective.

The next table summarizes the results of all onshore auctions in the group over the years. In 2016, Spain made a 500MW auction announcement which was 100% auctioned. In the same year, Germany and France also launched their first onshore wind auction. However, the outcome was an important failure, 0MW of the announced capacities were closed for both countries. Unfortunately, announced capacities are unavailable for the UK (thus, realization rates either). In 2017, both France and Germany had updated their auction schemes and closed 100% of their announced capacities. However, in 2018, while Germany keeps on obtaining satisfying results, France had a disapointing 24% realization rate. Italy auctioned 800MW in 2016 while the UK closed in 2015 749MW.

FIGURE 39: ONSHORE AUCTIONS RESULTS

Year	Countries	Announced capacity (MW)	Auctioned capacity (MW)	Realization rate
2018	France	500	118	24%
	Germany	2710	2653	98%
2017	France	500	500	100%
	Germany	2800	2820	101%
2016	France	2000	0	0%
	Germany	5700	0	0%
	Italy	NC	800	NC
	Spain	500	500	100%
2015	UK	NC	749	NC

The graph below summarizes the impacts of the different EMS expenditures for wind deployment. In Italy, the amount of the sliding premium paid to wind electricity producers has decreased from 140$/MWh in 2013 to less than 80$/MWh in 2016. France's expenditures for wind power deployment are similar to Italy, with a FIT payment of 75$/MWh paid to producers in 2017. In the UK, producers have agreed to build projects at an agreed strike price varying between 109$/MWh and 114$/MWh in 2015. Germany seems to be a different case than other member states, a slight increase in FIP support level between the auctions closed in 2017 and the auctions closed in 2018 has been observed. This may means than Germany has reached the maximum of its cost optimization for onshore wind.

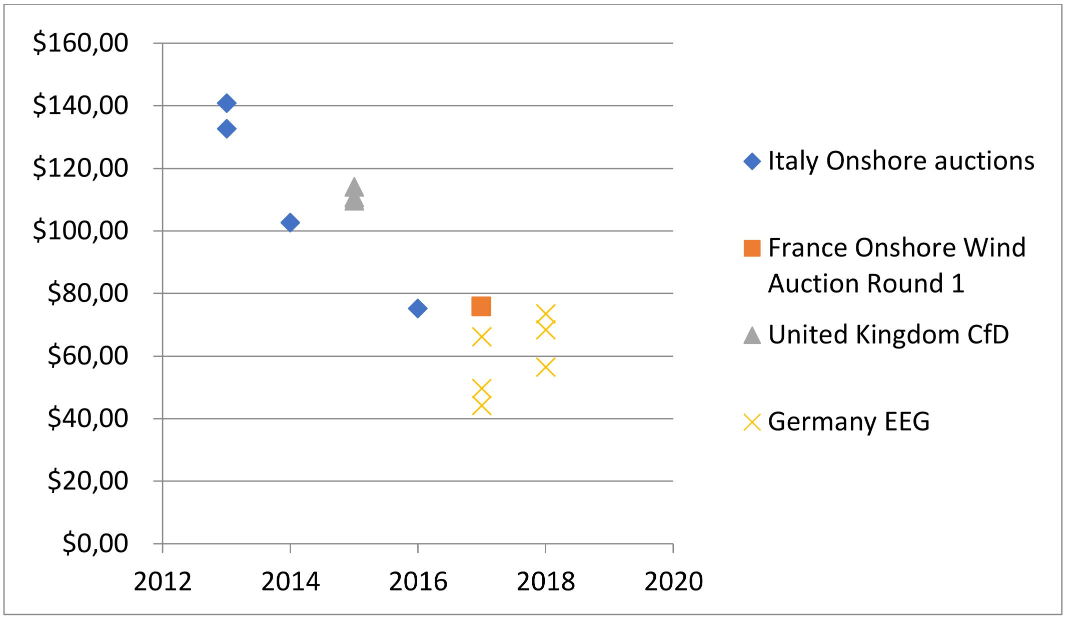


FIGURE 40: SUPPORT LEVELS AND UK STRIKE PRICES FROM ONSHORE AUCTIONS ($/MWH)

The graph below shows the evolution of the onshore wind LCOE for all countries of the group. Countries having large auctioned wind power capacities and high realization rates have the lowest LCOE (Germany, Spain, and Denmark.) The Spanish LCOE broke the record of lowness with 59$/MWh. In 2017, Germany, Denmark and Italy had almost the same LCOE. In France and the UK, efforts in cost decrease do not seem to be as effective as they used to. This graph shows that LCOE tend to be more stable since 2016 except in Spain and Italy.

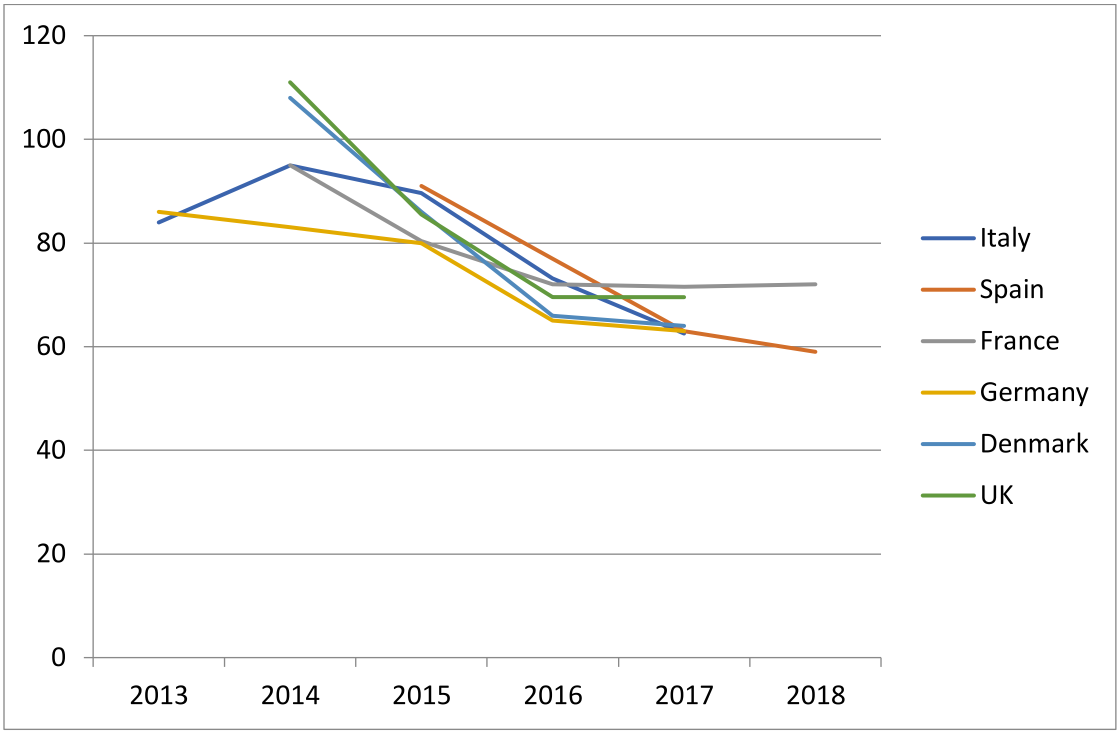


FIGURE 41: EVOLUTION OF ONSHORE WIND POWER LCOE ($/MWH)

6.1.3 Analysis of Offshore auctions

As shown in the table below, Denmark, Germany and the UK have auctioned very large capacities of wind power over the last 2/3 years with high realization rates. However, offshore auctions in Italy and France were important failures since they only allowed the building of a 30MW essay power plant in Italy.

FIGURE 42: OFFSHORE AUCTIONS RESULTS

Year	Countries	Announced capacity (MW)	Auctioned capacity (MW)	Realization rate
2018	Germany	1500	1610	107%
2017	France	750	0	0%
	Germany	1500	1490	99%
	UK	NC	3050	NC
2016	Denmark	1000	950	95%
	Italy	NC	30	NC
2015	UK	NC	1162	NC

The outcome of the Italian offshore auctions is described into the next graph and shows the evolution of support levels. In Italy, offshore auctions signed in 2013 show little difference of support level in comparison to auction signed 3 years later. This means that the offshore wind support scheme has not allowed an important cost reduction so far. The agreed strike prices in the UK have decrease by over 50$/MWh between 2017 and 2017. In Denmark, support level has also importantly decreased going from 116$/MWh in 2015 to a minimum of 56$/MWh in 2017. Again, Germany seems is different than other countries since it is the only member states which has lightly increased its FIP support level (+5$/MWh between 2017 and 2018 auctions).

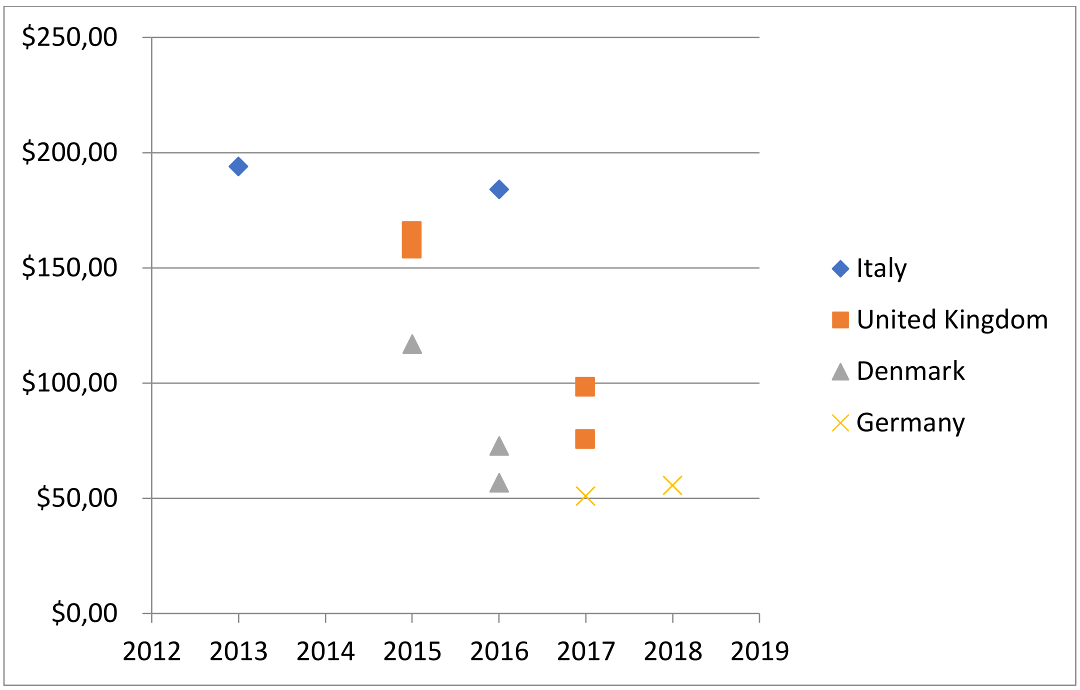


FIGURE 43: SUPPORT LEVEL AND UK STRIKE PRICES FROM OFFSHORE AUCTIONS ($/MWH)

Differences in LCOE values are almost inexistent between the UK and Germany since 2017. However, Denmark is by far the country with the cheapest offshore electricity with an LCOE of 80$/MWh in 2017 compared to 132$/MWh in the UK and Germany.

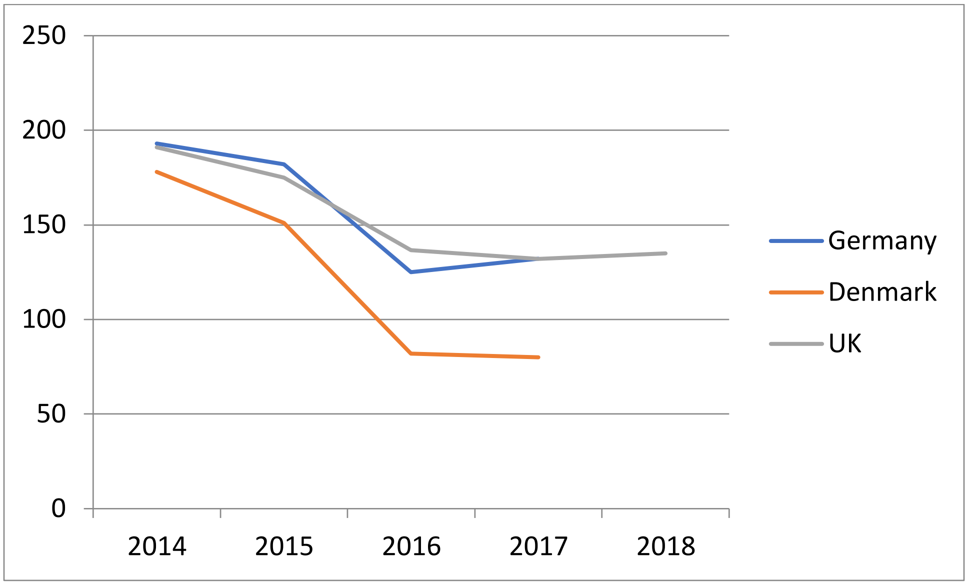


FIGURE 44: EVOLUTION OF OFFSHORE WIND-POWER LCOE ($/MWH)

6.1.4 Analysis of renewable auctions

The table below summarizes the renewable auction results of the selected countries since the incentives have been created. Realization rates in this table may be seen as wrong. This is because they express the ratio being auctioned in comparison to the quantity being announced. Auctions have been very successful in 2017 for Spain since a total of 8000MW was auctioned from which, 4000MW were wind power capacities. Spain seems to have a good design for renewable auctions. However, Germany and Italy have failed to copy that success. 8400MW were announced in the 2018 German renewable auctions, but only 200MW were closed so far. Italy has not closed any percentage of its 4700MW announced capacity in 2017 and the UK seems to have struggled as well on the launching of its first renewable auctions in 2017. France in 2018 closed 200MW of renewable auctions gathering wind and solar PV on competition. While the realization rate of 100% may be viewed as a success, it is still a very small capacity compared to the remaining French wind power potential.

FIGURE 45: RENEWABLE AUCTIONS RESULTS

Year	Countries	Announced capacity (MW)	Auctioned wind capacity (MW)	Realization rate	Notes
2018	France (wind vs solar)	200	200	100%	NC
	Germany	8400	200	2%	NC
	Italy	4700	NC	NC	NC
2017	Spain	8000	4000	100%	4000MW awarded to Solar PV
	Denmark	140	0	0%	NC
	UK	0	0	0%	NC
2016	Spain	700	500	100%	200 MW awarded to solar PV

The following part of that section gives emphasis on the relevant design parameter allowing auctions to be beneficial for wind power deployment according to my observations. The complete design parameters of every selected country can be seen in the appendix.

- Category of auction

Onshore: While France and Germany have opted for wind technology specific auctions, Italy, Denmark and the UK decided to organize their auction schemes in a way that RES can compete together in regards with their maturity. For the 3 countries, this resulted in renewable energy auctions gathering wind and solar power in the same auction rounds. Spain allows all technologies to compete in the same auctions; as a result, wind has the biomass technology for main opponent.

Offshore: In France and Germany, offshore wind is supported via technology specific auctions. In Denmark, the government proposes market players to bid for predetermined projects. In the UK and Italy, auctions are technology neutral. In the UK, offshore wind projects are competing in pots of technologies with advanced conversion technologies and combined heat and power.

- Nature of Auction

Germany makes a differentiation in the prequalification requirements depending on the nature of bidders. Community projects have lighter requirements compared to private companies. This incentive aims to involve German citizens into the energy transition. In France, no special differentiations regarding who can compete in the wind onshore sector auction are observed. Concerning countries having technology neutral auction, prequalification requirements vary among technologies competing in the same rounds.

- Bidding procedure

All countries have opted for a "call for tender" as bidding procedure. This means that governments invite market players to bid for completion of specific projects. The regulatory authority then chose the most efficient project without negotiation based on predetermined selection criteria.

France makes an exception when competition is not judged sufficient between bidders and process "competitive dialogue procedures". Based upon the prequalification requirements for entering the auction, the ministry of energy enters in dialogue with bidders and decides together on the criteria with which, their bids will be selected or not. The ministry of energy alone then does the selection process.

- Support payment method

In Germany and Italy, the reference bid price per KWh is used as basis for sliding feed-in premium to be paid to wind power producers.

France and Denmark respectively use feed-in tariffs and fixed feed-in premiums as support payment methods. The French government aims to shift from the use of FIT to a "compensation mechanism". The UK has the most exotic approach with contract for differences auctions. In such auctions, producers agree with regulatory authorities for a strike price of electricity. Then, the reference bid price per KWh is used as basis for strike price. In Spain, all bidders receive a payment, which is the result of the lowest accepted discount rate for the return on equity.

- Price awarding mechanism

Except England and Spain, all countries have opted for "a pay as bid" as main price awarding mechanism. Germany makes an exception for community projects and uses the "uniform pricing" mechanism. The "pay as bid" mechanism rewards power producers with the value of their actual bids. Under the "uniform pricing" mechanism, all suppliers receive the same payment, which is the set of the highest support level observed within the awarded bids.

In the UK, the national regulatory authority examines all proposed bids before starting the selection process and decides based upon the delivery time of the different projects and the budget available for each groups of technologies in competition whether it is better to do a constrained or unconstrained allocation procedure. The unconstrained allocation happens when the total value of all relevant application do not exceeds the support budget. Then, all projects are approved successful. The constrained allocation happens when the total value of bids exceed the dedicated budget. At that moment, the regulatory authority reorganizes an auction round where budget and capacity caps and floor are reevaluated.

- Setting of min/max bid volumes

Onshore: In France, a minimum (7 wind turbines or 1 wind turbine with capacity superior to 3MW) and maximum bid volumes (500MW per rounds) are fixed in every auction rounds except for community project where the 18MW maximum volume is to be re-settled. Germany follows a different approach.

The German government re-evaluates every years the minimum and maximum bid volumes in order to adapt them as much as possible to the deployment objectives. The UK and Italy have fixed minimum and maximum bid volumes for every round. In Spain, the last auction round had a maximum bid volume of 300MW. However, this floor is to be re-evaluated before the announcement of every auction rounds. Denmark follows a similar approach than Spain. Since the Danish government often proposes the realization of national projects trough out auctions, minimum and maximum bid volumes are always being re-calculated.

Offshore: In France, Germany, and the UK, minimum and maximum bid volumes are evaluated before announcement of any offshore auction round schedules. Since France has only made one unsuccessful auction round so far, no information regarding the values of these bid volume limits are available. Information is not available for Denmark because these values differ among every projects being auctioned. In Italy, the 5MW minimum and 30MW maximum bid capacities are fixed and will be recalculated when deemed necessary.

- Setting of min/max bid prices

Onshore: In Spain, Italy, France and Germany, maximum bid prices are calculated every for every auction rounds based on the results of the previous auctions in order to avoid over-compensation. The UK has a fixed maximum strike price of GBP90/MWh, which is recalculated only when deemed necessary. Information is not available for Denmark.

Offshore: In all countries except Italy, a ceiling price is recalculated before every auction round announcement based on the bid prices of the previous ones. Italy has a fixed maximum bid price of €165/MWh. There is no information regarding how the Italian government plans to readjust this price.

- Participation fees

Onshore: Information is not communicated for Spain, the UK and Denmark. Italy has a fixed participation fee of 2200€ which has to be paid before entering the auction. In France and Germany, the participation fee is based upon the capacity of the projects (€30/MWh).

Offshore: Italy has a fixed participation fee of 2200€ which has to be paid before entering the auction. In Germany, the participation is 4727€. In the UK, charges are at latest state of the project. No information regarding the values of those charges is available. There is no observed participation fee in France for this technology. Information is not communicated for Denmark.

- Duration of support

Onshore: In Italy, Denmark, France and Germany, the support for wind power production lasts 20 years while it is 15 years in the UK. Duration of the Spanish support for wind power production was not available.

Offshore: France, Germany and Denmark's durations of support are 20 years. In the UK, support is guaranteed for 15 years only against 25 years in Italy. Germany proposes market players an extension to 30 years of guaranteed support based on an assessment of the project lifetime.

- Frequency of tenders

Onshore: France and the UK are making an onshore auction round per years. In Germany, between 3 and 4 auction rounds are taking place per years. Italy processes onshore auctions on a yearly basis while in Spain and Denmark, no auction round schedules seem to have been fixed.

Offshore: While in Italy and Germany, offshore wind auctions are planned and a yearly basis, 2 rounds per years are made in the UK and France. Denmark makes three rounds per years.

- Project realization time

Onshore: It lies between 2-3 years for all countries.

Offshore: In France, the realization of projects does not contain specific rules. It is 2 years in Germany and the UK. In Denmark, the realization time depends on every projects being auctioned specifically. Italy imposes to projects leaders, the realization of their offshore plants within 43 months.

- Presence of support budget limit

Onshore: In Germany, no budget limit is being fixed before auctions take place. In Italy, the yearly budget for onshore auctions is €6 billion. Information is not communicated for other countries.

Offshore: Information weren't communicated regarding the existence of a maximum budget value for the offshore auction technology schemes in France, Denmark and the UK. Italy has defined a budget limit which isn't published yet. Germany made it important for every auction not to have a maximum budget in order to be able to realize every potentially interesting project.

6.2 Outcome of the auction schemes analysis

Generally, the auction system (contract for difference) adopted by the UK has proven to be effective. However, it is in my opinion a more complicate system than the others are. Moreover, if the UK decides to organize joint auctions with another country like Germany did for solar PV with Denmark, the UK will be constrained to adapt its auction system. I think that thanks to their more "traditional" support schemes, other countries can cooperate more easily are better placed to open the auction market as widely as the power market already is.

According to me, as countries are all developing their new renewable energy schemes, they should worry about grouping RES technologies in regards to the maturity of their markets so that importance is given to drive the costs of expensive technologies down. I think that it is positive for the wind power sector to be in competition against solar PV on auction rounds. Combining auctions with FIP seems to be the most advanced mechanism for large-scale deployment now. However, countries should always care about adjusting minimum and maximum bid prices and volumes in order to protect the ability of all bidders having realistic projects to participate in the auctions. I do not think that it is relevant to make comments regarding the value of these minimum and maximum bid prices and volumes seen above since they are calculated to be fitting to specific markets, which are all different in size, geography and macro-economic situations. I think what is important regarding these criteria is how countries have planned to keep these values updated. To me, these values should be recalculated before the announcement of any auction rounds as it is done in Germany or Italy.

The participation fees observed above are widely differing from each other. I think that the information published in this report are too small to propose assumptions regarding whether observed participation fees are high or low or constituting a barrier for generator to enter auctions. The 20 years warranty for support in the onshore wind sector adopted by most countries seem to be a fair offer, however, as offshore project benefit from less experience and are more capital intensive than onshore ones, I think that countries should re-think the duration of support with regards to project lifetimes.

Concerning the lead time of projects, there are no comments to do on the onshore wind sector as all countries compel projects holders to finalize between 2 and 3 years after the closing of auctions. However, as technology still progress very quickly in the offshore sector; I think that realization time of projects should be updated to every single project as difficulties in building processes and costs seem to vary widely within countries. The use of project specific auctions like in Denmark may be more useful to adapt the auction design to the complexity of the technology.

The existence of budget support limit means that countries have settled maximum amounts of support they are ready to spend on wind power deployment. In my opinion, it is not the most important criteria to assess since so far, budget limitations have not been a cause of auction failure. However, it is good to me that Germany for example made it important not to have a budget limit in order to make sure that every single realistic project will be supported and motivate market player to realize their most ambitious projects.

Renewable energy auctions are in my opinion the best system for the deployment of large-scale onshore wind power. Even if solar PV may sometimes be awarded more capacity than wind, the Spanish example has shown that solar PV and wind are competing together and both technologies have been able to develop so far. The case is different for offshore wind, as it may be grouped with least mature technologies like biomass or combined heat and power for renewable energy auctions; the best design observed so far for offshore wind support has been project specific auctions. The problem is that project specific auctions are difficult to combine with other renewable technologies. The example of the UK putting in competition offshore wind with advanced conversion technologies and combined heat and power was efficient. I think that the challenge for most member states having large-scale offshore wind potential is to success to create a scheme proposing offshore projects competing in open renewable auctions.

The solar PV joint auction agreement signed in 2017 allows Danish solar PV plants owners to compete in the German auction market and vice-versa. I think that this incentive opens a new door to countries as they could develop least mature technologies making benefits from the experience acquired by neighboring member states. For example, French offshore wind deployment, which has been unsuccessful so far, could benefit faster from the experience acquired by Dutch or German offshore wind policy makers.

7 Conclusion

The aim of this study was to determine the different ways EU countries organize the deployment of wind power for electricity generation. An empirical analysis was the method adopted for determining the tools available for policy makers are in order to exploit member states wind electricity potentials. Feed-in systems allocated trough auctions are the most used method of support. Observations concern the 6 biggest wind turbine fleets in the EU which are Italy, the UK, Germany, France, Spain and Denmark. A decline has been observed in the use of quota systems. However, they are still operated in the UK under the form of renewable obligation. The only country in the group using a support scheme which is criticized as not in favor of wind power deployment in the group is Spain with the so-called "regulated return on investment."

In the country description section, emphasis is given on the way electricity sources are being managed in every country. Results show very different policy and renewable energy management profiles. The UK, Germany and Denmark are the only countries having developed offshore wind projects on a large scale yet. Danish wind electricity generation capacity account for 42% of the country's generation mix. In Germany and Spain, over 20% of the shares are being filled by wind power while France and Italy remains under 10% of wind power in their capacity mixes. Generally, Denmark and Germany benefit from more experience on wind power deployment while countries like France or Italy seem to have been focusing more on solar PV deployment.

The UK having Gas and wind power combined with solar PV for first and second power sources supports wind power trough feed-in tariffs and contract for differences. These are renewable energy auctions with a different design. Spain using Gas, wind and hydropower as core energy sources suffers retroactive changes in its Res-E policy. As a result, investments in the wind power sector have been almost inexistent in 2013 and 2014. The introduction of new auction schemes combined with a slow increase in investments show positive signs for evolution in 2017. In France, 48% of the capacity mix shares are filled by nuclear power. The French government offers 3 different auction schemes, one for the onshore wind sector, one for the offshore wind sector and a new renewable energy auction scheme. On the long term, feed-in tariffs used as main support payment method are to be replaced by feed-in premiums called the "compensation mechanism". France also has incentives for the development of RES for self-consumption.

Similarly to Spain, Italy has large gas and hydro power-plants. However, solar PV is in Italy twice more important than wind in term of capacity connected to the grid. The Italian government allocates support for wind power via renewable energy auctions. Any projects having been awarded through an auction are then receiving a feed-in tariffs payment. Small-scale wind power productions are supported via feed-in premiums. In Germany, wind power combined with solar PV account for almost 50% of the capacity mix shares, however, since the country has committed to phase out its 25% shares of coal in the capacity mix by 2050, a large space for wind power deployment is opening up. Germany supports small-scale production (<100kw) via feed-in tariffs and any projects having won a tender round via feed-in premiums. In previous years, renewable energy auctions were organized via technology specific auctions for onshore and offshore. Since the creation of the new renewable energy auctions, Germany now puts renewable sources in competition together. The German direct marketing obligation incentive seems to show effectiveness at showing support transparency and may be an exemplary incentive for neighboring member states.

While Coal and Gas account for 34% of the shares, the wind sector holds a record of 43% shares in the Danish 2016 capacity mix. Denmark has a relatively simple way to support wind power, the payment method is feed-in premiums for all projects, small and large scale. However, large scale and offshore projects must have been successful in an auction round to obtain the FIP payment. Growth calculations of wind power capacities per year showed different performances among countries. Generally, average growth over the last 3 years showed better accuracy when being used as an indicator of policy effectiveness than average growth over the whole period of observation (2000/2016). This due to the fact that the speed of wind power deployment has meet fluctuations over the years, especially after the 2013 support schemes reforms. Globally, as countries fleets of wind turbines increase, wind power capacity growth rates decline slowly. Germany, France and the UK have the best growth per year over the 3 last years with respectively 11.7%, 11.5% and 9.9%.

When thinking of the design of their schemes, policy makers give special attention to the eligibility criteria, the support level and the way support schemes are being held updated to RES costs decline. Feed-in premiums have been preferred against feed-in tariffs due to the fact that FITs tend to distort the market conditions. FIPs encourage competition between new generation of conventional and renewable sources. FITs may still be interesting to support small-scale production since they are relatively easy to operate and offer secured hedges against electricity prices volatility. However, countries using FITs for large scale deployment should shift to FIPs which have higher average payments per kWh but a smaller long-term cost to society. Sliding feed-in premium have been observed more than fixed FIPs in the study, which means that government together with generators have taken the option to delete overcompensation risks. The use of sliding FIP requires policy makers to create a design perfectly adapted to market conditions so as to make sure that market prices volatility won’t cause any changes in RES investments. Concerning the duration of support, countries have most often decided to guarantee 20 years.

Since 2016, renewable energy auctions have been the most used allocation system for RES state support. Except in Spain and the UK, all countries have decided to combine auctions with the support of a feed-in system. Germany and Spain have the biggest capacities of auctioned wind power. France and the UK's wind auction markets are similar in size. Realization rates of auctions give information regarding whether capacities announced on auction are being closed or not. These rates are used as an indicator of policy effectiveness because auction design parameters may sometimes be responsible for the success of a round. While realization rates in the UK were unavailable, Spain and Denmark respectively closed 99% and 89% of the capacity announced previously to each auction rounds. Germany (44%), France (56%) and Italy (32%) appeared to have more difficulties closing announced capacities. The second criteria having been used to evaluate the effectiveness of auctions was their impacts on the wind power costs or support levels. This assessment gave similar results than the realization rates calculations, countries having auctioned large scales of wind power are benefiting from cheaper generation costs than others. Germany has the lowest support level for onshore wind. German auctions are the only observations where support levels for onshore as well as offshore have slightly increased between 2016 and 2018. Support levels and LCOE have been significantly decreased since the booming of auction schemes. Since 2016, onshore wind costs have stabilized to a level of around 65€/MWh for all countries except in Italy and Spain. France and the UK remain the highest costs observed while Germany and Denmark are the lowest after Spain.

Offshore costs have different profiles since the offshore market is less developed. Denmark is bar far the country where offshore wind is the cheapest with 80$/MWh followed by Germany and the UK both located around 130$/MWh at this time. These observations allow expecting that the offshore LCOE will keep decreasing, especially in countries where the market is underdeveloped. LCOE values in the onshore wind sector are also expected to decrease. However, the stability observed in the German market compels market players in other countries to prevent a cost stabilization which could occur as market sizes are growing.

Concerning the auction designs, observations showed that since 2016, a global switch has been done from the use of technology specific auctions to technology neutral ones. The fact that renewable auctions favors competition and cost decrease between RES sources motivates policy makers to follow this turn. Spain has been a pioneer in the topic. In 2017, 8000MW of RES have been auctioned with an equal share of wind and solar capacity. The 100% realization rate of these auctions proves that the auction design has matched bidders' expectations. Germany which announced 8400MW of renewable energy auction to be held is in phase of taking technology neutral auctions to another level of importance. All countries are developing renewable auction at their own speed. Generally, the wind onshore sector is to be competing with the other most competitive RES sources of the country. For example, solar PV competes with onshore wind in the first technology group (A) of Italian renewable energy auctions. The offshore wind sector is in that case competing in the third technology group (C) with other geothermal projects.

When creating their auction schemes, policy makers tend to combine auctions with sliding FIP. Further reports from the CEER have shown that it was the most market-oriented method to allocate large wind power capacities cost-efficiently. Differences in the design of wind auctions are large. However, in all cases, special attention is required for the adjustment of support level to decreasing wind power costs. The use of minimum and maximum bid prices and volumes allow policy makers to adapt the schemes perfectly to industry capabilities. However, these values have sometimes failed to be fitting like in 2016 in Germany and France for example. Support is in most countries guaranteed for a period of 20 years. Fluctuations are observed in the frequency of tenders. The reading of large market players “ENEL” and “ÖRSTED” earning calls showed that the frequency of tenders was one important parameter having impacts in companies' abilities to build projects if tender frequency is inferior to 2.

This study allows concluding that policy makers have developed tools allowing them to control wind power deployments in a transparent and competitive way. The efficiency of these tools varies among country profiles and markets players experiences in the related onshore or offshore market. The most important challenge regarding wind power policy is not to create new schemes but to success to keep existing schemes updated to market conditions. As RES costs are decreasing, policy makers must show abilities for gradually declining support levels. The creation of schedules of schemes adjustment is an option to be evaluated for further studies.

Finally, the creation of common schemes or joint auctions between member states might also generate a changing force to the above assumptions. Such joint auctions could allow better exchanges of responsibilities and experience between member states.

8 Discussions and Recommendations

When looking for literature, the main difficulty met was to find data which were comparable. "Bloomberg New Energy Finance" has contributed to almost all of the data inputs gathering energy quantities and costs, policy descriptions and general country profiles. The empirical analysis has provided a wide range of information allowing making assumptions for justifying the differences in countries wind power deployment per years. Unfortunately, data regarding the capacities of wind power being allocated through support schemes other than tenders and auctions were not sufficient to allow any comparison. This is the reason why auctions/tenders have been analyzed separately to others. For further studies, an analysis based of the direct costs of support would give a more transparent view on countries expenditure for wind power deployment and would allow the making of simpler assumptions.

The study gives emphasis on support schemes which are design to deploy wind power in a large scale. Thus, small-scale or self-consumption schemes like net metering or taxes incentives are to be compared in further studies.

The sample selected gathers the 6 biggest EU fleets of wind turbines, but some efficient policies coming from member states having smaller wind power portfolios have been omitted in the evaluations. Moreover, non-EU countries might also have efficient wind policy profiles.

This thesis would give more precise key development parameters of wind power policies if the sample of countries being studied made no difference between the sizes of wind turbines fleets. I also recommend to anyone getting involved into such research work to include the country investment risk profile as one of the auction success factor in order to find out if design parameters are the only criteria impacting realization rates.

Finally, I think that a more specified empirical analysis gathering only the onshore or the offshore sector or for example only one kind of support scheme (ex: comparison of renewable auction schemes) would allow more precise observations and give us more justifications regarding the increase of such auction uses.

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Company Earnings call

1/ Ørsted A/S, Denmark.

2/ ENEL Spa, Italy.

10 Appendix

10.1 Description of country's support schemes in force except auctions and tenders incentives

10.1.1 German support schemes design

Next to the auction schemes, 2 incentives supporting wind power are in force currently in Germany, the FIT and the FIP. Onshore wind is supported via both FIT (small-scale) and FIP while the offshore wind sector is essentially being supported via FIT. Since 2014, direct marketing is mandatory for all RES-E projects having a bigger capacity over 400MW. This means that renewable energy producers are required to communicate their production and sales forecasts and pay intra-days balancing charges. The characteristics of the German FIT and FIP are listed as follow:

	FIT	**FIP**
Eligibility	Any RES-E plants with capacity <100kW	Any project which has been successful in a tender round.
Accreditation requirements	Agreement to respect grid connection rules	The rights to obtain FIP payment requires that electricity is feed into the grid. Other accounting and technical requirements are assessed before getting provided with FIP payment
Support level	For onshore, FIT are fixed for the first 5 years, and then adjusted to their locations and the wind conditions. Prices are between €ct 4.66 and 8.38 per kWh depending on the duration of payment. For offshore, there are 2 options: - Basic FIT: 14.9 euros/MWh for 12 years then 3.9 euros/MWh for remaining 8 years. - Accelerated FIT: 18.4 euros/MWh for 8	For onshore: between €ct 4.66 and 8.38 per kWh depending on the duration of payment. For offshore until 2020: between €ct 3.9 and 1.4 per kWh (varying in regards to duration of payment and scheme chosen by plant operator)

	years then 3.9 euros/MWh for remaining 12 years.
Adjustment of support level	For onshore, the payment is reduced every first day of the month. If the deployment objective of 2500MW per year is not being reached, the degression rate which is usually of 1.05% is respectively decreased. In case that the objectives are largely reached, the degression rate may also be increased. For offshore wind, degression will be between 0.5 and 1.0 ct/kWh from 2019, depending on the year and the tariff
Duration of support	20 years

In Germany, both feed-in payment systems are not linked to inflation. On a long term, FIT are supposed to be used to develop immature technologies and small-scale. This means that for the wind power sector, sliding FIP are expected to be the most-used support scheme resulting in successful tender rounds.

10.1.2 French support schemes design

The main part of France's fleet of wind turbines is supported via Feed-in tariffs. However, France has reduced the allocation of FIT payments to special kind of projects while the FIP"compensation payment" is about to replace the use of FIT. The characteristics of both incentives are as below:

	Feed-in tariff (Tarif d´achat)	**FIP "compensation mechanism",**
Eligibility	1/ Any floating wind power project having won a call for tender. 2/ Wind energy plants located in an area particularly exposed to cyclonic risk and equipped with a device for forecasting and smoothing electricity production.	Onshore wind energy plants with a maximum power capacity of 3 MW per generator and a maximum of 6 generators are eligible to the premium tariff.
Support level	For eligible project from a tender call (category 1 above), the FIT is granted with the value of the observed bid price. For projects located in special areas (category 2 above), support level= €ct 23 per kWh for all plants during the first 10 years and then between €ct 5 and 23 per kWh for the next five years, depending on the overall time of operation per year.	Project smaller than 6 turbines can request for a FIP payment directly, larger project have to be successful in an auction. The value of the FIT is equal to the bid price for auctioned projects. For special area projects, the premium tariff corresponds to the difference between the reference tariff and the tariff obtained by the producer for the sale of its electricity production on the wholesale market.
Degression of support level	Tariffs are inflation indexed; the rate of tariffs subject to reduction is off 60%.	Tariffs are inflation indexed; the rate of tariffs subject to reduction is off 60%.
Duration of support	15 years	20 years

10.1.3 UK support schemes design

In Great-Britain, 3 support schemes are currently in force, with the aim of supporting wind power deployment for RES-E. A the first, the quota system called " Renewable Obligation" in giving electricity suppliers the order to prove that a percentage of electricity supplied to final consumed has been produced from renewable sources. Proofs that electricity has been produced by renewable sources are green certificates in this case. The table below summarizes the design of renewable obligation scheme:

Characteristics of the Renewable obligation scheme	
Eligibility	Both onshore and offshore are eligible, different capacity rules are still being tried
Accreditation requirements	None, electricity supplier are an obligated party under this scheme
Support level	Amount of quota, period of application and number of certificates per technology are pre-settled before the start of every new year (2015 average certificate price: 54.54 €/ROC)
Procedure	Supplier may prefer buying certificates to RES-E producers instead of producing their own RES-E. When doing so, a buyout price is monthly indexed to inflation.

The last support scheme currently active in the development of wind power in the UK is the feed-in tariffs for small-scale generation plants (<5MW). Thanks to this incentive, producers having been through the accreditation process are selling their electricity to suppliers via a FIT license with predetermined rates. The characteristics of this scheme are listed below:

Characteristics of the FIT scheme		
Eligibility	Any plant <5MW	
Accreditation requirements	If capacity is <5kw, then producer must take part in the Micro-generation Certification Scheme. Otherwise, standard accreditation process (ROO-FIT process)	
Support level	**Capacity**	**GBP per kWh**
	≤ 50 kW	0.0826 (approx. 0.0925 €/kWh)
	50 kW - 100 kW	0.0488 (approx. 0.0546 €/kWh)
	100kW - 1.5 MW	0.0258 (approx. 0.0288 €/kWh)
	> 1.5MW	0.008 (approx. 0.091 €/kWh)

Application for accreditation	Micro-generation certification scheme or ROO-FIT accreditation
Adjustment of support level	So-called "default" and "contingent" degression
Cap	GBP 100 million annually allocated between technologies
Duration of support	20 years

The Micro-generation Certification Scheme (MCS) is an independent scheme dealing with the standards of all small scale (<50kW) plants. The ROO-FIT accreditation applies for wind and solar plants who have been allocation via renewable obligation and are eligible to the FIT scheme.

The quarterly “default degression” refers to a set of standard values classifying how in general the level of support is decreasing over the time. The”contingent degression” categorizes the plants projects depending on their size on adapt the decrease of support level to it. This degression parameter is designed to respond to spikes in deployment.

10.1.4 Italy support schemes design

The FIT in Italy have been suspended retroactively. However, they are still being used as subsidy schemes for projects being successful awarded in auctions. The characteristics of the schemes in force in Italy are as follow:

	Italy Feed-in Premium for Small-scale Non-PV Projects	**FIT (tariffa onnicomprensiva)**
Eligibility	Are eligible, all plant between 1kW and 5MW of capacity	Any wind project having been awarded in a tender
Accreditation requirements	Plants with capacity between 60kW and 5MW have to be listed in the official register to get the accreditation	Plants with capacity between 60kW and 5MW have to be listed in the official register to get the accreditation
Support level	Onshore Projects between 1-20kW: 291€/MWh, Projects between 20-200KW: 268(€/MWh), Projects between 200 and 1000kW: 149 (€/MWh), Projects between 1000-5000KW: 135€/MWh. For onshore: 0€/MWh.	No tariffs are available for the offshore sector. In the onshore sector, there are capacity rankings. For projects between 1-20kW: 250€/MWh. For projects between 20-60 kW: 190€/MWh. For projects between 60-200kW: 160€/MWh. For projects between 200-1000kW: 140€/MWh.
Degression of support level	No degression rate settled yet.	No degression rate settled yet.
Duration of support	Onshore: 20 years Offshore: 25 years.	20 years

10.1.5 Denmark support schemes design

In Denmark, support for wind is organized only via feed-in premiums. The country shows simpler support schemes than neighboring member states:

Characteristics of the Danish feed-in premiums	
Eligibility	Any wind power plant. Offshore projects have to be successful in a tender to get the premium payment.
Support level	So-called "maximum" and "guaranteed" bonus, depending on production level and location. For project commissioned after January 2017, the total aid for the life of the project can't exceed €15 million.
Degression of support level	Degression is included into the predetermined payments above. FIP payments are re-evaluated every year in regards to the previous year payment.
Duration of support	20 years (12 years for pilot projects)

The "maximum" bonus refers to a maximum amount of premium, project managers will be allowed to get paid. The "guaranteed" bonus exists when RES-E producers are given a bonus on top of the market price. Every year, bonus payments are re-calculated and adjusted to the decrease of wind power costs.

Description of the Danish premium payment system (2017/2018)

Categories	Maximum bonus	Guaranteed bonus	Duration of payment
On-shore plants commissioned between 01.01.2014 and 20.02.2018 + off-shore wind turbines outside tenders	€8ct (for the sum of 6,600 full load hours and 5.6 MW per 1 m2 rotor area plus €ct 0,2 for balancing costs compensation)	€3ct	20 years
On-shore plants financed by utility companies	€4ct	€1ct	10 years
Offshore plants financed by utility companies	€5ct (applicable to 42,000 full load hours)	€1ct	No dead-line (Extra-bonus of €0.1ct exists for producers paying grid

		expenditures when they feed the electricity in)
Off-shore wind plants part of pilot projects + projects in the exclusive economic zone	€9ct (for the sum of 15,000 full load hours and 12.7 MW per 1 m2 rotor)	No dead-line
Self-consumption <10 kW	€28ct	12 years from the date of grid connection
Self-consumption from 10kW to 25kW	€18ct	12 years from the date of grid connection

10.1.6 Spain

In Spain, the current operational regulated return on equity is an incentive designed to allow RES-E to compete in the power market with conventional energy sources. Therefore, it's not qualified as a support scheme since its first aim is not to boost the deployment of wind power. Basically, a set of standard plants is used as model to calculate the rates allowing a reasonable profitability for the RES producer businesses. This ROE incentive is the only one in force. The allocation method is a tender procedure. Allowed returns are published publicly every year for the next one.

10.2 Design parameters description of country's auction schemes

10.2.1 Design parameters of onshore auctions in France/Germany

	Elements of onshore wind auctions	**France**	**Germany**
1	Nature of auction	Technology specific	Technology specific
2	Category of Auction	No differentiation observed	Different prequalification for professional bidders and community projects
3	Bidding procedure	Call for tenders or competitive dialogue procedure	Call for tenders
4	Determined value through auction	Reference price per kWh is used as basis for FIT	Reference price per kWh is used as basis for FIP
5	Support method	FIT to be replaced by "Compensation mechanism"	Sliding FIP
6	Price awarding mechanism	Pay as bid	Pay as bid (for standard projects), uniform pricing (for community projects)
7	Prequalification requirements	Administrative identification of the bidding company + environmental authorization	Permit registration + Approval of the building/land owners + Location analysis
8	Setting of min/max bid volumes	Min= 7 turbines or 1 turbines (>3 MW) Max= 500MW/rounds (18MW for community projects)	Min =750kW Max= 1. Mai 2017: 800 MW 1. August and 1. November 2017: 1000 MW 1 February, 1 May, 1 August and 1 November both 2018 and 2019 each 700 MW Beginning with 2020: annually on 1 February 1000 MW and on 1 June and 1 October annually 950 MW
9	Setting of min/max bid prices	Ceiling price to avoid overcompensation (2017 = €74.8/MWh)	For 2017: € ct. 7/kWh. For 2018, the price cap will be calculated with regard to the value of the winning bids of the year 2017

10	Participation fees	30€/Kw	Security deposit: €30/kW
11	Duration of support	20 years	20 years
12	Frequency of tenders	2 rounds/years	3 to 4 rounds per years
13	Presence of support budget limit	NC	No

10.2.2 Design parameters of onshore auctions in the UK/Denmark

	Elements of onshore wind auctions	UK	Denmark
1	Nature of auction	Wind vs Solar	Technology Neutral
2	Category of Auction	Contract for difference (Different prequalification regarding technologies)	No differentiation observed
3	Bidding procedure	Call for tenders	Call for tenders
4	Determined value through auction	Reference price per kWh is used as basis for strike price	Reference price per kWh is used as basis for FIP or Bonus
5	Support method	CFD, payment of the difference between strike price and market price	Fixed FIP
6	Price awarding mechanism	Constrained or unconstrained allocation	Pay as bid
7	Prequalification requirements	Budget notice + planning consents + being successful in an allocation round + connection agreements	Building permit
8	Setting of min/max bid volumes	Min: 5MW, Max= 1500MW	NC
9	Setting of min/max bid prices	Strike price 2018/2019= 90 GBP/MWh	NC
10	Participation fees	NC	NC
11	Duration of support	15 years	20 years
12	Frequency of tenders	2 rounds/years	NC
13	Presence of support budget limit	NC	NC

10.2.3 Design parameters of onshore auctions in Spain/Italy

	Elements of onshore wind auctions	**Spain**	**Italy**
1	Nature of auction	Technology Neutral	Technology neutral
2	Category of Auction	No differentiation observed	No differentiation observed
3	Bidding procedure	Call for tenders	Call for tenders
4	Determined value through auction	Reference price per kWh is used as basis for "reasonable profitability" payment	Reference price per kWh is used as basis for FIP
5	Support method	"reasonable profitability payment" (= return on equity)	Sliding FiP
6	Price awarding mechanism	Pay as bid	Pay as bid
7	Prequalification requirements	Qualification assessment to obtain the auction certificate	Declaration of a banking institution + Provisional caution to ensure the quality of the project
8	Setting of min/max bid volumes	Last auction round had a cap of 3000 MW to be auctioned	Min= 5 MW Max= 800MW
9	Setting of min/max bid prices	Ceiling price to avoid overcompensation	Ceiling price to avoid overcompensation (110€/MWh + project max 800MW)
10	Participation fees	NC	€ 2,200
11	Duration of support	NC	20 years
12	Frequency of tenders	No schedule settled	1 round/years
13	Presence of support budget limit	NC	Yes

10.2.4 Design parameters of offshore auctions in France/Germany

	Elements of offshore wind auctions	**France**	**Germany**
1	Nature of auction	Technology specific	Technology specific
2	Category of Auction	No differentiation observed	Different prequalification for professional bidders and community projects
3	Bidding procedure	Call for tenders or competitive dialogue procedure	Call for tenders
4	Determined value through auction	Reference price per kWh is used as basis for FIT	Reference price per kWh is used as basis for FIP
5	Support method	FIT to be replaced by "Compensation mechanism"	Sliding FIP
6	Price awarding mechanism	Pay as bid	Pay as bid (for standard projects), uniform pricing (for community projects)
7	Prequalification requirements	Administrative identification of the bidding company + environmental authorization	Permit registration + Approval of the building permit owner + bidder must be owner of an existing plant + Location analysis
8	Setting of min/max bid volumes	NC	Min= 750 kW Max= 2017 and 2018: 1550 MW each. After 2021 the annual volume caps will be in the range of 700-900 MW
9	Setting of min/max bid prices	Capped on bid assessment with decreasing FIT	For 2017: € ct 12/kWh. For 2018, the lowest winning bid of 2017
10	Participation fees	None	4,727 €
11	Duration of support	20 years	20 years (possible extension to 30 years)
12	Frequency of tenders	2 rounds per years	1 round per years
13	Realization time	NC	2 years
14	Presence of support budget limit	NC	No

10.2.5 Design parameters of offshore auctions in the UK, Denmark and Italy

	Elements of offshore wind auctions	UK	Denmark	Italy
1	Nature of auction	Wind vs advanced conversion technologies vs energy from waste with combined heat and power	Project specific	Technology neutral
2	Category of Auction	Contract for difference (Different prequalification regarding technologies)	No differentiation observed	No differentiation observed
3	Bidding procedure	Call for tenders	Call for tenders	Call for tenders
4	Determined value through auction	Reference price per kWh is used as basis for strike price	Reference price per kWh is used as basis for FIP	Reference price per kWh is used as basis for FIP
5	Support method	CFD, payment of the difference between strike price and market price	Fixed FIP	Sliding FIP
6	Price awarding mechanism	Constrained or unconstrained allocation	Pay as bid	Pay as bid
7	Prequalification requirements	Budget notice + planning consents + being successful in an allocation round + connection agreements	Building permit, Bidders must agree with tendered project capacities	Declaration of a banking institution + Provisional caution to ensure the quality of the project
8	Setting of min/max bid volumes	Settled before each round (limited to the capacity to be auctioned)	NC	5 MW minimum, 30MW maximum plant capacity
9	Setting of min/max bid prices	Strike price 2018/2019= 140 GBP/MWh	Ceiling price to avoid overcompensation	Max= 165€/MWh

			(depending on projects)	
10	Participation fees	Charges are at latest state of the project	NC	2,200 €
11	Duration of support	15 years	20 years	25 years
12	Frequency of tenders	2 rounds per years	3 rounds/years	1 round per years
13	Realization time	2 years	NC	43 months
14	Presence of support budget limit	NC	NC	Yes