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THE GREEN FUTURE OF ELECTRICITY: THE CASES OF URUGUAY AND THE EUROPEAN UNION

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THE GREEN FUTURE OF ELECTRICITY: THE CASES OF URUGUAY AND THE EUROPEAN UNION

Abstract:

The objective of this paper is to understand the policy and regulation changes in Uruguay and the European Union that led to the adoption of non-conventional renewable sources of energy in a short time span. Uruguay is one of only 3 countries in the world with more tan 90% of the electricity coming from renewable sources (98% in Uruguay) and where nonconventional renewables provide a significant contribution to it. Uruguay has also recently launched the first electric route in Latin America, with 500 Km and charging stations at 60 Km intervals. The European Union is an international reference in the promotion of sustainable economic growth and sustainable development. Therefore, we will also look at the experience of the European Union in the development of a green agenda where renewable sources of energy are a fundamental part of it.

Keywords: Electricity, Non-conventional Renewable Sources of Energy, Energy Policy, Energy Regulation, Uruguay, European Union.

EL FUTURO VERDE DE LA ELECTRICIDAD: LOS CASOS DE URUGAY Y LA UNIÓN EUROPEA

Resumen:

El objetivo de este trabajo es entender los cambios de política y regulación en Uruguay y la Unión Europea que llevaron a la adopción de fuentes de energía renovable no convencionales en un corto período de tiempo. Uruguay es uno de los 3 países del mundo con más del 90% de la electricidad proveniente de fuentes renovables (98% en Uruguay) y donde las renovables no convencionales aportan una contribución significativa. Uruguay también ha lanzado recientemente la primera ruta eléctrica de América Latina, con 500 km y estaciones de carga a intervalos de 60 km. La Unión Europea es una referencia internacional en la promoción del crecimiento económico sostenible y del desarrollo sostenible. Por lo tanto, también examinaremos la experiencia de la Unión Europea en el desarrollo de una agenda verde en la que las fuentes de energía renovables son una parte fundamental.

Palabras clave: Electricidad, Fuentes de energía renovables no convencionales, Política energética, Regulación energética, Uruguay, Unión Europea.

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Introduction

The energy market is changing worldwide. It is moving toward renewables, decentralized energy production and digital technologies (Corneli et al., 2015). This change is mostly driven by consumers. Consumers are demanding an energy market which allows them to have less impact on the environment, have a say in how energy is generated, generate electricity themselves, manage their own energy demand, assist networks in managing demand and choose a provider who meets their needs. As a consequence, these changes meet the social need to supply society with energy in a sustainable way (see for example Lutz et al., 2017; Scheer, 2011; Sathaye et al., 2011). This is fundamentally changing the way markets function and therefore the regulation needed.

Innovation in digital technologies is enabling a disruptive change in the way energy systems are operated. Digitalization can also be an important catalyst for decarbonization. Smart meters, smart grids, electric vehicles and distributed energy resources (DER), are creating a huge range of opportunities for consumers to use data to better manage consumption of energy.

Energy suppliers, meanwhile, can optimize their operations and develop new offers. System operators can benefit from increased availability of real-time data to manage their grids more efficiently and to integrate an increasing amount of variable renewables into the system.

Innovation and economies of scale in the production are driving down the cost of technologies, in particular in renewables (IRENA, 2018). Old sources of energy, based on carbon, fuel, etc. are being replaced by solar and wind. Even though these sources of energy have the problem of intermittency, new technologies are being developed to provide support for these intermittent technologies. For example, battery storage is becoming more efficient and is being trialed to support renewables. Now producers and consumer-producers (prosumers) are making decisions, for example, about when to store, sell and buy electricity.

In Latin America, Uruguay is leading the way towards renewable energy production and consumption. Indeed, in the last 10 years, there has been a significant structural transformation in the sector, characterized by a strong growth in the share of non-conventional renewable sources of electricity (46% in 2017), mainly wind and biomass.

Worldwide only 17 countries generated more than 90% of their electricity with renewable sources in 2017 (REN21, 2018). Uruguay is one of them with 98% of the electricity in the year 2017 coming from renewable sources. Moreover, in only three of them – Uruguay, Costa Rica and Ethiopia – wind power also provides a significant contribution. In the case of Uruguay, wind power accounted for 25% of generation and 33% of installed capacity in 2017. According to monthly electricity data for Uruguay, wind and solar reached 44% of total generation in January 2018, a new record that surpasses a previous 42% record set in December 2017.

Uruguay has recently launched the first electric route in Latin America with 500 Km of extension and charging stations at approximately 60 Km intervals (REN21, 2018). This is another example that shows that Uruguay is at the forefront of the green energy technology adoption in Latin America.

The European Union, and particularly the Nordic countries, is an international reference in the promotion of sustainable economic growth and sustainable development. Therefore, in this paper we will also look at the experience of the European Union in the development of a green agenda where renewable sources of energy are a fundamental part of it.

The objective of this paper is to understand the policy and regulation changes in Uruguay and the European Union that led to the adoption of renewable sources of energy.

The paper is organized as follows. Section 2 describes the main trends in the adoption of renewable sources of energy worldwide. Section 3 presents the Uruguayan case, describing the energy policy and the regulation of the electricity market. Section 4 provides an overview of the evolution of the regulatory and policy framework of the electricity market in the European Union, with special focus on the Nordic countries. Finally, section 5 concludes and discusses policy implications.

1. Main trends in the electricity sector worldwide

In this section we briefly describe the past trends in terms of supply and demand of electricity and the increasingly important role of renewables. We also show how the future looks like for renewables in the production of electricity.

1.1 The past and present

The world production of electricity has been multiplied by 4 in the last 40 years (Figures II.1 and II.2). The total global production of electricity reached 24,100 terawatts in 2015 (Figure II.2). Three quarters is generated with non-renewable resources. Hydropower accounts for most of the renewable power (17.2%). Wind and solar explains only 4.5% of total electricity production. Still, wind and solar were increasing fast in the last decade and are projected to be important sources of electricity in the future.

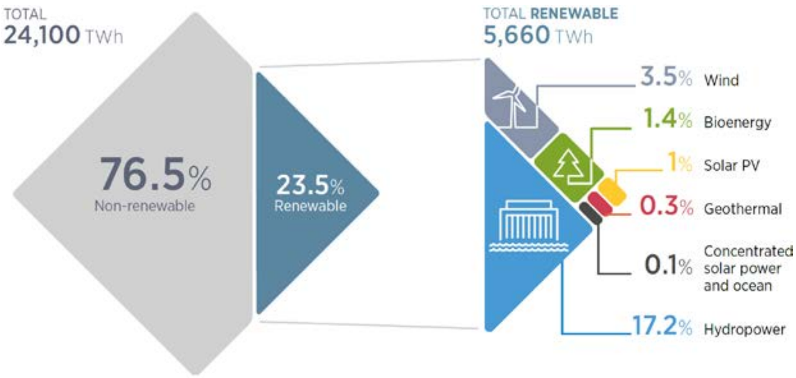
The total global electricity consumption in the year 2015 was 22,200 terawatts, of which 42% corresponded to industry consumption, 27% residential, and 22% commercial and public services (Figure II.3).

One interesting trend is that the capacity added is coming increasingly from renewable sources (Figure II.4). In 2016, almost 60% of the new capacity came from renewables. The installed capacity of renewables exceeded in 2016 28% of the world's total power-generating capacity (56% hydropower, 23% wind power, 15% solar power, 6% the rest of renewable sources). Moreover, while the annual capacity added of non-renewables has stagnated around 100 gigawatts in the last 15 years, the capacity added of renewables went from approximately 30 gigawatts in 2001 to more than a 150 in 2016. Solar PV and wind are leading the transition. The average annual growth rates of world solar PV and wind power in the period 1990-2016 was 37% and 24% respectively (Figure II.6).

Figure II.1. Global electricity production, 1973-2010

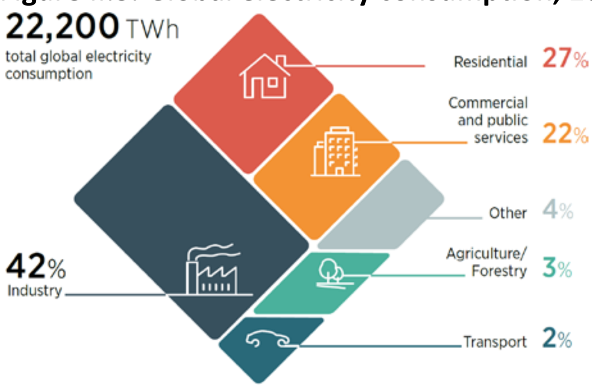
Source: IEA (2012).

Figure II.2. Global electricity production, 2015



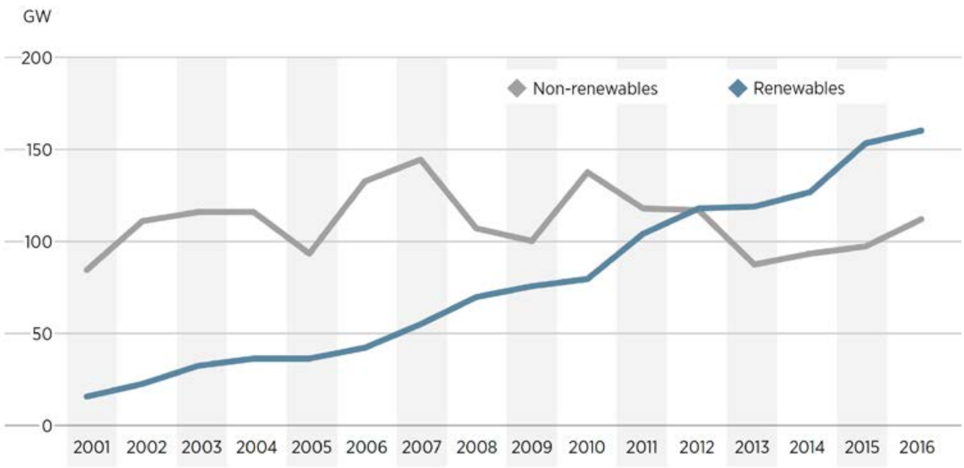
Source: IRENA, IEA and REN21 (2018).

Figure II.3. Global electricity consumption, 2015



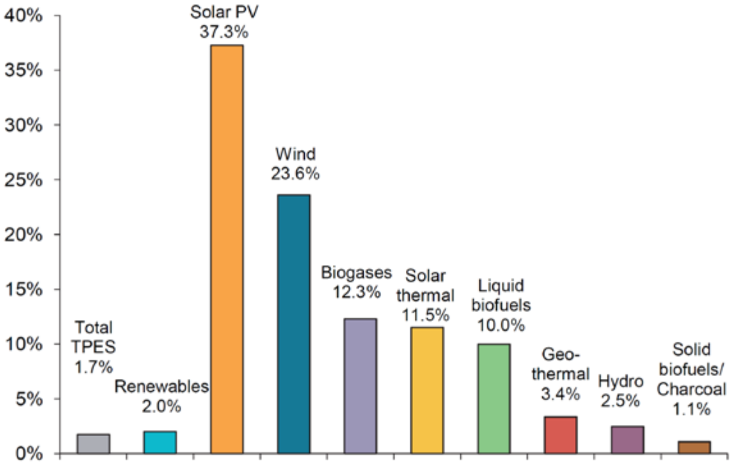
Source: IRENA, IEA and REN21 (2018).

Figure II.4. Global renewables and non-renewables capacity added



Source: IRENA, IEA and REN21 (2018).

Figure II.5. Average annual growth rates of world renewables supply from 1990 to 2016



Source: IEA (2018).

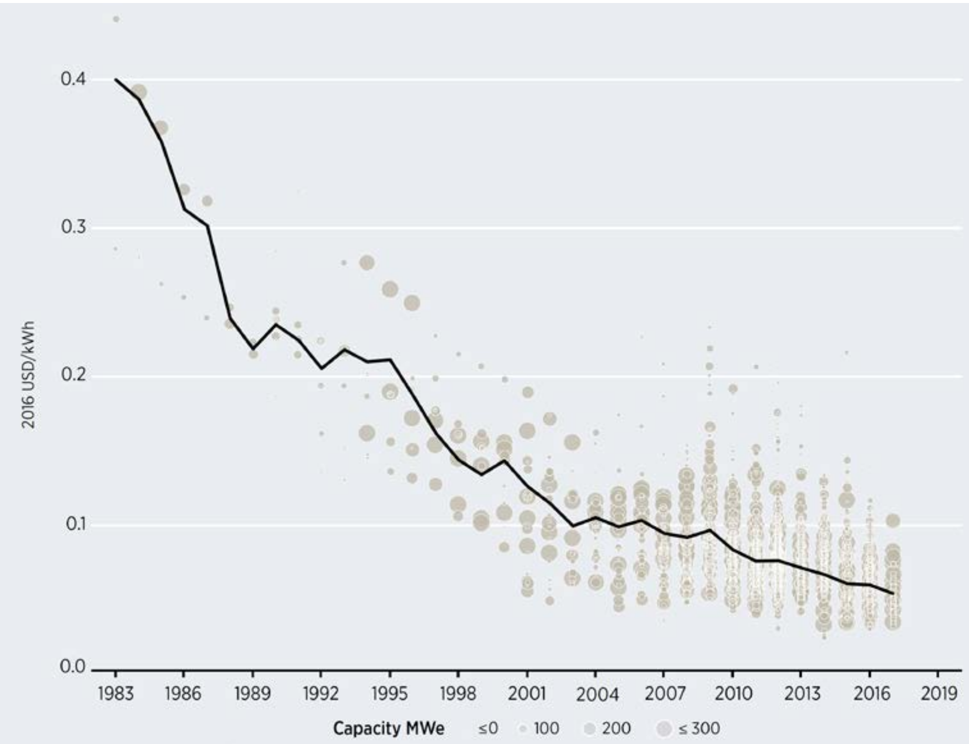
The increase in the renewables capacity of production, particularly solar PV and onshore wind, *vis a vis* non-renewables is explained by the continuous technology change and economies of scale gains that is making renewables cheaper over time. In Figure II.6, we show the trends in the levelized cost of electricity by generating source.[1] Onshore wind and solar photovoltaic is today competitive with the cheapest sources of electricity, particularly with hydropower.

[1] The levelized cost of electricity includes "equipment costs, total installed costs, performance (capacity factors), operation and maintenance (O&M) costs and weighted average cost of capital (WACC). The LCOE is an indicator of the price of electricity required for a project where revenues would equal costs, including making a return on the capital invested equal to the discount rate or WACC." IRENA (2018, p. 27).

Figure II.6. Global weighted average levelized cost of electricity (LCOE)

Note: The diameter of the circle represents the size of the project, with its centre the value for the cost of each project on the Y axis. The thick lines are the global weighted average LCOE value for plants commissioned in each year. Real weighted average cost of capital is 7.5% for OECD countries and China and 10% for the rest of the world. The band represents the fossil fuel-fired power generation cost range.
Source: IRENA (2018).

Figure II.7. Global weighted average levelized cost of electricity (LCOE) of onshore wind



Note: The diameter of the circle represents the size of the project, with its centre the value for the cost of each project on the Y axis.
Source: IRENA (2018).

Solar photovoltaic has reduced its price by more than 70% in 7 years, reaching a cost of 0.1 US dollar per kilowatt. Onshore wind has a cost of 0.06 US dollars per kilowatt, similar to hydro (0.05) that is the cheapest source of renewable energy. Onshore wind has reduced its cost by 85% in a period of 35 years, and this trend continues (Figure II.7).

1.2 The future

As described above renewables are increasingly positioned as the future of the electricity and more generally, energy production. They are becoming competitive with other sources of energy and some countries, particularly China, are investing heavily in facilities to produce in increasingly efficient ways the machines required for production of energy with clean and renewable sources.

The weight of renewables in the electricity matrix in 2060 varies according to different scenarios (IEA, 2017). Under a reference technology scenario (RTS) renewables in 2060 will double the current participation of renewables in the electricity matrix, accounting for more than 40% of the electricity generation in that year. Under the 2DS and B2DS scenarios more than 70% of the total electricity will be produced with renewable sources of energy (Figure II.8).

Under all the scenarios solar and wind power will become the main renewable sources of electricity by 2060. In the case of a B2DS scenario, solar and wind are set to dominate the production of electricity coming from renewable sources, relegating hydropower to a third place of importance (from the first position it currently has) (Figure II.9).

Scenarios

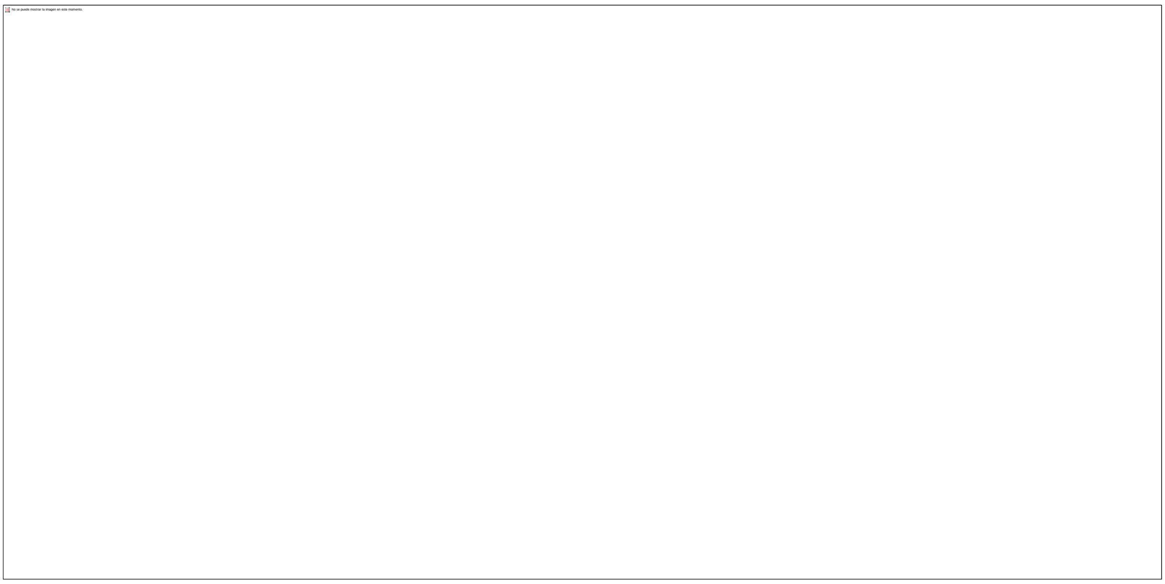
- The **Reference Technology Scenario (RTS)** takes into account today's commitments by countries to limit emissions and improve energy efficiency, including the NDCs pledged under the Paris Agreement. By factoring in these commitments and recent trends, the RTS already represents a major shift from a historical "business as usual" approach with no meaningful climate policy response. The RTS requires significant changes in policy and technologies in the period to 2060 as well as substantial additional cuts in emissions thereafter. These efforts would result in an average temperature increase of 2.7°C by 2100, at which point temperatures are unlikely to have stabilised and would continue to rise.

- The **2°C Scenario (2DS)** lays out an energy system pathway and a CO_2 emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C by 2100. Annual energy-related CO_2 emissions are reduced by 70% from today's levels by 2060, with cumulative emissions of around 1 170 gigatonnes of CO_2 ($GtCO_2$) between 2015 and 2100 (including industrial process emissions). To stay within this range, CO_2 emissions from fuel combustion and industrial processes must continue their decline after 2060, and carbon neutrality in the energy system must be reached before 2100. The 2DS continues to be the Energy Technology Perspectives's central climate mitigation scenario, recognising that it represents a highly ambitious and challenging transformation of the global energy sector that relies on a substantially strengthened response compared with today's efforts.

- The **Beyond 2°C Scenario (B2DS)** explores how far deployment of technologies that are already available or in the innovation pipeline could take us beyond the 2DS. Technology improvements and deployment are pushed to their maximum practicable limits across the energy system in order to achieve net-zero emissions by 2060 and to stay net zero or below thereafter, without requiring unforeseen technology breakthroughs or limiting economic growth. This "technology push" approach results in cumulative emissions from the energy sector of around 750 GtCO2 between 2015 and 2100, which is consistent with a 50% chance of limiting average future temperature increases to 1.75°C. Energy sector emissions reach net zero around 2060, supported by significant negative emissions through deployment of bioenergy with CCS. The B2DS falls within the Paris Agreement range of ambition, but does not purport to define a specific temperature target for "well below 2°C".

Source: IEA (2017).

Figure II.8. Electricity generation fuel mix by scenario



Notes: Reference Technology Scenario (RTS), 2°C Scenario (2DS) and Beyond 2°C Scenario (B2DS).
Source: IEA (2017).

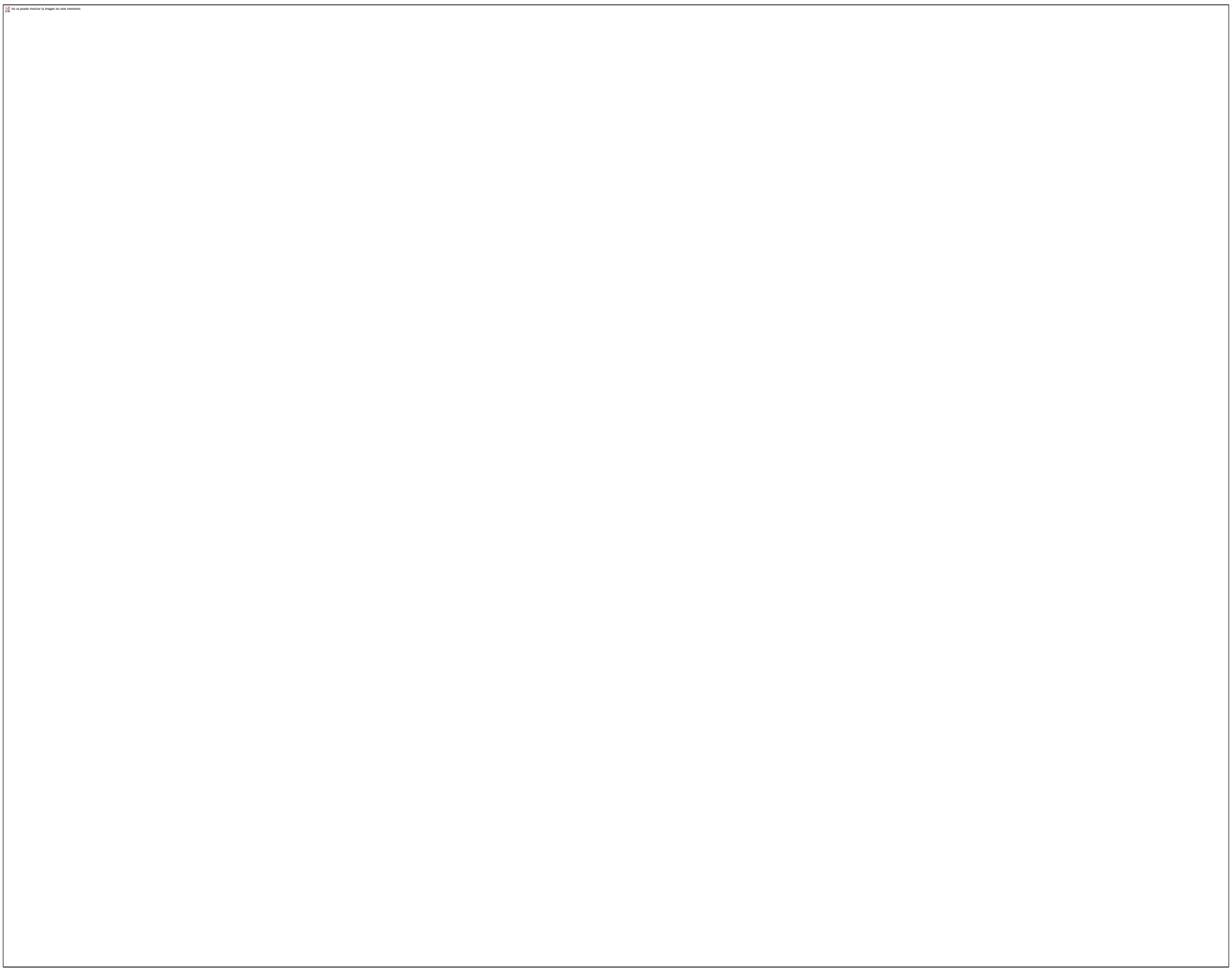
Figure II.9. Electricity generation by fuel under a B2DS scenario

Notes: Carbon Capture and Storage (CCS), Solar Thermal Energy (STE), Solar Photovoltaic (Solar PV).
Source: IEA (2017).

Still, hydropower will be an important source of clean energy in the future. Today hydropower still is the cheapest source of clean energy available (Figure II.6) and according to IEA (2012), in Latin America 74% of the hydropower potential is not currently used (Figure II.10). Moreover, hydropower has an important characteristic *vis a vis* wind and solar, it can be cheaply stored. With the current batteries' technology, pumped hydro storage (Figure II.11) is a very efficient way of energy storage (Figure II.12 and II.13).

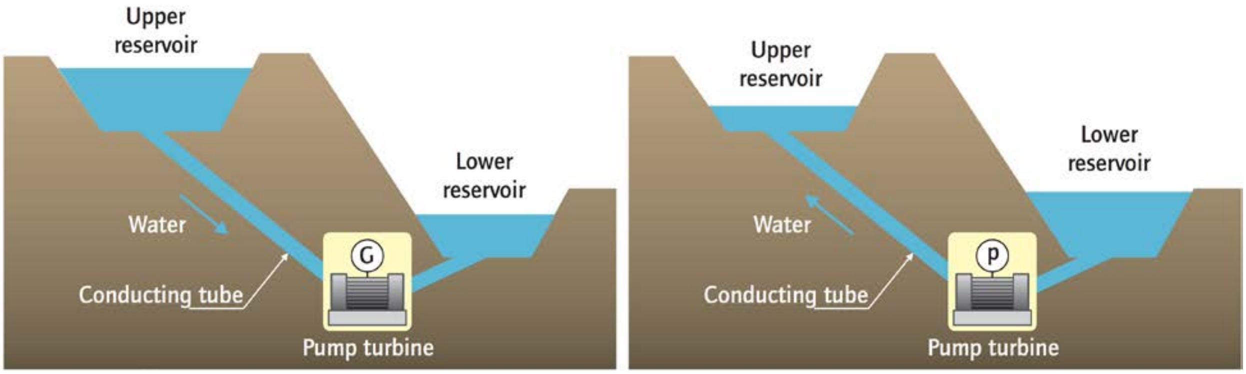
Of course, this can change in the future. On one hand, hydropower is a mature technology that is not set to important gains in efficiency. This implies that wind and solar, that are improving their efficiency fast, can be in a foreseeable future the cheapest sources of clean energy. On the other hand, batteries are becoming increasingly efficient and therefore could be in the future a cheaper system of energy storage. Batteries costs are falling rapidly. The cost today per kilowatt is less than one third of the cost fifteen years ago (Figure II.13). In addition, it is projected that, from the hand of the electric vehicles, the installed battery storage will increase significantly in the next 45 years. Electric vehicles are projected to increase to almost 300 hundred million by 2040 from the 2 million today (Figure II.14). Still, batteries are not projected to be a relevant source of energy storage *vis a vis* pumped hydropower storage in the foreseeable future (Figure II.15).

Figure II.10. Hydropower technical potential by region



Source: IEA (2012).

Figure II.11. Pumped storage system



Source: IEA (2012).

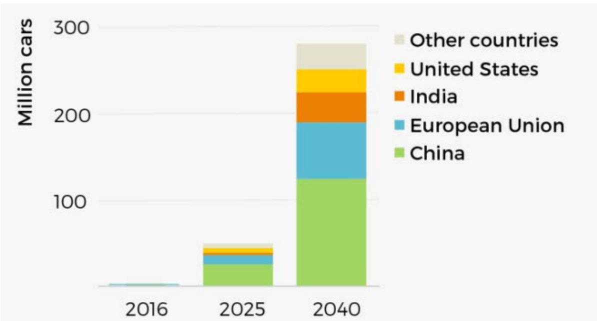
Figure II.12. Cost of different energy storage systems

Note: PEM FC = Proton exchange membrane fuel cell; SOFC = Solid oxide fuel cell; NiCd = Nickel cadmium battery; NaS = Sodium-sulphur battery; Va Redox = Vanadium redox flow battery; CAES = Compressed air energy storage. For the high case the assumed price for electricity is USD 0.06 per kWh; for the low case USD 0.04/kWh.
Source: IEA (2012).

Figure II.13. Installed batteries storage and costs under different scenarios

Source: OECD/IEA (2017).

Figure II.14. World electric car fleet



Source: IEA (2017).

Figure II.15. Globally installed storage capacity by source

Source: IEA (2017).

According to IEA (2017) clean energy technology is improving unevenly. It has made very important progress in solar PV, onshore wind, energy storage (batteries) and electric vehicles. However, accelerated improvement is needed in other renewable energy sources, nuclear energy, energy-intensive industrial processes, lighting, appliances and building equipment and in transport (particularly, in fuel economy of light-duty vehicles). Finally, technology has made little progress in carbon capture and storage, building construction, more efficient coal-fired power and transport biofuels.

2. The Transformation of the Electricity Sector in Uruguay

To properly assess the scope of the recent transformations of the electricity sector and its regulatory environment in Uruguay, one has to take into consideration the way in which the institutional structure of the provision of electricity was shaped in this country since the early 1900s.

The Administración Nacional de Usinas y Transmisiones Eléctricas (UTE), the State Owned Enterprise (SOE) acting as a monopoly in the transmission and distribution of electricity in the country, was created as such in 1912 (Law 4.273), even though the Uruguayan Government managed the provision of electricity in Montevideo (the capital of the country) since as early as 1897.

The creation of UTE was part of a broader political process of both the nationalization of existing privately provided public services and the creation of SOEs with multiple purposes. Amongst these, we can find economic, social and political goals (Bergara and Pereyra, 2005), all of which are relevant to understand the institutional characteristics of the sector today.

The economic goals explicitly pursued by legislators enacting the nationalization or creation of SOEs laws were to decrease prices of public utilities, improve the quality of services, and contribute to mitigate the regressive characteristic of the contemporary fiscal structure (by means of cross subsidies).

The social objectives referred to in the minutes of the parliament included the universal provision of public services, considering solidarity as one of the most important goals to pursue. Instrumental to the latter social objective, came the political aims, one of which assumed that the public interest comes before the private interest of firms (thereby granting the State the right to participate in the provision of "key" services fundamental to economic growth). Finally, the State was considered a good administrator: it was argued that it could create independent SOEs efficiently managed, without the burden of excessive bureaucracies (Nahum, 1993).

Despite the years, or maybe due to the passing of time, all of these elements are today profoundly entrenched in the Uruguayan idiosyncrasy. As an example, these considerations were key elements to prevent the privatization of many SOEs in the 1990s through direct democracy instruments.

In addition to considering the broader political process in which UTE was born, we also have to take into account the specific governance rules that apply to SOEs in Uruguay in general, and to UTE in particular, before the recent institutional transformation.

UTE is an Autonomous Entity, with an organizational structure and governance rules set by articles 185 to 201 of the Constitution of the Republic, which apply to Autonomous Entities and Decentralized Services. Other articles of the Constitution determine rules like the drafting, approval and control of its budget and the oversight of its financial management practices (Domingo and Zipitría, 2015).

According to Bergara et al. (2005), even though SOEs like UTE enjoy a certain degree of autonomy, the Executive Branch exerts considerable control over them by means of setting limits and holding the approval decisions of their budgets. Every five years, at the beginning of each government period, the Office of Planning and Budget (OPP, by its Spanish acronym), which depends of the Executive Branch, sets the guidelines of the SOEs´ budgets. This office also sets the parameters as to which the investment plans of the SOEs have to adhere.

With respect to the electricity market in particular, the Executive Branch authorizes the installation of new generators, and the export and import of electricity via contracts. Considering the price of electricity, UTE can propose yearly adjustments to the current price according to article 14 of Law 15,031 (1980). The final decision, however, is taken by the Executive Branch after taking into consideration the opinion of the Ministry of Economy and Finances (MEF, by its Spanish acronym).

Given this legal structure, key variables like their budgets, the prices of services, investments and debt management practices require the approval of the Executive Branch, therefore granting the latter veto power over the life of these companies. Interestingly enough, this framework exhibits the characteristic that none of the agents with veto power hold specific knowledge about the markets in which the SOEs operate. This is in part due to the fact that these agents (the Executive Branch, OPP, etc.) have multiple other goals to attend to and that the qualified human resources needed to ascertain the characteristics of each market are mostly employed by the corresponding SOEs.

In addition, as noted by Domingo and Zipitría (2015), in the last decades there has been a paradigm shift in the purposed role of public companies, where they are seen as a driving force of economic development. In this view, regulatory bodies are considered obstacles to the fulfillment of political objectives. These authors argue that this vision represents a great step back not only from an institutional perspective, but also for the companies itself. Considering consumer welfare, and realizing that most of them have access to considerable market power, regulatory bodies are the only ones that can guarantee that these companies achieve some degree of technical efficiency in the use of their resources. Finally, Domingo and Zipitría (2015) consider that this setback translated into a greater freedom of public companies to act in their markets regardless of the environment.

As mentioned before, the particular institutional framework is a fundamental ingredient to consider if one wants to answer questions related as to how the regulation of the future of the electricity sector in Uruguay will be shaped. New regulation will have to contemplate both UTE´s SOE structure that implies a particular type of interaction with the Executive Power, and, its interaction with its regulator and other relevant market participants that operate in the private sphere of the economy.

2.1 Recent modifications of the institutional framework of the electricity sector

Until 1997, the sector was regulated by the National Electricity Law (enacted in 1977), which established the monopoly of the generation, transformation, transmission, distribution, export, import and commercialization of electricity in favor of UTE. As a consequence of the enactment of the Law of Regulatory Framework of the Electric Sector (number 16.832 of 1997), the sector suffered relevant transformations.

The 1997 law established free competition in the generation and commercialization stages, creating the Electricity Wholesale Market (MMEE, in Spanish) and designating the Electricity Market Administration (ADME, for its Spanish acronym) as its administrator. The public service regime for the transmission and distribution of electricity was maintained as monopoly, with UTE being the owner of such services. Both for the transmission and distribution of electric power, prices (tolls) are regulated, as is the quality of the service, and the principle of free access to the networks governs, which allows the competition of the generators within the market.

As implied by its main provisions, the Law of Regulatory Framework of the Electric Sector looked for a redefinition of the electric sector in Uruguay. The main goal was to promote competition at the generation step of the production process and to separate generators from the transmission and distribution operators of the grid. As mentioned above, the last two activities remained in the hands of UTE (as regulated natural monopolies), while the principle of equal access to the grid was sanctioned for all generators. The idea was to break a vertically integrated enterprise (UTE) so that the incentive to discriminate against other generators would be mitigated. Although the commercialization (or retail sales) of electricity is also opened to competition by this norm, as of today no other agent than UTE is performing this task.

These provisions are in line with changes promoted in electric sectors worldwide, looking for greater competition and leaving regulation in the hands of sectoral regulatory entities, as will become evident in further sections of this document.

Exploiting the fact that generation is now defined as a free activity, subject to competition, and open to participation by the private sector, several generation projects have been developed by companies to sell their energy to UTE in recent years. The private sector participates as a supplier of UTE in Engineering, Procurement and Commissioning (EPC) contracts, or simply in contracts for the supply of equipment, both in generation projects, and in electricity transmission and distribution network infrastructure

The Electric Energy Regulatory Unit (UREE, by its Spanish acronym), the regulatory agency for the electricity sector was created in 2000. During its short life, it mostly developed proposals tending to increase the competition in the sector. The autonomy of the UREE was relative, as it could propose regulations related to the operation of the electricity market but the approval of them corresponded to the Executive Branch. In 2002, this regulatory unit was modified, and it was renamed the Energy and Water Services Regulatory Unit (URSEA, by its Spanish acronym). This modification established the inclusion of other sectors within the markets to be regulated (water, fuel and gas) and reduced its autonomy, through the reduction of its funding and therefore technical capacities.

As of today, URSEA´s regulation objectives include: the protection of user´s and consumer´s rights, the enforcement of current regulations, setting the requirements to be met by those who carry out activities related to these sectors, settling claims presented by users, to propose to the Executive Branch fees of regulated services, and to prevent anticompetitive conducts and abuse of dominant market positions.

Contributing to the limited regulatory control exerted by the URSEA over UTE is the fact that the set of requirements that UTE has to abide to (from being an SOE) comes before the creation of the regulatory body and has a Constitutional rank. This means that there is little room for URSEA to monitor or regulate other that the quality of the electricity service and some other specific aspects of the business: ensuring that the principle of free entry into the grid is guaranteed, checking all contracts between market players to identify possible abuse of market power, estimating the toll paid to UTE for the use of the transmission and distribution network, etc. Finally, it is interesting to note, as mentioned earlier, that the veto power over some key UTE´s decisions (budget, investments, etc.) does not rest with the URSEA, but with the Executive Branch, through the OPP and/or the MEF.

In addition to the structural reforms imposed by the Law of Regulatory Framework of the Electric Sector of 1997, additional Decrees contributed to the actual regulatory framework of the sector. Amongst the most important, we can cite Decree 276 of 2002, which approves the regulatory framework of the national electric system, following the principles of freedom of choice of supplier (for big consumers only), free competition of generators, transparency, and regulated prices according to costs of production. During the same year, the corresponding regulatory frameworks for the transmission, distribution, and operative aspects of the electric market are approved, by Decrees 278, 277 and 360 of 2002 respectively. This set of norms, altogether with the regulatory entity (URSEA), built the current scenario in which the electric sector operates in Uruguay.

2.2 Promotion of non-conventional renewables sources of energy in Uruguay (NCRS)

Uruguay constitutes a rather unique example in the successful construction of a solid political consensus to modify its energy matrix. This process started in 2005, and materialized in February 2010, when the Government approved the "2005 – 2030 Energy Policy" (PE, for its Spanish acronyms) with the agreement of all political parties with parliamentary representation.

In general, the PE determined that energy should reach all inhabitants in a secure way, at affordable prices, promoting the competitiveness of the domestic industry, respecting the environment and making use of the energy policy as an instrument to build both productive capacities and a more cohesive society.

From an institutional point of view, this is the instrument by which private actors were encouraged to interact with SOEs to reach the below described goals. It also states that the regulatory framework should be clear to all actors involved (including regulatory agencies) and determines the roles of each actor (Executive Branch, SOEs, private actors, regulatory agencies, etc.). Finally, it specifies that prices of different energies (electricity included) are to be determined by the Executive Branch and that, in case that subsidies exist, they should be clearly stated.

With respect to the supply of energy, the PE states that the energy matrix should be diversified (both in terms of sources and suppliers), if possible adopting *local resources of energy* (in particular renewables). The PE calls for a promotion of energy efficiency practices in all sectors of national activities. The public sector must be an example, by using its resources efficiently, and promoting, through education and cultural change, the adoption of energy efficient practices at all levels (residential, commercial and industrial).

Additionally, efforts should be made to reduce the cost of energy, the dependence on the imports of oil, and the impact on global warming. One application of this goal involves the transport sector, the highest consumer of energy at the country level. According to the PE, policies should be implemented to encourage the adoption of electric transportation. These include tax exemptions, fostering of public transportation, inclusion of biofuels, etc.

Considering the electric sector in particular, the PE translated into the promotion of investments in wind farms, solar photovoltaic panels, and other types of infrastructure to capture energy from NCRS (i.e. biomass and solar thermic).

The PE aimed to reach year 2015 with 50% of the energy matrix from renewable local sources, 15% of electricity generation coming from NCRS of energy (wind, biomass and hydraulic microgeneration) and 30% of agroindustrial and urban waste being used to generate energy. The PE was implemented through a series of Laws and Decrees fostering the adoption of NCRS of energy and promoting the culture of energy efficiency (on the demand side).

A non-exhaustive list of norms that promoted the change in the energy matrix in general, and the generation of electricity from NCRS of energy in particular, includes the following Decrees:

• Decree 354 of 2009 grants specific tax incentives for the sector of NCRS of energy based on article 11 of the Law for the Promotion and Protection of Investments (Law 16.906).

• The Law for the Promotion of Solar Thermal Energy (Law 18.585 of 2009) declares of national interest the research, development and training in the use of solar thermal energy. In this sense, it includes investments in the manufacture, implementation and effective use of solar energy as some of the activities available to access the exemptions provided by Law 16.906 mentioned above.

• Decree 173 of 2010 authorizes subscribers connected to the low voltage distribution network to install generation of wind, solar, biomass or mini-hydro renewable origin, previous fulfillment of some requirements in relation to installed power.

Specific Norms (Laws and Decrees) about the promotion of wind energy

• Decree 284 of 2016 sets the price of energy demanded by industrial consumers that generate electricity from wind energy as stated in Decree 158 of 2012.

• Decree 116 of 2013 determines the (updated) price of energy demanded by industrial consumers and producers of electricity based on wind energy.

- Decree 158 of 2012 fosters and sets the terms of buy-sale contracts of electric energy between UTE and industrial consumers that are also producers of electricity using wind energy.

- Decree 424 of 2011 encourages buy-sale contracts of electric energy between UTE and non-beneficiaries of competitive auction K41938.

- Decree 403 of 2009 promotes the celebration of contracts between UTE and generators of electric energy based on wind energy. It set the guidelines for such contracts up to a total of 150 MW of nominal installed power, leaving for further norms the calling for the extra 150 MW necessary to reach the goal set for 2015.

- Decree 258 of 2009 calls for the implementation of a "wind map of Uruguay", giving priority to exploit this resource to those individuals (public or private, national or foreign) that provides relevant measurements at given coordinates.

- Decree 007 of 2006 sets the total nominal installed power between biomass, wind and small hydraulic power plants sources at 60 MW (evenly divided between each source).

2.3 Renewables in the electricity matrix in Uruguay

In general this new framework promoted the inclusion of NCRS of energy by making investments in the necessary infrastructure profitable for the private sector. Most of the mechanisms put forth by laws and decrees during this period mandated UTE to auction contracts to buy directly from generators (up to 300 MW in total by 2015). The latter usually stated that UTE only (while the contract is effective) will buy all the energy generated, and that the unitary variable cost would be set to zero. This last provision meant that the electric energy would be always dispatched when generating. Additionally, NCRS of energy will pay no distribution charges. These conditions were specified for a long enough period so that the initial investment would turn eventually into a profitable business opportunity at a reasonable rate, usually fifteen or twenty years. The type of restrictions set to the (mostly) private generators based on NCRS of energy was based on power capacity, usually a maximum of 10 or 50 MW.

Therefore, generators of electricity that used NCRS of energy were beneficiaries of what is known as a feed-in tariff: the producer receives a price for the electricity it pumps into the grid that is above market prices, with the aim of securing the return on its investment. As is usual with pay schemes that distort prices, the risk of over subsidizing these investments is present.

The promotion of NCRS of energy was a success. By December 2015 the energy supply matrix reached 57% of renewable sources, exceeding the 50% expected goal, and electricity was not imported for the third consecutive year. By the same date, the country had 26 wind farms, of which 19 were installed in the last two years (note that the starting point in this regard corresponds to the year 2005 when there were no large wind farms). This represented a 21% share of wind power in the electricity generation matrix in 2015.

Figure III.1 shows the evolution of total installed power of the Interconnected National System (SIN, by its Spanish acronym) for the period 2005 to 2017. One can appreciate the recent sharp increase in installed power experienced by both wind and solar sources. Installed power available at the SIN for the former increased by 250% between 2013 and 2017, while installed power available at the SIN for the latter increased by 150% in the same period.

To make this evolution more evident, we include Figures III.2 and III.3 that show the available installed power capacity at the SIN for years 2005 and 2017. Between 2005 and 2017, the participation of fossil fuels decreased from 24% to 18%.

Renewables sources of energy represent now 82% of the total installed power capacity to generate electricity.

Having the capacity to produce electricity from NCRS represents a good achievement in itself, but one has to consider if incentives are aligned so that this potential is exploited. As we can observe from Figures III.4-III.6, electricity in Uruguay is generated almost exclusively from primary renewable sources of energy (they accounted for 98% of the electricity produced in 2017)(see the 2017 energy balance of Uruguay in Appendix 2).

Figure III.5 shows the generation of electricity matrix in 2005, highly dependent on hydro power and fossil fuels. The aforementioned dependence on rainfall meant that in 2006 (an exceptionally dry year, technically, the driest year in the previous 100 years), 36% of electricity was produced based on fossil fuels.

This situation had a heavy impact in the cost of production of electricity, as the matrix was not enough diversified. As one can appreciate in Figure III.6, the current generation matrix exhibits greater diversification, and NCRS of energy have a strong presence.

To consider the evolution of prices, we average prices of electricity for each type of consumer: residential, commercial and industrial.

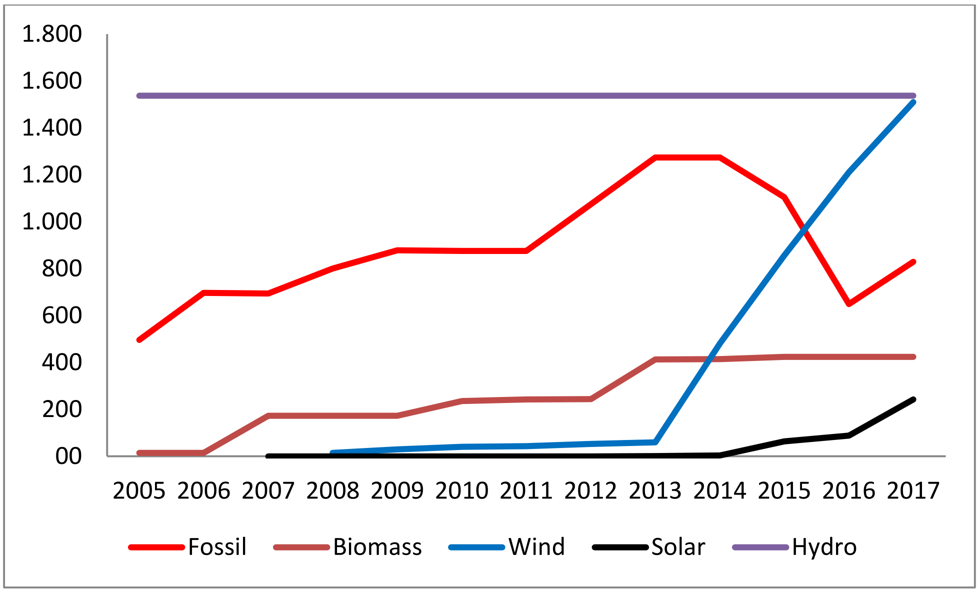
Averages are obtained over prices for each applied price scheme for each type of consumer (e.g. simple residential, residential basic, simple general, etc. for residential consumers). Figure III.7 shows the evolution of monthly prices from February 2010 to September 2018.

Visual inspection confirms that all types of consumer´s prices evolve in a similar way over the period. Additionally, industrial clients pay lower prices of electricity of all three types of clients, whereas residential consumers pay the highest price. Prices of electricity in the period remained relatively stable. Indexes of prices over the period show that the price for residential clients is the same as in February 2010, the price for commercial consumers is

95% of the price at the beginning of the period, and the price for industrial consumers is 99% of the price in February 2010.

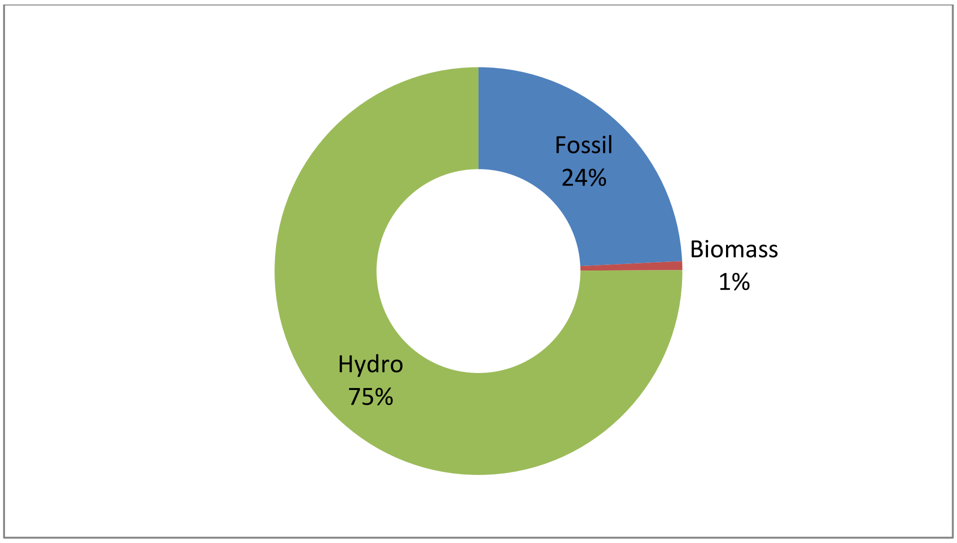
Additionally, the National Energy Efficiency Plan (regulated by Law 18,597 of 2009) established the implementation and deepening of various lines of work for the promotion of energy efficiency, as well as the appropriate financial mechanisms for the promotion of the efficient use of energy in the country.

Figure III.1. Installed power by source (in MW)



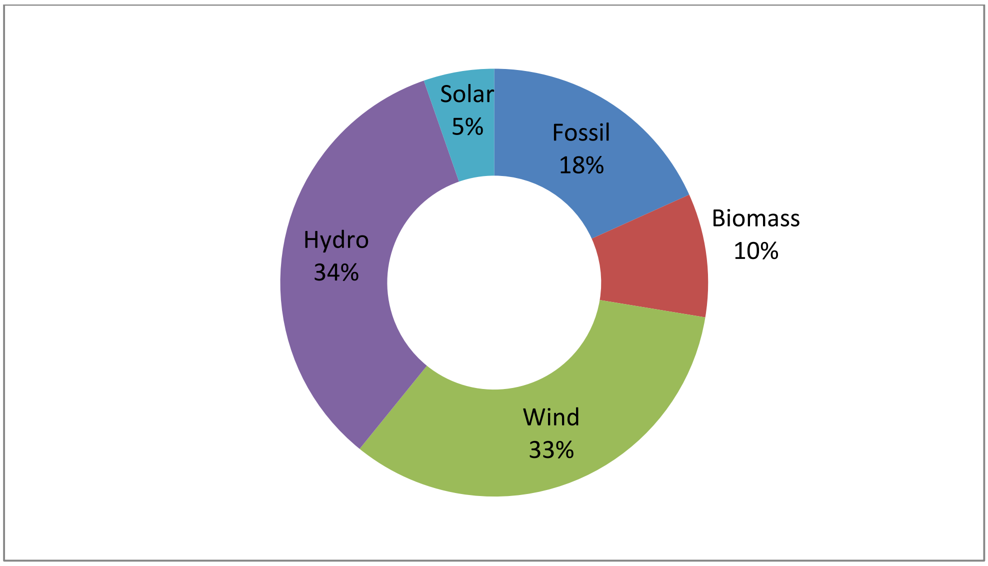
Source: Energy Balance Uruguay 2017 (MIEM)

Figure III.2. Installed power by source in 2005 (in %)



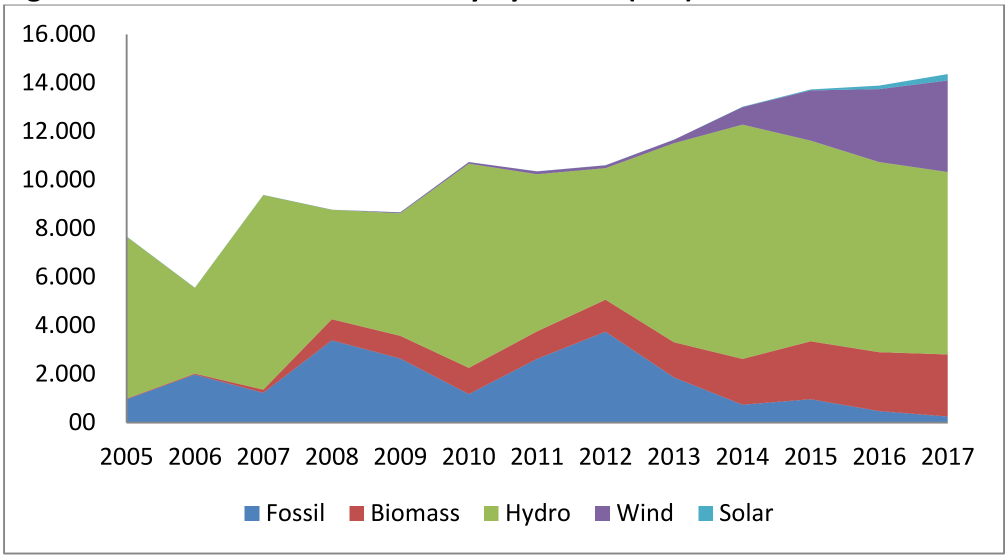
Source: Energy Balance Uruguay 2017 (MIEM)

Figure III.3. Installed power by source in 2017 (in %)



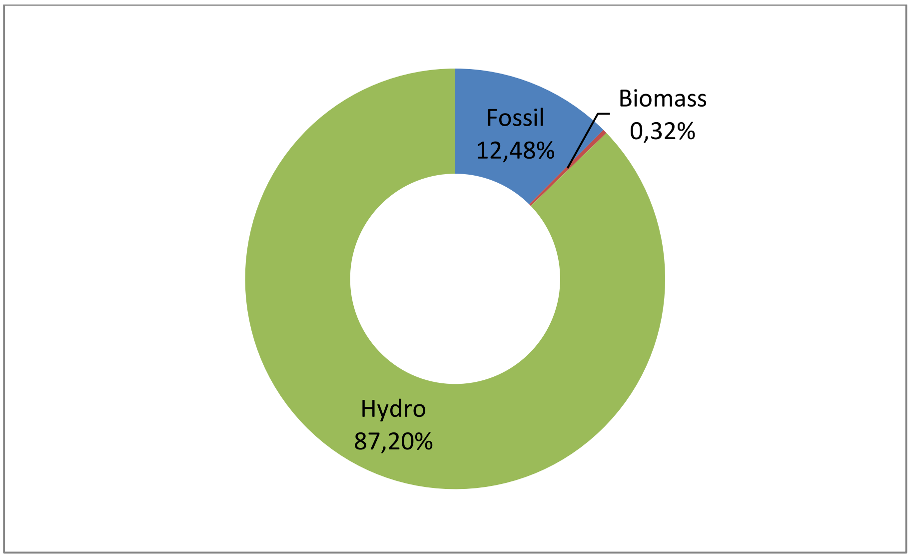
Source: Energy Balance Uruguay 2017 (MIEM)

Figure III.4. Generation of electricity by source (GW)



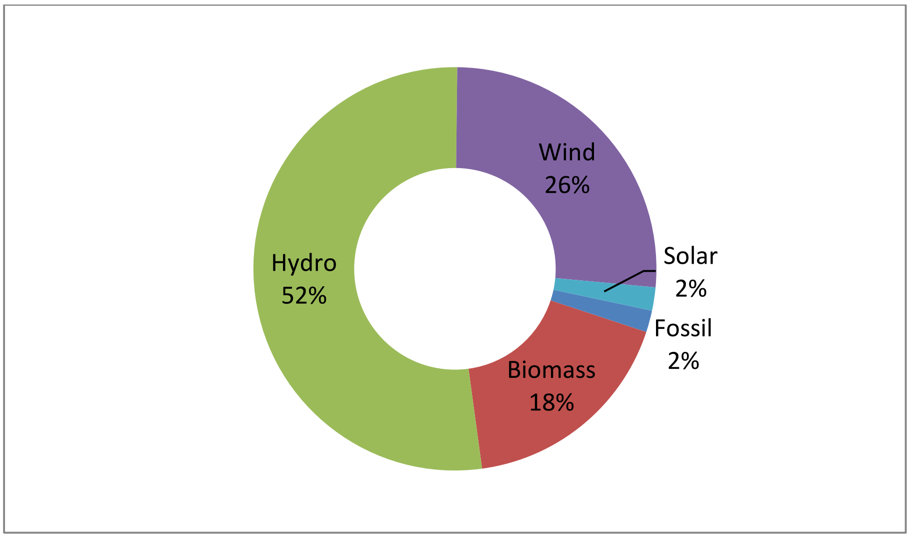
Source: Energy Balance Uruguay 2017 (MIEM)

Figure III.5. Generation of electricity by source in 2005 (in %)



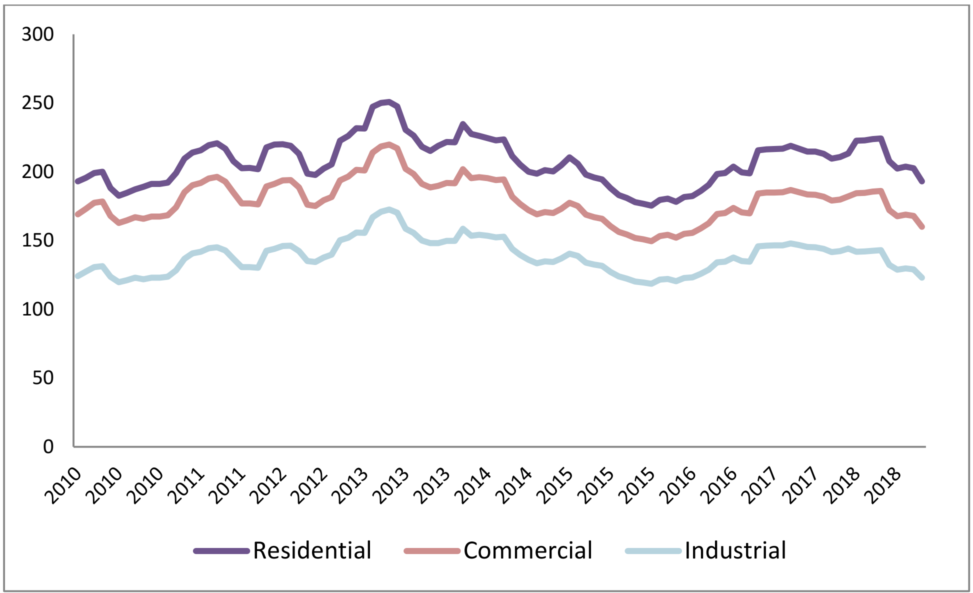
Source: Energy Balance Uruguay 2017 (MIEM)

Figure III.6. Generation of electricity by source in 2017 (in %)



Source: Energy Balance Uruguay 2017 (MIEM)

Figure III.7. Average price of electricity (USD/MWh)



Source: Series Estadísticas de Energía Eléctrica (MIEM)

2.4 Operation of the electricity market

2.4.1 Markets Structure

The transmission and distribution of electricity operate as regulated natural monopolies, with UTE being currently both the transmission system operator (TSO) and the distribution system operator (DSO). Tolls for both the transmission and distribution of electric energy are regulated, as well as the service´s quality standard. The generation of electricity is dispatched according to variable costs of production in an hourly basis by the National Cargo Office (DNC, by its Spanish acronym). Market transactions take place either in the term contract market or in the spot market.

Medium to long-term transactions are conducted by contract. These instruments are used to hedge risk and as insurance of the availability of firm capacity in the event of a shortage of electric energy generation. However, it is impossible to satisfy all transactions based on contracts, as it is impossible to determine future demand. Therefore, surpluses and shortfalls that arise as a difference between contracts and actual consumption are traded in the spot market. In this market the price is determined on an hourly basis by the DNC and published daily by ADME. The short term system dispatch takes place independently of transactions set by contracts and ensures that energy reaches consumers at its lowest possible cost at all times. Sales in the spot market arise naturally for generators that are dispatched for a quantity larger that they have compromised in contracts. For generators that have no contracts and are dispatched, all their energy sells in the spot market.

2.4.2 Market agents and participants

The regulatory framework defined MMEE agents and participants. The former are sector stakeholders and big consumers. The latter are agents authorized to buy or sell energy at the MMEE and authorized marketers that represent one or many agents.

Generators are considered MMEE participants. Although according to the regulatory framework they can sell energy at the spot or contract markets (to distributors, big consumers, marketers and other countries), in practice this does not happen. A number of restrictions prevent generators to sell to the above mentioned entities: tolls (or fares) to be paid to UTE per the use of the network are not yet fully estimated, and contract design restrictions apply (UTE buys all the energy from generators). Firms that generate electricity for self-consumption (i.e. prosumers) are also considered MMEE participants. Since 2010, micro-prosumers of renewables are allowed to sell their excess supply.

The transmission agent, currently UTE (TSO), is not a MMEE participant. It operates a regulated monopoly, and the Executive Branch has the opportunity to designate another entity in the case of a grid expansion. Fees (tolls) paid by users of the grid are regulated.

The distributor is currently UTE (DSO), which operates the network as a regulated monopoly. As in the case of transmission, the Executive Branch can designate other regional entities as distributors. The distributor is an agent, but not a participant in the MMEE.

Big consumers (that require power greater or equal to 250kW) are MMEE participants. They can buy electricity directly at the MMEE, skipping the distributors. To date all big consumers still buy from UTE.

Transactions in the contracts markets can take the form of a supply contract, a backup contract or a special contract. Supply contracts are created to maintain the ability of the system to supply electricity (i.e. avoid rationing during a year with low precipitations). Considering the first two types of contracts, generators can only pledge in these contracts their firm capacity (energy delivered with more than 95% probability). Generators with variable capacity (wind, solar) only can sign backup contracts with other generators. Big consumers have to contract a year in advance at least 70% of their load curve (energy needs) through supply and backup contracts, where prices and conditions are freely set between parts. The Distributor also has to contract in advance using these contracts, but percentages are a function of the amount of regulated (small-consumers) and (potential) non-regulated consumers (i.e. big consumers). In general these percentages are set at 90% and 70% respectively.

Annually, and three years forward, the Executive Branch sets the objective of national backup (installed generation) for Uruguay. If the generation pledged in contracts is not enough, the ADME auctions the shortage. Both new generation (to be installed) and current market players (with no contracts) can participate in the auction.

Special contracts are agreements between a producer and a group of consumers. There are two types of them: supply special contracts (analogous to supply contracts), and secondary energy special contracts. The latter have the following characteristics: they do not include the purchase of firm capacity, and every time generators are producing, they are selling to the contract (unless all energy is already pledged in supply or backup contracts). These types of contracts apply mostly to variable capacity generators (i.e. wind).

Finally, the ADME manages both the MMEE and the DNC. This last function implies enforcing contracts between generators, distributors and big consumers and the satisfaction of the electricity demand based on guidelines set forth by Law 16.832 (Regulatory Framework for the National Electric System). To comply with these goals and ensure the transparency of the system, ADME´s board of directors is composed of five representatives from the system stakeholders (one for each of the following): the Executive Branch (who presides ADME), UTE, the Salto Grande Dam, Big Consumers, and Generators.

The following diagram summarizes the different agents that interact in the electricity market.

2017 Total Available Installed Power: 4,289 MW

Generation

UTE
- Hydro (593)
- Solar PV (0.5)
- Wind (87)
- Thermic (827)

Private Generators
- Hydro (945)
- Solar PV (241)
- Wind (1,351)
- Thermic (3.2)
- Biomass (176)

Public/Private
- Wind (65.1)

URSEA: enforces the principles of free entry, free competition, and no abuse of dominant position in generation contracts.

Executive Branch: determines the maximum stock of installed power per renewable source of energy

Transport

Transmission (High Voltage):
UTE (Transmission System Operator). Public Service operated as a regulated natural monopoly.

Distribution (Medium and Low Voltage):
UTE (Distribution System Operator). Public Service operated as a regulated natural monopoly.

URSEA: advises the Executive Branch on prices per use of the grid (network tolls)

Electric Energy Wholesale Market (MMEE) and National Cargo Office (DNC)

The DNC dispatches generators according to variable costs of production in an hourly basis.

Transactions take place at the contract or spot market. Spot price is determined on an hourly basis and by the DNC and published daily by the administrator of the MMEE.

Commercialization

Regulated Consumers
Buy from UTE at prices set by the Executive Branch.

Big Consumers
Consume more than 250 kW, and can buy from UTE (DSO) or from any other generator.

Prosumers
Buy and/or sell energy at the contract or spot markets (at the MMEE)

Exports

URSEA: regulates the quality of the service (reliability, wave quality, etc.) + sets fines to the DSO in case of no compliance to quality standards.

2.5 Uruguay 2050

According to our meetings with representatives of UTE and the DNE, UTE´s future plans with respect to electricity generation are focused on the inclusion of more solar photovoltaic energy. This is primarily due to the existing installed generation power of wind energy: close to 1500 MW, around one third of total installed power (Balance Energético Nacional 2017, DNE), and the fact that wind farms generate electricity mostly at night, while photovoltaic energy is generated during the day (as of today there are around 200 MW of installed power in photovoltaic energy). Additionally, the price of the photovoltaic infrastructure recently decreased and is comparable to investing in wind energy. As both sources of energy cannot be stored (at manageable costs), it is crucial for an optimum use of the grid to have both sources complementing each other. This being said, it is not clear which agents will invest in this technology. As of now, and this is safe to expect in the short term, the cost of installation of photovoltaic panels make this investment non profitable for resident consumers.

Therefore, we can expect the surge of more wind farms (either owned by UTE, by private agents, or by a combination of both) in the near future. The amount of installed power will of course be determined by the Executive Branch, but in close consultation with UTE (which estimates the need for installed power). However, even in the short run (with current relative prices) it is possible that a group of resident consumers may choose to install photovoltaic panels in an effort to lower their electricity bill. Additionally, if photovoltaic technology (panels, batteries, transformers, etc.) prices experience a sharp decline it might be possible for residential consumers to start shifting to this source of energy to satisfy their electricity needs.

Most innovations in terms of products and/or strategies defined to promote a more efficient use of the grid are currently coming at UTE´s initiatives, in close coordination of the DNE. The following are examples of how UTE is currently defining strategies to combine a more efficient use of the grid in a scenario of technological change determined mostly by the incorporation of generation of electricity based on NCRS of energy (mostly photovoltaic).

UTE has already gathered information about the demand for electricity used to heat water by residential consumers. The purpose of this program is for UTE to be able to offer a different rate, in which residents grant UTE the ability to turn on and off their electric water heater in exchange for lower electric bills. In this way, based on the behavior of residents, UTE can turn on and off these appliances at its will, thereby optimizing the use of the grid. As an example, if hot water will be used only once per day at around 8 to 10 pm, UTE can turn on the water heater at 3 pm (off peak consumption of electricity hours), thereby lowering the flow of electricity in the grid at peak hours. This action has the potential to decrease the need and/or frequency of (very costly) grid (maintenance and/or expansion) investments without affecting residential consumers´ comfort.

UTE participates in programs aimed at including electric taxis in Montevideo. In January 2018, the local government of Montevideo auctioned 30 electric taxis licenses. By then, the Executive Branch (through the MIME) decided to subsidize the adoption of 20 of them (a total amount of USD 5,000 per taxi), whereas UTE contributed with additional funds to subsidize the other 10 taxis. UTE is a major stakeholder in this process that aims to incorporate 400 electric cars by 2020 (there are 54 operative electric taxis in Montevideo as of today, the next move being the conversion of 90 internal combustion engine taxis to electric ones).

Additionally, UTE pushed for the inclusion of Article 325 in the Execution Bill of the 2017 National Budget. This article grants the Executive Branch the ability to implement a subsidy to promote the transition to electric public transportation at the national level. This article states that the Executive Branch can subsidize the acquisition of electric buses up to the difference between the purchase price of an electric bus and a diesel bus (other provisions apply as well). UTE is also providing expertise and technical support to the installation of electric cars charging stations. By the end of November 2018, six more electric cars charging stations were inaugurated in Montevideo. This adds to the ones available throughout the 500 Km route that connects Colonia and Chuy (namely all of the southern border of Uruguay from west to east).

The promotion of electric transportation has many implications for UTE. Amongst them, in the future UTE can not only optimize the use of the grid, by encouraging owners of electric cars/buses to charge their batteries at off peak hours and maybe buying electricity from car/buses batteries when needed (at peak demand hours). Of course the opportunity to conduct such trades will be shaped not only by technological changes (that will make electric means of transportation more affordable, for example) but also by future regulation.

It is worth noting that on top of the strategies described immediately above; UTE has been implementing multi hour fares for its clients for more than 25 years now, precisely to optimize the use of the grid. These fares encourage the demand for electricity off peak hours. At the same time, grid investment have been financed mostly by the big consumers (which are the ones creating the need for grid upgrades). This policy is implemented by designing fares in brackets, with higher prices at higher consumption levels.

According to current regulations, consumers of electricity are not authorized to generate its own electricity and have batteries at the same time they are connected to UTE´s grid. This will probably have to change, as it is a possibility that prices of batteries and solar panels decline by that much that people will opt to disconnect from the grid. Changes in the regulatory framework can be pushed by UTE or by the regulator (URSEA).

3. The development of renewable energy and its regulation in the European Union

The European Commission aims the European Union to keep being (or become) an international reference, a global leader, in the promotion of sustainable economic growth and sustainable development. Part of this goal is echoed in the promotion of renewable sources of energy.

The European Commission requires the EU to achieve at least 20% of its total energy needs with renewables by 2020, although different goals have been established for different countries within the Union (being the lowest target 10% in Malta and the highest 49% in Sweden). At the same time, by 2020, at least 10% of transport fuels should come from renewable sources (ec.europa.eu, 2018a). By 2030, the target for the proportion of renewables in the final energy consumption was set to 32%, with a clause for an upward revision by 2023 (ec.europa.eu, 2018c). The EU has proposed to reduce greenhouse gas emissions in the Union by at least 40% by 2030 (European Parliament, 2016a).

The existing differences in the generation and use of renewable energy within countries in the European Union and other associated countries makes the regulatory framework of extraordinary importance for the efficiency of the electricity market and for promoting environmental sustainability through the increasing role of renewables.

In the last decades, the European Union (EU) has shown a commitment to encourage competition in wholesale and retail markets for energy and in particular for electricity and to promote the development of renewables sources of energy. This commitment is shown by the continuous modifications in the regulation of this market in consecutive legislative packages given first by Directive 96/92/EC (European Parliament, 1996) which provided some common rules for the internal electricity market, then by Directive 2003/54/EC (European Parliament, 2003), which enabled the entry of new electricity suppliers into the market and provided customers the choice among them, and Directive 2009/72/EC (European Parliament, 2009a), which provided a step further and liberalized the market with an effective separation of generation, distribution and supply, providing market access to third parties and increasing the transparency of retail markets.

The regulatory framework clearly improved in Europe. A great deal of attention has been given to the effective separation of distribution networks from activities of generation and supply (effective unbundling). The goal was to avoid any risk of discrimination in the market produced by vertical integration (that might affect the operation of the network and the appropriate investment) and therefore, any conflict of interests between producers, suppliers and transmission system operators. It has also the objective of promoting the right incentives in the supply side, by facilitating the access to market and to invest in new power generation, including in electricity from renewable energy sources, and in the demand side, looking for a more efficient use of energy.

Provision of universal access to all households was imposed, as also cooperation amongst energy regulators (through Regulation 713/2009) (European Parliament, 2009b). Also, the goal of construction of a European Energy Union has been present in Regulation 714/2009

(European Parliament, 2009c), that regulates conditions for access to the network for cross-border electricity exchanges.

However, even if the market for electricity has improved, there are still major concerns in Europe. In particular, the challenge of the transition towards a low-carbon energy system with the integration of renewable sources of energy, the trend towards a decentralized renewable energy production with greater participation of consumers (and prosumers), and the requirement to ensure security in supply, are still open issues (Erbach, 2018). At the same time, the goals are very demanding.

As an answer to those challenges, the European Commission published in 2009 the Directive 2009/28/EC (Renewable Energy Directive) (European Parliament, 2009d). It has the objective of promoting the use of renewable sources for electricity with priority grid access, besides other competition and tax policies. In 2016 a number of other legislative proposals were put forward with the same purpose (e.g. the Directive for the Electricity market in the EU) (European Parliament, 2016b).

The current main concern of regulators at the European level for the electricity market is to improve efficiency in the market both in the supply side (generation, transmission, distribution) and the demand side (promotion of an efficient use of energy) while promoting the increasing use of renewable energy and the functioning of the Energy Union with improved interconnection between the electricity produced in different countries.

The current main objective of the regulation in the European Union is to have “a more competitive, customer-centred, flexible and non-discriminatory EU electricity market with market-based supply prices” (Erbach, 2018).

3.1 Renewable sources of electricity in the European Union

In order to understand the current status of the European regulation in the electricity market, it is important to look first at some descriptive statistics of production and consumption of electricity, and especially of renewable electricity. This can illustrate which markets within Europe were more successful in promoting the generation and use of renewable energies.

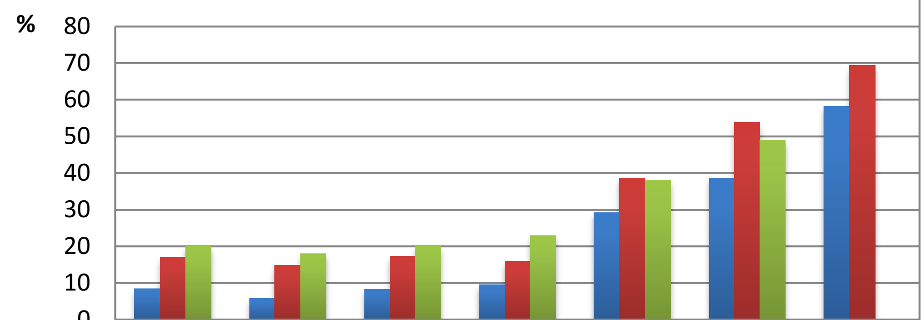
The production of renewable energy in the European Union was of 2,519 million MWh in 2016, compared 1,501 million MWh in 2006 and 1,029 million MWh in 1996. As a consequence, in the last years, the EU28 increased its generation of renewable energy by 46% from 1996 to 2006, and by 68% from 2006 to 2016 (Figures IV.1 and IV.2).

However, there are important differences in the evolution of the generation of renewable energy by countries. In the analysis that follows, we use as examples six European countries: Norway (it is an EU’s associated member of the electricity market), Sweden, Finland, Germany, France and Spain.

Figure IV.3 shows that countries like Germany, France or Spain have significantly increased their generation of renewable energy in the last decade. However, Norway, Sweden and Finland are the countries with the highest share of renewable energy (Figure IV.1).

Norway, Sweden and Finland are the leaders in terms of the development of renewable energy markets in the European Union. The share of gross inland consumption of renewable energy in the total consumption of energy in the European Union was of 13% in 2016.

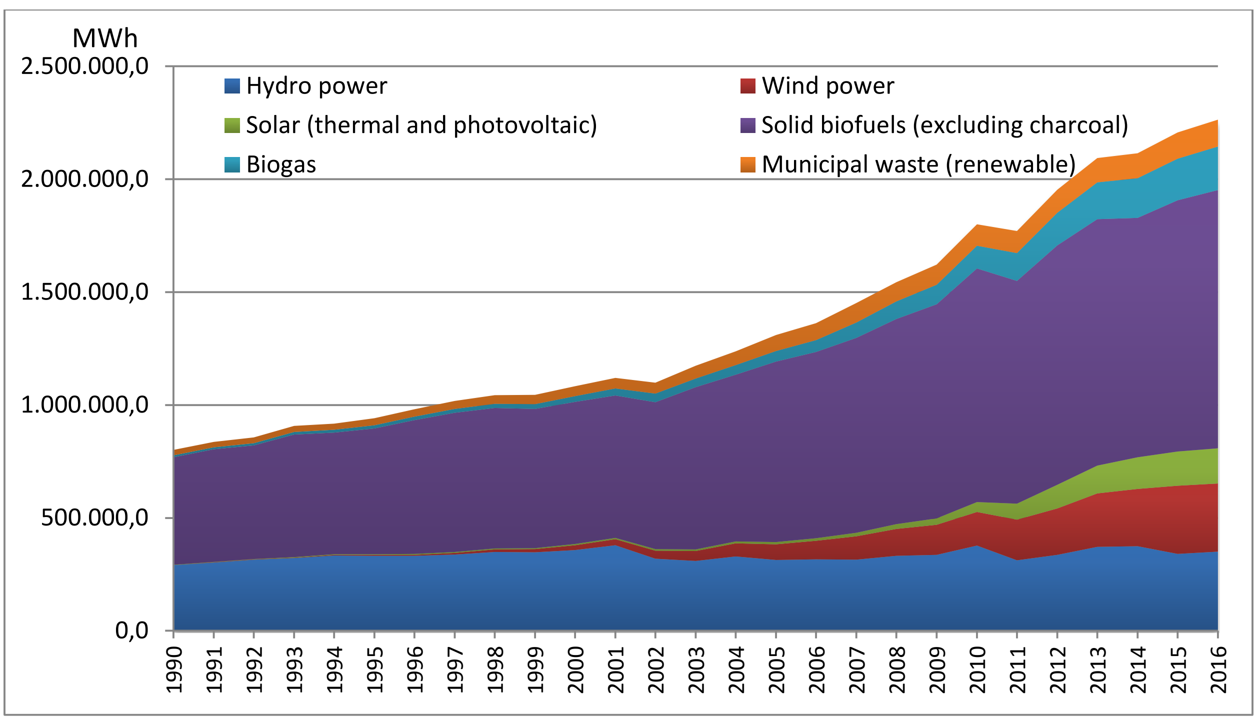
Figure IV.1. Share of energy from renewable sources in six European countries (in % of gross final energy consumption) and target set by the UE for 2020



	EU (28 countries)	Germany	Spain	France	Finland	Sweden	Norway
2004	8,5	5,8	8,4	9,5	29,2	38,7	58,1
2016	17	14,8	17,3	16	38,7	53,8	69,4
TARGET	20	18	20	23	38	49	0

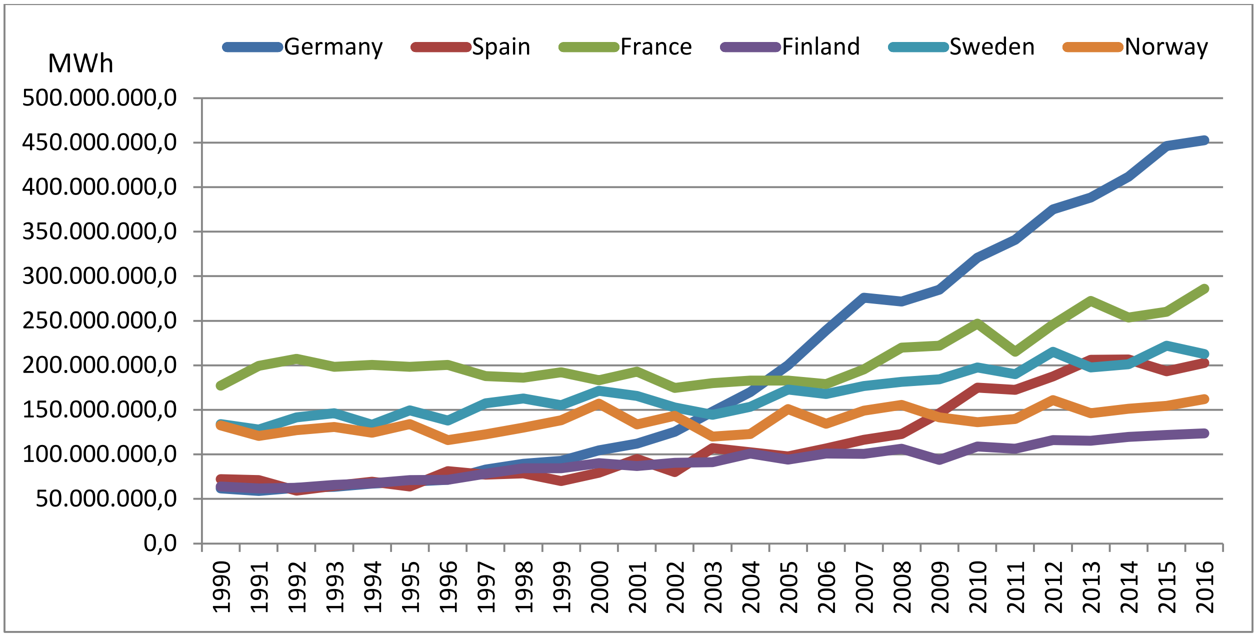
Source: Elaborated by the authors with data from Eurostat (2018).

Figure IV.2. Energy production from renewable sources, EU-28



Source: Elaborated by the authors with data from Eurostat (2018).

Figure IV.3: Production of renewable energy in six European countries



Source: Elaborated by the authors with data from Eurostat (2018).

It is also important to look at the evolution of the matrix explaining which of the renewable sources of energy are more developed in the different countries.

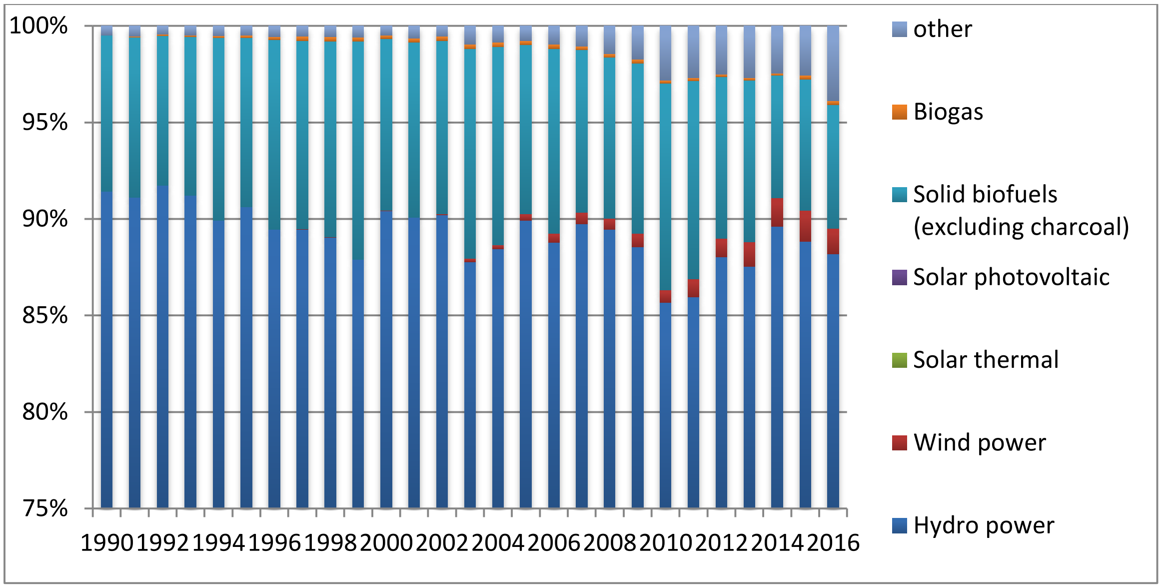
Among renewable energies, the most important source in Norway is hydro power, accounting for about 90% of all renewable energy produced in the country. The second most important is solid biofuels. However, in the last decade wind power has gained participation as well as other sources of energy such as biogas, although their percentage in the energy matrix is still very small. Norway's topography and hydrological conditions, with rainfall in the western part of the country and high run-off through waterfalls and rivers, have helped the development of hydro power in the country.

For other Nordic countries, such as Sweden or Finland, also hydro power and solid biofuels are the most important renewable energy sources. However, in these countries, solid biofuels are more important than hydro power. The same applies to Germany and France.

Spain is slightly different. Solid biofuels and hydro power used to be the most important renewable energy sources. However, wind power was early developed back in the 1990s and solar power is also being developed in the last decades, with growing relative weight in the matrix. As a result, solid biofuels account for about 30% of the renewable energy, wind power 24%, and solar (thermal plus photovoltaic) and hydro power both 18%. Therefore, the Spanish matrix is the one presenting a greatest degree of equity in the sources of renewable energy.

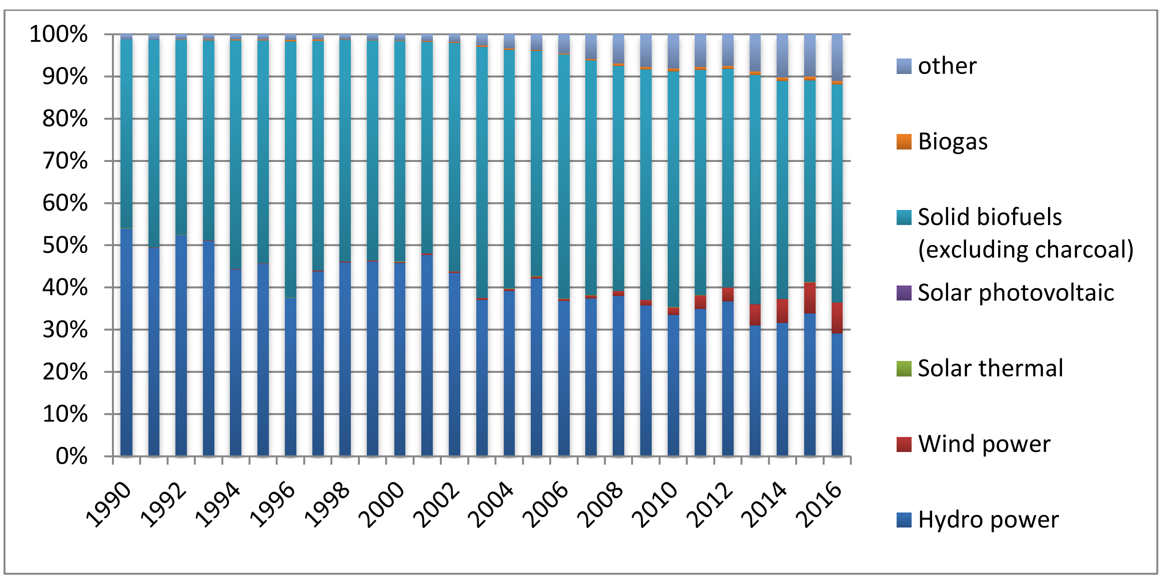
It is worth also noting the significant growth of the relative weight of wind power, solar photovoltaic and biogas in the last decade in Germany.

Figure IV.4. Renewable matrix in Norway



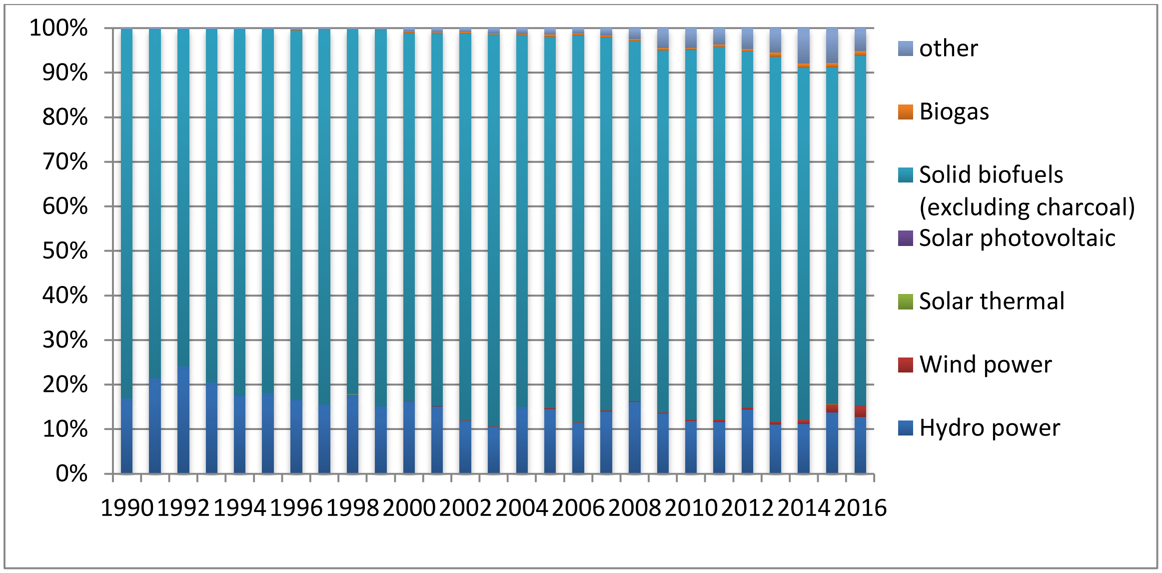
Source: Elaborated by the authors with data from Eurostat (2018).

Figure IV.5. Renewable matrix in Sweden



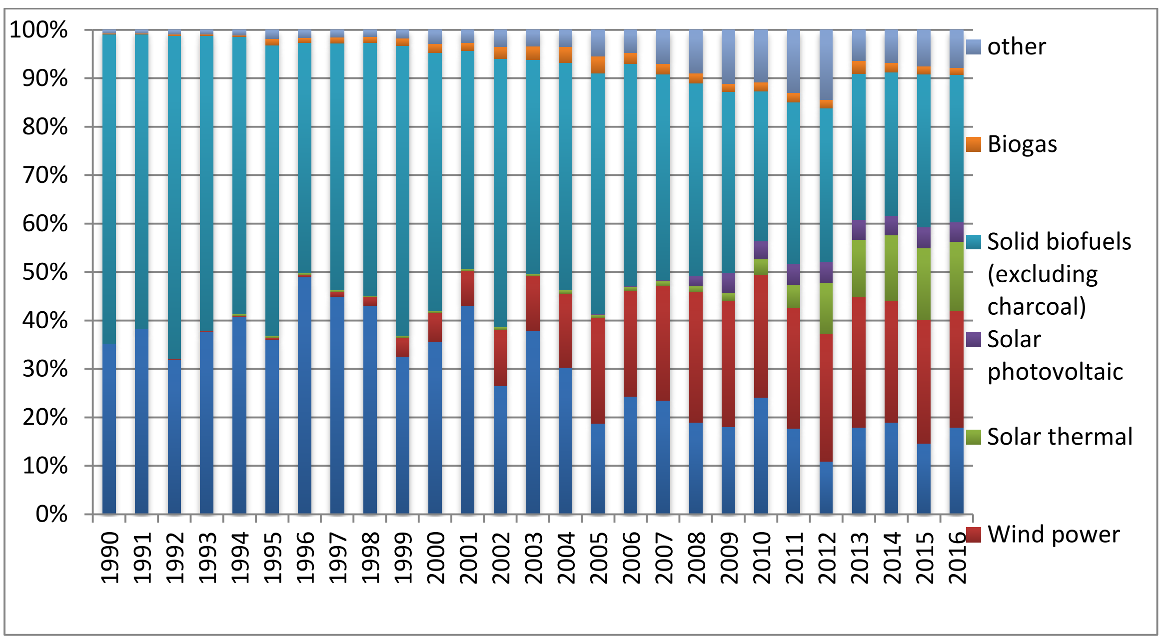
Source: Elaborated by the authors with data from Eurostat (2018).

Figure IV.6. Renewable matrix in Finland



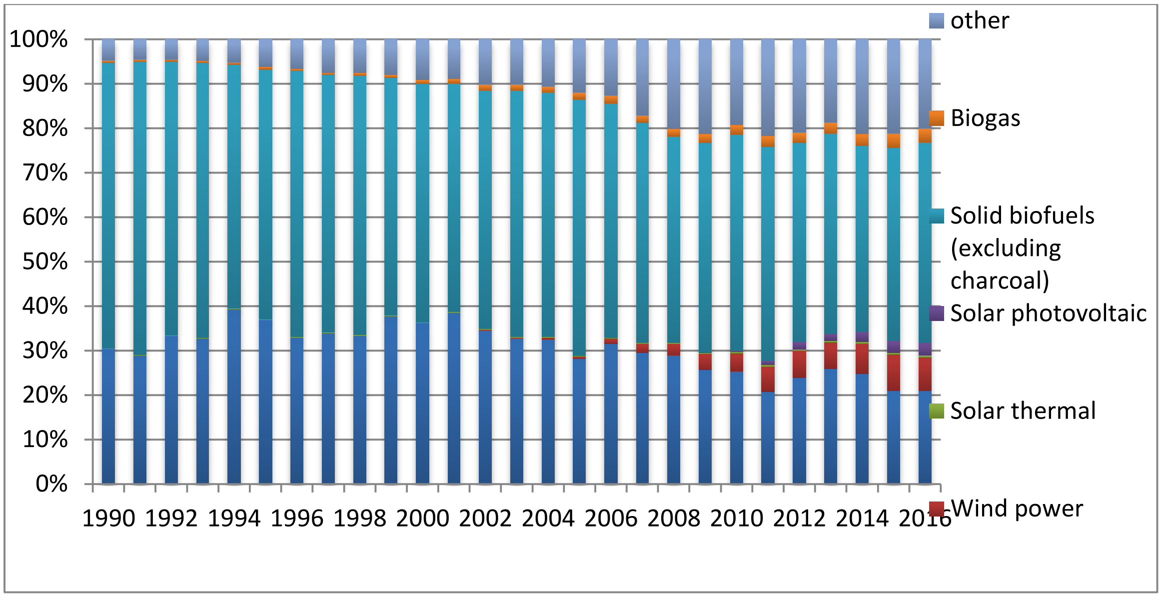
Source: Elaborated by the authors with data from Eurostat (2018).

Figure IV.7. Renewable matrix in Spain



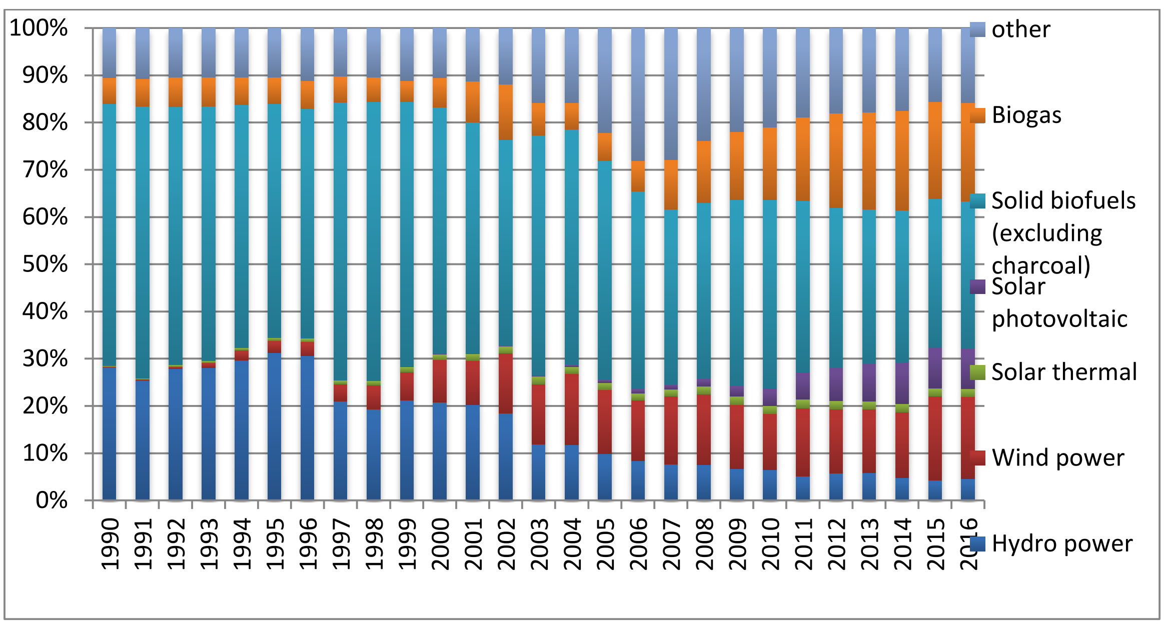
Source: Elaborated by the authors with data from Eurostat (2018).

Figure IV.8. Renewable matrix in France



Source: Elaborated by the authors with data from Eurostat (2018).

Figure IV.9. Renewable matrix in Germany

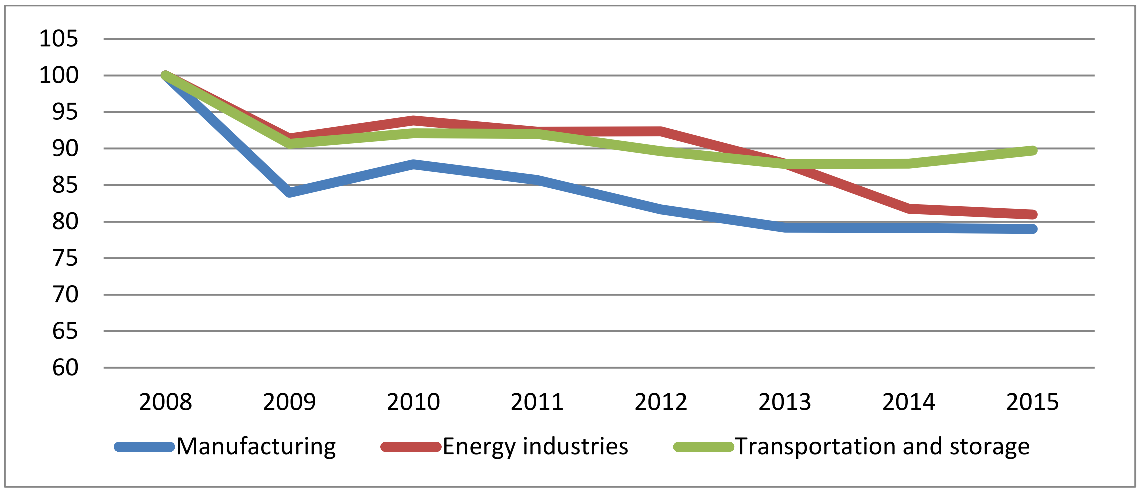


Source: Elaborated by the authors with data from Eurostat (2018).

The European Commission looks at the transport sector with special attention because it explains almost a quarter of Europe's greenhouse gas emissions and it is also the main cause of air pollution in cities (ec.europa.eu, 2018d). Looking at data of greenhouse gas emissions in Figure IV.10, we can see that the transport sector has not been able to replicate the same gradual decline in emissions as other economic sectors. While manufacturing or energy industries have significantly reduced their emissions in the period 2008-2015 by about 20%, the transport sector has only been able to reduce its emissions in only about 10% in the same period. About 73% of all emissions are produced by road transportation (ec.europa.eu, 2018d), which explains the importance of policy actions towards the restriction of use of cars in cities, or the promotion of the use of electric cars.

Hence, the goal of using by 2020 at least 10% of transport fuels coming from renewable sources responds to the objective of fighting against climate change and supporting sustainable growth and sustainable economic models in the European Union.

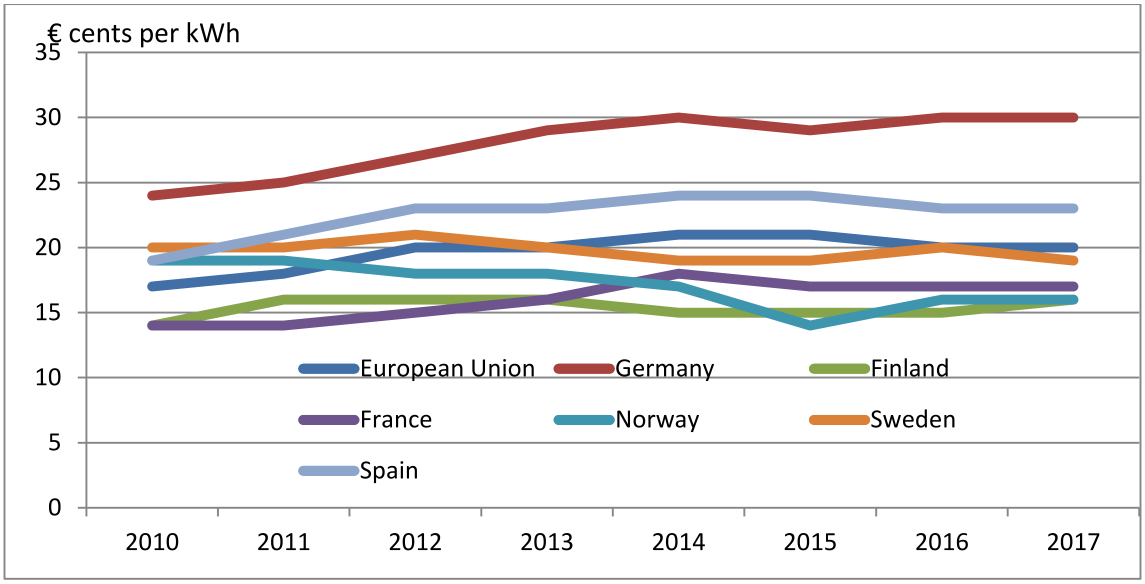
Figure IV10: Evolution of greenhouse gas emissions from different activity sectors including transportation and storage



Source: Elaborated by the authors with data from Eurostat (2018).

A last piece of information on the development of energy markets with special focus on electricity is the evolution of prices in the set of countries of analysis in Europe. The prices of electricity in Germany are the highest in our sample of countries (Figure IV.11). Norway and Finland, on the contrary, have the lowest prices of electricity. Interestingly, in the last years, the prices for electricity in Norway and Finland have become almost the same, and Sweden has reduced the gap with the other two Nordic countries.

Figure IV.11. Evolution of prices for electricity in six European countries (€ cents per kWh)



Source: Elaborated by the authors with data from Eurostat (2018).

3.2 The Nord Pool and the electricity market in the European Union

The previous subsection has provided data on the development of renewable energy in Europe, with special focus on six countries. Among those, there are three with an important development of renewable sources of energy: Norway, Sweden and Finland. They are all part of the so called Nord Pool.

The Nord Pool Spot AS is an energy market. The origin of the Nord Pool is in the year 1991, when the Norwegian Parliament decided to deregulate the market for electricity. In order to do so, the first step was to break the public monopoly and separate the publicly owned company Norges vassdrags- og Energiverktorat (NVE) into Statnett (for the development of the power grid) and Statkraft (for production of electricity) by 1993.

In a few years, the Norwegian market for electricity grew and in 1996 the Swedish market for electricity joined the Norwegian market and this exchange market was named Nord Pool ASA. Two years later, in 1998, Finland joined the Nord Pool, and after two more years, in 2000, Denmark also joined the pool.

Nord Pool is therefore the first international energy exchange market, in which now, besides Norway, Denmark, Sweden or Finland, many other countries operate, as the Baltic Republics (Estonia, Latvia and Lithuania), Germany and the UK. 380 companies, from 20 countries, trade on the Nord Pool markets. Also, Nord Pool is a Nominated Electricity Market Operator (NEMO) in 15 European countries that include countries like Austria, Denmark, France, or the Netherlands. Currently, more than 80% of the total consumption of electricity in the Nordic market is traded through Nord Pool (nordpoolgroup.com, 2018).

In a way, the increasing role of Nord Pool in the European Union is consequence of the objective of the development of the European Energy Union (EEU), a very important project for the European Commission. Hence, understanding the principles of functioning of the Nord Pool and the increasing role of renewable energy means to understand also the principles of what European Union aims to implement.

The following principles guide the functioning of the market:

- **Separated markets.** Effective unbundling or separation of networks from activities of generation and supply is needed. Avoiding vertically integration reduces the risk of discrimination in the operation of the network and generates the right incentives to invest and improve the network itself. Therefore, it is important to have separated markets for generation, transmission and supply.
- **Choice of the consumer.** Incentives for efficiency in the market for electricity can only exist if the consumers are free to choose their suppliers. The interconnection of international markets for electricity helps those incentives for efficiency, and the Energy Union aims to provide a framework for efficiency in this market. That way, prices of electricity should be controlled by competition among providers.
- **Promoting the efficient and sustainable use of electricity.** Efficiency and sustainability in the market for electricity does not only depend on the free choice of provider but also the right mix in the sources for energy. That includes the promotion of renewable energy.
    - In the demand side, an efficient use of energy is promoted through the price. A flexible (hourly) price will provide more incentives to consume efficiently than a flat rate.
    - In the supply side, producers should have the right incentives to invest in new power generation technologies, especially those coming from renewable energy sources, as they are promoted for the sustainable growth aim. For that, a promotion to investment policies might be needed.
- **Quality control.** Regulatory authorities should have the capacity to throw out of the market those agents who do not comply with the effective separation between producers, transmission system operators and suppliers. Also, they should provide the needed certificates to operate in the market only to those who comply with the standards, no matter whether they come from a different country through interconnection.
- **Security of energy supply.** All households should continuously be able to receive supply of energy. As a consequence, it is needed to provide a transparent and non-discriminatory market in which balancing service is ensured in the shortest time needed.
- **The active role of prosumers.** The development of green technologies allow for the participation of small consumers to become also producers of renewable energy. It is needed that regulators allow for the free entry of small producers taking into account the size of the investment needed to enter, and the social benefits of their entry.

Although all the mentioned elements are of importance, the last feature is one of the most relevant for our study and therefore we will discuss it in further detail.

As mentioned, the European Commission is looking forward to increase the share of renewable energy with the target of 20% by 2020 and 32% by 2030. For that goal, it is important that as many small prosumers as possible enter actively in the market for electricity.

A prosumer is a consumer that both produces and consumes electricity. In case the electricity they produce is greater than the electricity they consume, they are able sell the excess to the grid. In case they consume more than what they produce, they would consume all their production and would buy from the grid the remainder electricity they need.

There are different types of prosumers in Europe: residential prosumers (mostly using solar photovoltaic panels on their rooftops or micro combined heat and power –micro-CHP), community/cooperative energy (non-commercial agents as cooperatives or foundations that produce energy meant for self-consumption; mainly solar PV panels and wind turbines), commercial prosumers (SMEs, or any business which main activity is different to electricity production, but that self-consume the electricity they produce), and public prosumers (as schools or hospitals, which generate electricity for self-consumption) (Sajn, 2016).

Having prosumers in the electricity market could be, in principle, very beneficial both for the market and for themselves, as described by the German Renewal Energy Federation (2016). First, for the market, because being active players in the market, through their investments in technology for renewable energy they help to attain the Energy Union, an important goal for the European Union. Also, their participation will help improve the design of storage and smart appliances. Thus, small innovations will improve efficiency. At the same time, the active participation of consumers will provide flexibility in the consumer electricity contracts, and as a consequence, that will reduce the peaks of production and consumption, which will be positive for the efficient use of the grid.

Moreover, the fact that prosumers self-consume their production relieve the grid and reduces transmission losses, accounted to be between 4% and 8% of all electricity produced (Rickerson et al., 2014).

With respect to the benefits for prosumers themselves, the fact that they can self-consume their production can be thought as insurance for the price of electricity. If they mostly self-consume they will not suffer any change in the price. At the same time, self-consumption can reduce the cost of the system and provide the sense of empowerment in the electricity market so that it conform the “energy democracy”, a concept that merges the technological energy transition with a strengthening of democracy and public participation (en.wikipedia.org, 2018).

However, the presence of prosumers in the market is not exempt of problems and challenges. First, the presence of prosumers who self-consume and buy less electricity from the grid reduces the market for traditional electricity producers and operators. As a consequence, they might suffer a decrease in their revenues and lower their incentives for investing in the infrastructure of the grid, which would provide a negative effect for the market (Sajn, 2016).

At the same time, it is important to note that the benefits derived from the active role of prosumers are highly dependent on their capacity to self-consume. That means that prosumers demand for electricity should be concentrated in the moment in which they can produce most. However, many times this is not the case. A typical residential prosumer produces electricity, for example with a solar panel during the day, when not at home, and mostly consume electricity at night when he is not producing. Therefore, there is no much self-consumption for many residential prosumers. In any case, different types of prosumers might behave with different patterns of self-consumption. For example, community prosumers from a residential building might provide more benefits from self-consumption. Also, different types of renewable energy technologies might also show different results, as wind power that is not dependent on the hours of daylight. This challenge is also highly dependent on the capacity to store energy. As technology improves, prosumers should be able to lower the cost of storing their own production of energy and they might increase their capacity to self-consume.

As a result, in order to obtain the benefits of self-consumption by prosumers regulation should promote:

- the active role of prosumers and their entry in the market, freely competing with other producers, and with security in the provision through electricity balancing regulation;
- the efficient use of energy, that is, should provide the right incentives for prosumers to increase their proportion of self-consumption;
- incentives to invest in technology for improving storage of energy, its design and smart appliances to be used in the efficient self-consumption.

3.3 Regulatory practices in the EU

The European Union and other associated countries in the European Economic Area (Norway and Iceland), especially Nordic countries, have a large experience, since the 1990s, in the development of regulatory practices devoted to promote a competitive (and efficient) market for electricity oriented to the active participation of consumers and the increasing role of renewable energy. Even if each country, with its own idiosyncrasy and needs, is different and not all policies and experiences are valid or useful for all countries, the set of many different policy initiatives that have been implemented at the EU provide a guide that might help addressing the design (or re-structure) of electricity markets in countries under different circumstances.

We have mentioned above that the market for electricity should present effective unbundling, choice of the consumer, promote the efficient use or energy, quality control, security of supply, and active role of the demand. In this subsection, we discuss the regulation in three different aspects: the design of the market, the supply and the demand.

3.3.1 The design of the market

3.3.1.1 Transmission system operators (TSOs) and distribution system operators (DSOs)

Effective unbundling or separation of networks from activities of generation and supply is essential in the design of the electricity market. That reduces the wrong incentives derived from vertical integration and monopoly power. This is one of the first features to be implemented for the functioning of the market and has been done in electricity markets in Europe. When the starting point is a public natural monopoly (generation and transmission, and maybe supply), it should be started by breaking the monopoly into different enterprises, so that they can interact in the market as completely independent companies, as in the case of Norway.

However, effective unbundling has to be monitored by the regulator. This refers to the action of both, transmission system operators (TSOs) and distribution system operators (DSOs). TSOs usually take care of the energy produced from the generation location to the energy transformers. After that moment, DSOs manage the distribution of electricity to final consumers. Prosumers (household and small non-household consumers), being small producers of energy, are usually unfamiliar with transmission or distribution contracts. The regulator has to guarantee a real degree of competition allowing their participation in the market preventing any type of abuse, given the market power of large TSOs and DSOs.

It is important to take into account both the participation (or not) of prosumers in the electricity market but also in its primary and secondary electricity balancing service, depending on their qualification. Also, the flow of information between prosumers, TSOs and DSOs has to be regulated so that the quality of the grid can be managed.

3.3.1.2 Business models and Power Purchase Agreements (PPA)

The European Commission (2018) has identified as a main concern the fact that many agents and investors do not find the right incentives to accomplish sustainable investments given the different regulation in different places of the European Union. The consequence is a lack of information and an increase in the cost of undertaking sustainable investments.

With the aim of solving such challenge, a proposed solution is to promote sustainable investments taking them into account through a classification of sustainable economic activities that should be declared by enterprises and institutions, with transparency to other agents so that there is information on the commitment investors have for the sustainability goal. The proposed regulation should "strengthen financial stability by incorporating Environmental, Social and Governance (ESG) factors into investment decision-making" (European Parliament, 2018).

Even though the current concern is very important, different policy measures have been implemented in Europe already to alleviate this problem. One of them is the promotion of Power Purchase Agreements (PPA). Perfect competition and efficiency usually means that no advantages are granted to any agent. However, prosumers without any type of subsidy might not find enough incentives to invest in renewable energy. The direct consequence would be a social cost in the long run with lower green electricity in the market.

In order to help consumers to become prosumers, different types of subsidies are justified for a period of time. One of them is promoted in Europe by RE-Source Platform (European Platform for corporate renewable energy sourcing, 2018), and takes the form of Power Purchase Agreements, that "allow corporates to purchase renewable energy directly from an energy generator". It is an agreement that should last in the long run, for at about 15 years or the time needed for the investment to yield a given return.

3.3.1.3 Quality control and promotion of research and development

One of the complexities of the market for electricity is the need of balance between generation and demand. If demand is greater than generation of electricity at a given moment, there will be low frequency. If the generation is higher than the demand, frequency will be high. For that reason, it is necessary to balance generation and demand so that the frequency remains stable.

With an increasing number of small producers in the market (prosumers), it might be more difficult to predict or manage the electricity generation and it is needed to make greater efforts to control for this. The regulator has to establish clear rules for the participation of large (and/or small) producers of electricity in the electric balance.

Also, and related to the facilitation of investment programs and business models, Europe is promoting research and development (R&D) programs to invest especially in electric storage, so that prosumers can increase their rate of self-consumption and the benefits of their active role in the market can be maximized.

The action of the regulator, to guarantee the functioning, security and quality in the provision of electricity must achieve all kinds of interaction between large producers, prosumers, TSOs, DSOs, and final consumers, and are further exposed in the subsections corresponding to supply and demand. Recently, the European Commission has published a new regulation following these principles, with a guideline on electricity balancing (European Commission, 2017).

3.3.1.4 Control of information and transparency

One of the effects of the efforts devoted in Europe to adapt to climate change is given to the way in which the progress is monitored. At the European level, by 2017, 28 countries had adopted a National Adaptation Strategy, 17 countries had adopted a National Adaptation Plan, and 14 countries had a Monitoring, Reporting and Evaluation (MRE) system (European Environment Agency, 2018).

Although the experience at different countries present different results in terms of the indicators that should be used, it is considered proven that the experience in the use of indicators in order to monitor the outcome of the market will improve the knowledge about its outcomes. Besides, transparency of information between the different agents in the supply and demand yields to efficiency. Databases should be created so that the regulator can provide a greater level of quality control in the market and identify any anticompetitive behaviour.

3.3.2 The supply of electricity

3.3.2.1 Access to the grid

Non-discriminatory access to the grid and to the distribution network has to be guaranteed for all producers, through a transparent process. The European Union is promoting the following principles for the electricity market (Erbach, 2018): no barriers to entry, with high degree of competition among producers, flexible and non-discriminatory.

The rules on the access (connection) to the grid should be transparent, as also the contracts between producers and prosumers and TSOs and DSOs so as to maximize incentives for efficiency.

3.3.2.2 Interconnection

The market for electricity should be as large as possible, allowing for interconnection among different national markets. In Europe, the Nord Pool is intended as a way to the Energy Union. The cost of that interconnection should be shared among the different participants.

As seen in figure IV.11 above, the interconnection in the Nordic countries seem to have had the effect of decreasing the differences in spot prices for electricity. This shows the effect of convergence in prices that a unique international market could be generating in the EU.

3.3.2.3 Measuring renewable electricity: roll-out of smart meters

Transparency in the non-discriminatory access of prosumers to the market for electricity requires the right measuring of the electricity that is generated by each prosumer.

The better the quality of information, the better the results in terms of incentives for prosumers in the market. Meters able to measure close to real time access to generation/consumption will provide the possibility to sign flexible contracts with hourly (or even per minute) prices for selling/buying the energy that is generated/consumed. This can increase the incentives for efficiency in the use of electricity by prosumers. If meters are not able to provide at least hourly information, then the suppliers needs to sign a fixed price contract and there will be lesser incentives for efficiency.

Nordic countries will finish the roll-out of smart meters by 2020. That means that the electricity market will allow for a consumer-centred model in which prosumers will be able to improve their engagement in demand response and micro-production (Thema Consulting Group, 2014). In Norway, Denmark and Finland, all information (hourly measured) is daily reported to the DSO. Although display at the prosumers' location is not mandatory in those countries, a mandatory standard communication provides that information. In Sweden, meters have less functionality as they were rolled-out earlier, and consumers are metered at least once a month unless they request hourly metering (Thema Consulting Group, 2014).

Another functionality that is recommended for meters is the remote control so that consumers, but also TSOs, can obtain information on the consumption and/or generation of electricity. As a consequence, they can better identify any lack of efficiency in the use, or to adapt the generation to the needs of the electricity balancing market.

Smart meters should also be able to establish net-metering, the (hourly) difference between consumption and generation, in order to allow for different compensation schemes.

In any case, the collection of information or access to the data at the meters of prosumers should always be possible, after their consent.

3.3.2.4 Compensation schemes

Production of electricity by prosumers should be compensated so that they have the right incentives to produce and self-consume. There are different schemes that have been implemented. Each of them has their own advantages and disadvantages and whether one of them is a better fit for a country depends on multiple factors. Here we present the main characteristics of the most important ones: Feed-in Tariffs, Feed-in Premiums, Net-metering, and Green Certificates.

Feed-in Tariffs (FIT)

Feed-in Tariff is a compensation scheme that encourages production of electricity and self-consumption. Under feed-in tariff, any eligible producer or prosumer of renewable electricity obtains a cost-based price for the contribution of electricity to the grid. This way, investors and prosumers are helped to obtain the return for the investment necessary for the installation of the equipment needed for the production of renewable energy (wind, solar, biogas, etc.).

A feed-in tariff works as follows: it provides compensation to the producer of renewable electricity that is above the market price for electricity in order to facilitate the return to the investment. These overprice might be decreasing in time or depending on the evolution of the cost of technology, or the number of adopters.

Many European countries have implemented feed-in tariffs, but their implementations present some differences. A review is presented by GfK Belgium Consortium (2017). For example, in France, feed-in tariffs are paid through power purchase agreements (PPAs). In the Netherlands the FIT is for 8, 12 or 15 years depending on the renewable technology involved, and it benefits more efficient technologies so that there are incentives for efficiency. The UK offers a fix payment for the energy supplied to the grid for 20 or 25 years.

Germany and Spain are other countries in which FIT have been implemented. In Spain, FIT were successful before the economic crisis until 2008 in attracting many prosumers. However, during the economic crisis, compensation was decreased in several policy actions, and since 2015 there are no FIT, and in fact, residential prosumers do not obtain any remuneration for the electricity contributed to the grid. Differently, regulation in Germany provides economic incentives for self-consumption by applying a reduced rate to the electricity not contributed to the grid but consumed at home (Tews, 2016).

Other European countries that have implemented some sort of FIT but that has been replaced or eliminated are Portugal, Czech Republic or Poland (GfK Belgium Consortium, 2017).

In summary, many European countries use or have used Feed-in Tariffs. Although in many cases this mechanism has being replaced in the last years for other schemes. It basically implies a compensation for renewable energy produced which distorts the market for electricity in favour of green energy. It also increases the cost of energy for final consumers that are not prosumers.

Feed-in Premiums (FIP)

Feed-in Premium is an additional compensation scheme reimbursed to producers of renewable electricity if they hold some kind of quality requirements established by the regulator. Countries such as France, Belgium or Croatia present some sort of feed-in premiums. In France, this type of premium can last up to 20 years, depends on the type of renewable technology and its application is subject to regulatory orders or public bids.

The use of Feed-in Premiums in France is not free of problems. In order to obtain that premium, prosumers and energy cooperatives must waive their right to the certificate of origin of the electricity produced (GfK Belgium Consortium, 2017).

Although both FIT and FIP promote the investment in renewable energy, the price distortion (decreasing in time) or the premium also produce inefficiencies in the market. These mechanisms might be recommended if other schemes are not feasible, and when the investment for a specific technology is large and, there is an important will of promoting that specific technology. However, it is needed a close monitoring of the evolution of costs of producing renewable energy, so that the over price is only given in case of real needs. If this control is not provided and an additional compensation is guaranteed for producers of renewable energy for 15 or 20 years, this would work as a subsidy without taking into account the real need for that subsidy, which might lead to situations of inefficiency, in which the subsidy is granted to producers even if the cost of the technology is low enough to not need that compensation.

Net-Metering

Net metering is a compensation mechanism under which prosumers provides to the grid all the electricity produced that is not self-consumed. They can consume that net production at another time, when the prosumer produces an insufficient amount of electricity. This means that the grid is used as a backup system for the excess power production (European Commission, 2015). Net-metering is used in many countries in Europe and one of the advantages of its implementation is that it is easy to understand and both, production and consumption, are calculated with the same meter.

There are, however, some concerns (which can be solved) with the use of net-metering that have to be taken into account. Compensation for the renewable electricity produced and supplied to the grid is usually made at a retail price that is greater than the cost of generating electricity. The reason is that net compensation of production minus consumption is applicable to the billing period, which can be hourly but also monthly or yearly. As for many other market characteristics, the more flexible the better for incentives for efficiency in the use of electricity (daily better than monthly, hourly better than daily, per minute better than hourly).

Let us assume that the billing period is monthly, and that the prosumer has contributed renewable electricity to the grid (consumption lower than production) when the cost of production is low, and has consumed energy from the grid (consumption greater than production) when the cost of production of electricity is high. Then, that prosumer would obtain a much greater benefit of the production of energy because of the rigidity in the contract.

Italy is applying a version of net-metering in which the billing scheme calculates the value of the excess electricity fed into the grid (at wholesale price). That calculated value can be used as credit for subsequent periods or be paid to the prosumer (European Commission, 2015).

Two countries that have reacted to improve the results of net-metering are Denmark and Belgium. Denmark allows for net-metering but there, the value of the excess of electricity provided to the grid or obtained from the grid is calculated at an hourly rate, and as a result, compensations are much lower. Belgium, differently, for systems up to 10kW, does not provide remuneration for excess electricity produced that is supplied to the grid (European Commission, 2015).

Quotes and green certificates

Another compensation scheme for the production of renewable energy is the system of quotes and green certificates that is used in Norway, Finland and Sweden. This is in fact a scheme in which a subsidy is provided to producers of renewable energy but where the cost of that subsidy is paid by end users (final consumers of energy).

Under this scheme, authorities or the regulator sets a quota of renewable energy in the market. That quota might be the target for the market share of renewable energy that has been committed by the government. Then, the regulator establishes a market for those green certificates.

The functioning of this market in Norway and Sweden is as follows (Swedish Energy Agency, 2018; Pobłocka-Dirakis, 2018). Electricity producers obtain a green certificate per MWh of approved renewable energy produced. For them, it is mandatory to hold, at the end of the period, a number of certificates, which depends on their level of production of electricity (quote). In case they do not comply with this obligation, they are punished. As a consequence, all energy producers have the right incentives to obtain their number of green certificates.

There is, however, a market for green certificates, in which energy producers that cannot obtain enough green certificates in the production stage can buy as many as they need in the market. In this free market, supply is composed by other producers that have obtained a number of green certificates greater than the ones they need.

As a consequence, in this competitive market for green certificates, price will depend on supply and demand. If there is a low production of renewable energy there will be too few certificates in the market and price will be high (the payoff of producing green energy will be higher and there will be more incentives to invest and produce more green certificates to sell). On the contrary, if there is an increase of renewable energy production, there will be more certificates in the market and the price will be lower.

End users, in their bill and depending on their consumption, pay the retail price of electricity plus a price for the green certificate of their provider. This way, end users pay the additional cost of renewable energy, and all providers have the incentive to produce renewable energy so that they can survive in the market.

Another good characteristic of the green certificate system is that it is technology-neutral, as it encourages only the development of the most competitive technologies.

Other countries that use different versions of green certificates are the UK, Poland and Romania.

Taxes and subsidies

Fiscal policy is an indirect regulation used by governments to have an impact in the economy. Subsidies or taxes could be oriented to promote the production of renewable energy. Through taxes, regulators could punish producers that do not comply with a specific target. Through subsidies, regulators could provide some compensation to producers of renewable energy. However, the efficacy of fiscal policy depends on whether it promotes or becomes a barrier for the investment in green technology.

There are different experiences related to fiscal policy in European countries, as tax credits granted in Spain, not directly related to renewable energy but in a more general framework, for technological innovation activities and R&D and technological activities (KPMG International, 2015). Also in Spain, some prosumers are exempt from energy tax (tax for producing energy that is provided to the grid), and prosumers also are benefitted from a reduction of the tariff of upgrading the grid as a compensation for their electricity production that is provided to the grid (GfK Belgium Consortium, 2017).

Other countries presenting tax deductions on self-consumed energy are Germany, The Netherlands, and France, where prosumers are exempt if they produce less than 240 GW and they consume all of their production (GfK Belgium Consortium, 2017).

VAT, in principle, might tax all production of renewable energy even if it is self-consumed, as it would fit in the definition of obtaining an income (not paying) for an economic activity (producing energy). That is the interpretation of the European Court of Justice from the Fuchs case 108 (C-219/12) (GfK Belgium Consortium, 2017). However, many countries include some VAT deductions on renewable electricity consumption. For example, the Netherlands refunds VAT of solar panel purchases. Also, in Poland, producing energy by prosumers is not considered an economic activity and therefore, prosumers are exempt from VAT and income tax related to the production of energy. France or Italy or the UK also present some kind of VAT reductions or tax credits related to self-consumption, and in the UK, residential prosumers are also exempt from the income tax related to their sale of energy (GfK Belgium Consortium, 2017).

It is recommended that VAT legislation and fiscal policy in general, when net metering is used, be flexible enough to provide the right incentives so that prosumers would only pay VAT for the net difference between the consumed and produced energy (Energy Community Secretariat, 2018).

Nordic countries as Sweden or Finland grant subsidies to hydropower producers so as to promote the production of renewable electricity (Bergaentzlé et al., 2017). Germany also presents a public subsidy program in the form of a Power Purchase Agreement (PPA) program for the installation of solar PV systems for residents, who pay their electricity at a lower price than retail price. France, The Netherlands, Czech Republic or the UK also allow for investment support schemes for sustainable energy programs (GfK Belgium Consortium, 2017).

3.3.3 The demand of electricity

We have mentioned the need of a competitive market in which consumers freely choose their provider of electricity. In order to obtain a competitive market, it is important to obtain high quality of information on the supply and the demand, not only in quantities but also in prices. This is translated into the need of smart meters informing on the real consumption (and production for prosumers) in or as close as possible to real time. This is so because cost of producing electricity is not constant in time, and long or fixed contracts with fix retail price for electricity eliminates any incentive to consume when electricity is cheaper and reduce consumption when electricity is more expensive. At the same time, this type of *flexible contract* with hourly prices or prices changing in real time, will promote the right incentives for the storage of energy and maximize self-consumption for prosumers.

When the market is competitive, consumers' choices depend on the quality of the energy provided and its prices. If the regulator secures electricity balancing, quality should be similar (becoming electricity from different providers, a homogeneous good) and prices will be the key determinant of the choice of consumers. In that choice, consumers should choose the lowest price provider, who is also the provider able to sell the electricity at the lowest retail price. As a consequence, consumers will prefer to buy from the provider obtaining electricity from the producer with lowest cost of production and best technology, or the one not needing to pay an extra cost for the green certificates.

3.4 Impact of regulation in Europe. The expected growth of prosumers

We have shown the European commitment to encourage competition in the energy market and in particular in the promotion of the increasing role of renewable energy. However, it is needed to evaluate what it is expected to happen to the decentralized renewable energy production by residential consumers or prosumers in Europe, taking into account the different policies that are being implemented by countries. This is so because the success of the different policies has to be related to the participation of consumers in the market of renewable energy production.

In the next paragraphs, we analyze the projections provided by GfK Belgium Consortium (2017) with the expected evolution of prices published at European Commission (2016) in a set of seven European countries. Four of them are included because of the high growth of the participation of this type of energy production. They are France, Germany, The Netherlands, and the United Kingdom. Then, we also include three Nordic countries which are a reference in the development of renewable energy and the single energy market, although they do not currently show a major participation of prosumers in the market. They are Denmark, Finland and Norway.

Every analyzed country presents increase in its residential solar PV capacity (Figure IV.12). However, this increase is significantly greater in Germany. Even if the trends are related to the size of the countries, it is important to note that Germany, the Netherlands, France and the UK present greater increases in relative terms.

When looking at the expected share of technical potential for residential solar PV (see Figure IV.13), Germany and the Netherlands present the most important forecasted growth. That is related to the expected participation of small producers in those countries. The expected number of residential solar PV prosumers (in thousands) is presented in Figure IV.14.

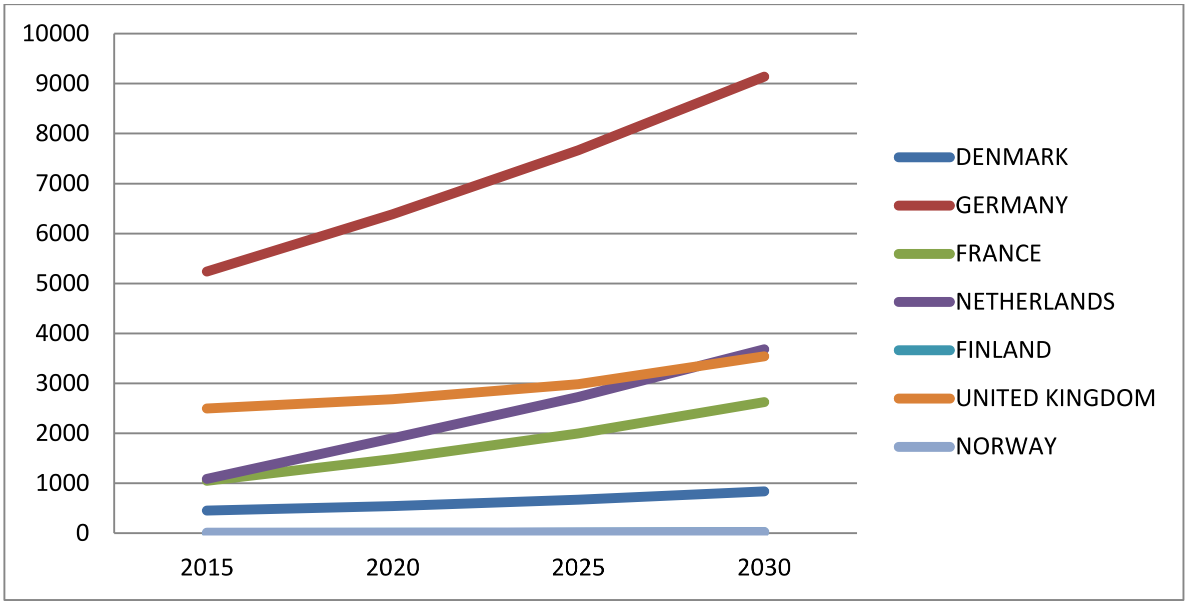
It is worth noting that Germany has a greater number of expected prosumers in the production of residential solar PV, followed by UK, France and the Netherlands. Given that one of the goals of the European Commission regulation is to increase the participation of small producers in this market, it is useful to check not only its size but also the rate of participation.

Figure IV.15 shows the expected share of households that will invest in residential solar PV. Countries such as Finland or Norway do not expect to obtain a significant participation of households in the market.

Differently, by 2030, The Netherlands expects to have about 9,5% of households producing energy at home through investments in residential solar PV. Denmark expects to reach 6,8% and Germany 5,8%. Therefore, in terms of relative participation, The Netherlands, Denmark and Germany are leaders.

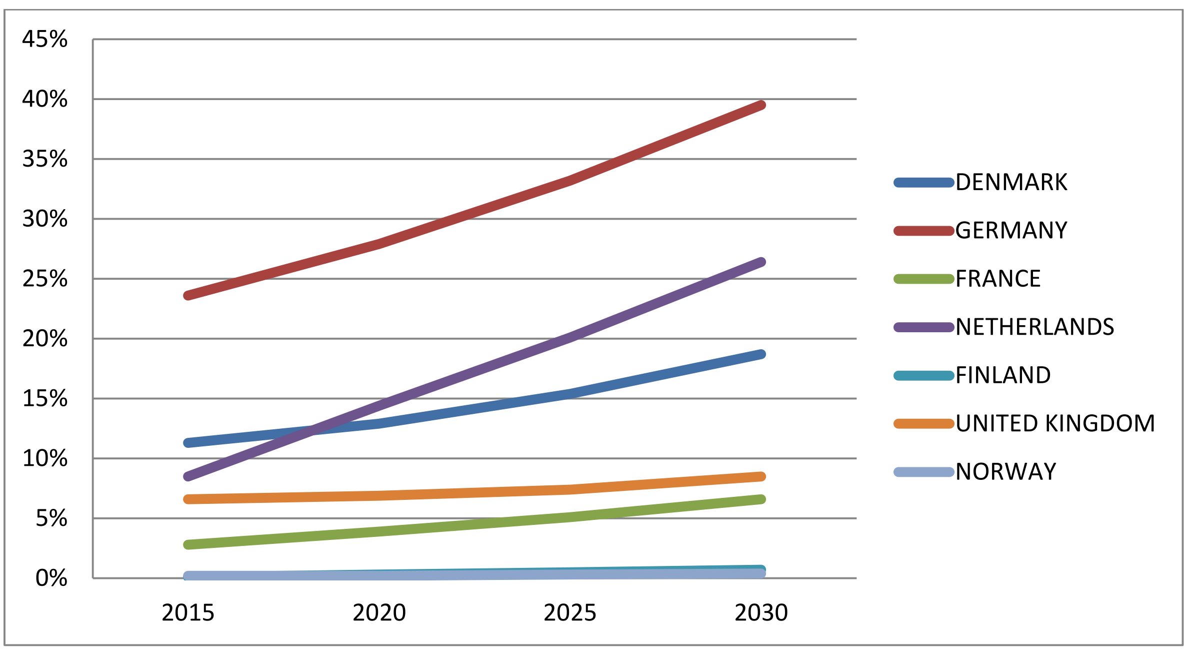
Germany, Denmark and The Netherlands are the only countries in which the expected period of time to payback the investment for residential Solar PV is less than 7 years (Figure IV.16). This shows that the technology is still expensive.

Figure IV.12: Expected residential solar PV capacity (in MW)



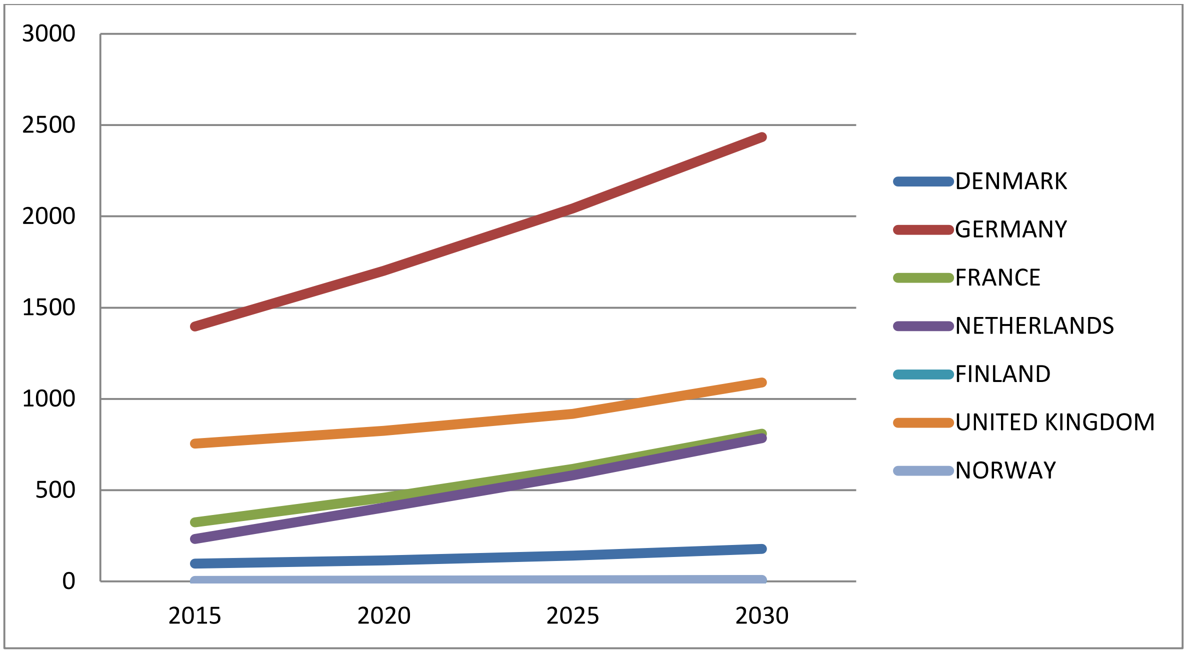
Source: elaborated with projections provided by GfK Belgium (2017).

Figure IV.13: Expected share of technical potential for residential solar PV



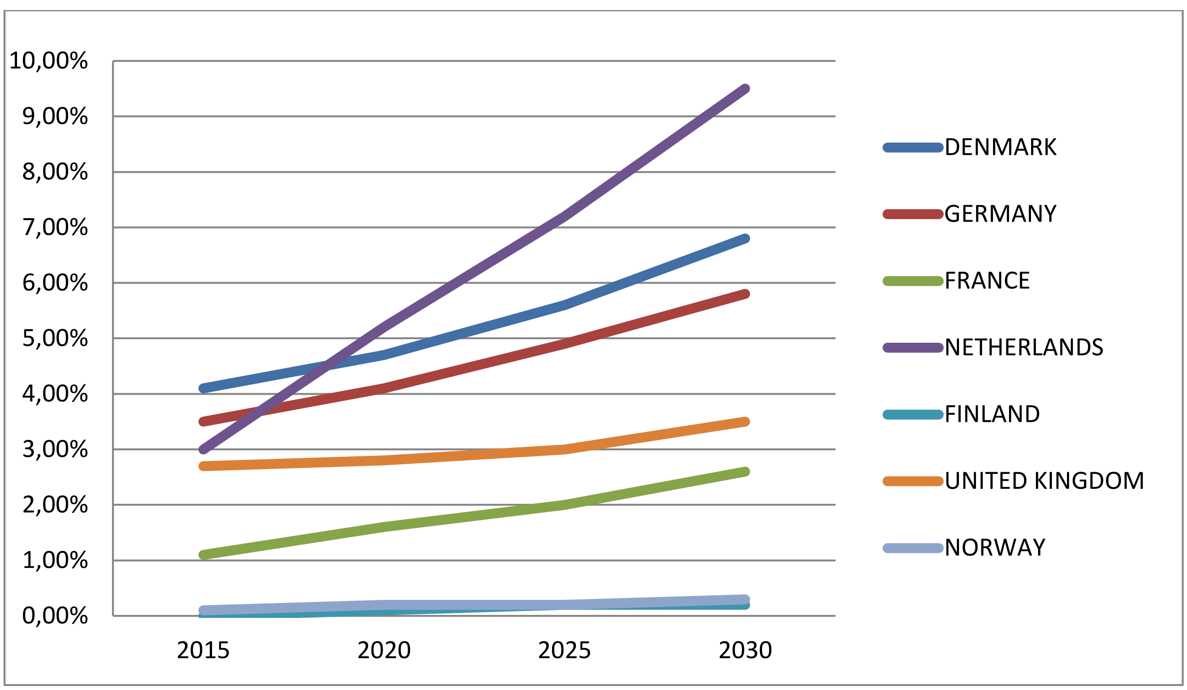
Source: elaborated with projections provided by GfK Belgium (2017).

Figure IV.14: Expected number of residential solar PV prosumers (in thousands)



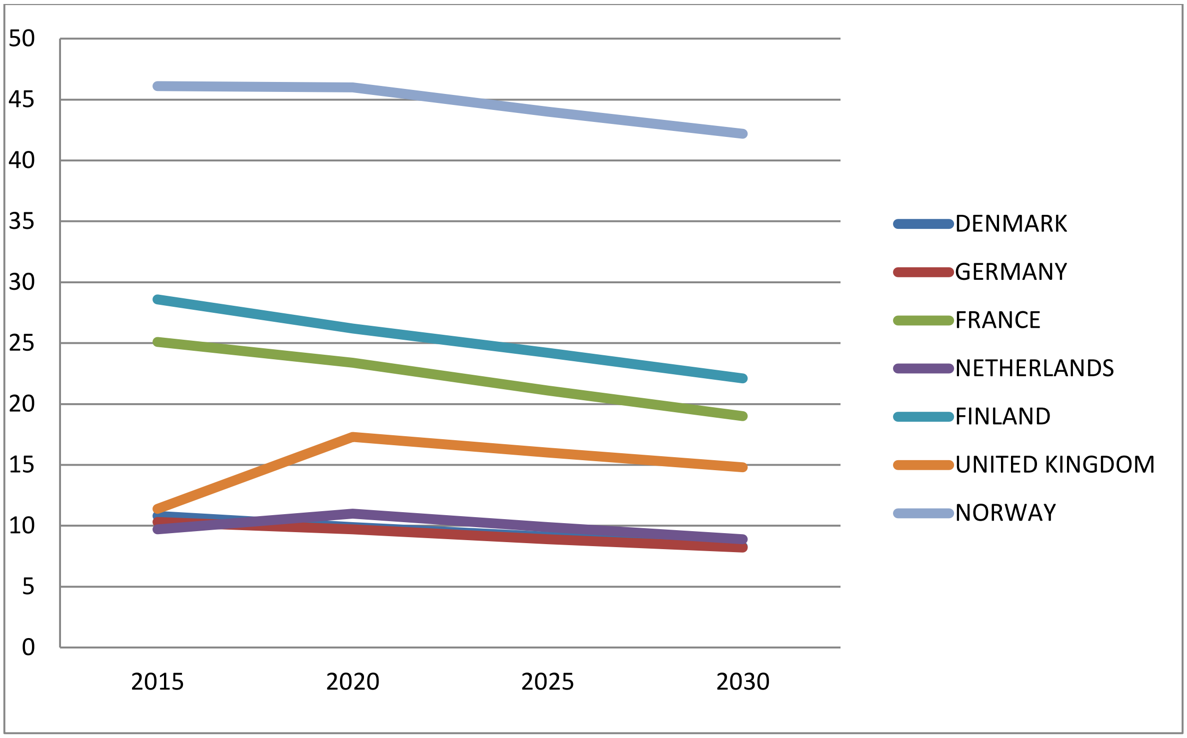
Source: elaborated with projections provided by GfK Belgium (2017).

Figure IV.15: Expected Share of households that invest in residential solar PV



Source: elaborated with projections provided by GfK Belgium (2017).

Figure IV.16: Expected mean payback period for residential Solar PV (in years)



Source: elaborated with projections provided by GfK Belgium (2017).

3.5 Policies to promote the efficient use of electricity in specific industries. The case of Norway

The promotion of environmentally friendly production and consumption of energy is an important aim in the European Union and countries in the European Economic Area, including Norway. With that purpose is financed "The Odyssee-Mure project", a project supported by H2020 programme of the European Commission, and part of the activity of the EnR Club[2].

The Odyssee-Mure project is aimed to monitor the consumption of energy so as to estimate and promote its efficiency, and evaluate the different polices implemented in the participant countries in this matter. They have developed the Odyssee database and the Mure database. The Odyssee database contains information on energy efficiency and CO_2 indicators on energy consumption and economic activity indicators. The Mure database describes the implemented policies aimed to increase the efficiency of energy consumption.

This project is aligned with the recent Proposal for a European Directive on common rules for the internal market in electricity[12] that states that national regulators "should facilitate cross-border electricity flows, customer participation including demand response, investments in flexible energy generation, energy storage, and the deployment of electro-mobility and new interconnectors" (Erbach, 2018).

[2] See http://www.odyssee-mure.eu

Although country profiles are currently available for 26 countries (out of the 31 participating in the project)[3], we focus our attention in Norway, which is, maybe, the best example to follow in terms of sustainable energy production and consumption.

In Norway, different sectors of economic activity present different behaviour in terms of consumption of energy. In fact, by 2015, industry was the economic sector with highest consumption of energy, although this consumption has shown a decrease of 17% since 2000. The most important concern in terms of energy consumption is the transport sector, which has presented an increase in energy consumption of 23% from 2000 to 2015, from 4,43 million tonnes of oil equivalent (MTOE) to 5,43 MTOE (Odyssee-Mure project, 2018) (see Figure IV.17). Transport is also the second economic sector with lowest improvement in energy efficiency after the service sector, opposite to the residential sector, which is the sector with greatest decrease of the Technical Energy Efficiency Index. While that index has decreased in average for total consumption of energy in Norway by 19% from 2000 to 2015, in the residential sector this decrease has been of 29% and in the case of the transport sector of only 13%.

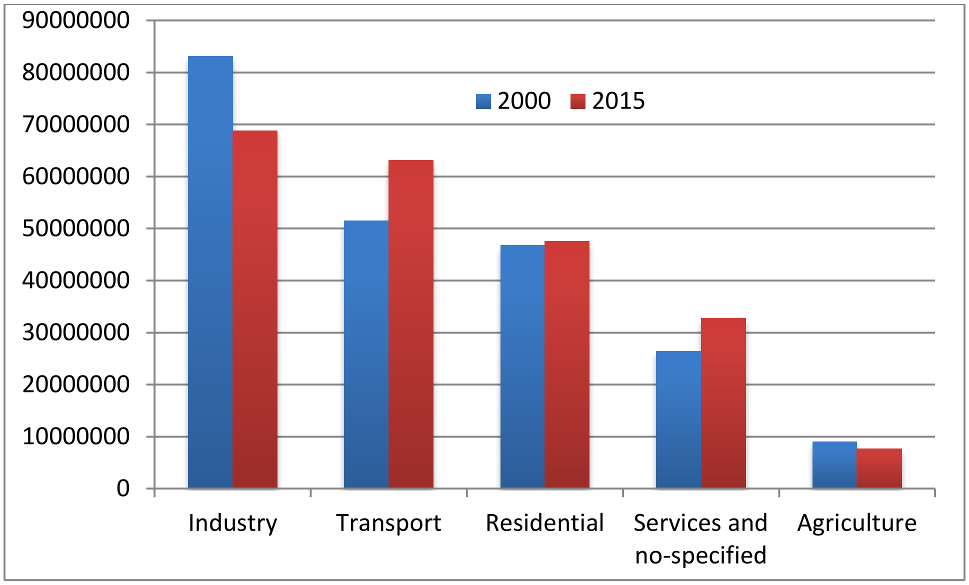
The government in Norway aims to continue with the same rate of decrease in the energy consumption and to decrease another 15% by 2030 from current levels of consumption. For that, it points to several measures in different sectors. With respect to the construction sector, there are measures regarding investment grants to energy efficiency in existing buildings and for energy measures for households (Odyssee-Mure Project, 2018), besides the construction of new nearly-zero-energy-buildings (NZEB) from 2020 (Brekke et al., 2018).

However, the major concern in Norway is constituted by the evolution of final consumption of energy in the transport sector, because of its relative weight in total energy consumption and the low decrease in its Technical Energy Efficiency Index. In that sector, the highest consumption of energy stems from cars (about 34%), followed by trucks and light vehicles (32%), air and water transport (17% and 13% respectively) and a minor relative weight of rail, bus and motorcycles (Odyssee-Mure project, 2018).

With respect to the measures that are being implemented in the transport sector, among others, the National Transport Plan 2018-2029 (ntp.dep.no, 2018) points to the specific goal of a number of low- and zero emission vehicles in 2025, or a plan for further increase of share of biofuels in transport fuels and new biofuels. Also, many local measures have been implemented as road pricing, reduced speed limits in specific areas or high taxes on registration of petrol and diesel vehicles, according to their CO2 emissions (Odyssee-Mure project, 2018).

[3] See http://www.odyssee-mure.eu/publications/efficiency-trends-policies-profiles/

Figure IV.17. Energy consumption by economic sector in 2000 and 2015 in MWh



Source: Elaborated by the authors with data from the ODYSSEE project.

It is important to note that in Norway, the introduction of battery electric vehicles has been faster than in most other countries in the world, as a result of different policies undertaken since 2001 such as the exemption from nonrecurring tax for vehicles, free parking and charging on public parking places, free drive in lanes for public transport and exemption from road toll (Odyssee-Mure project, 2018).

By 2015, the market share of electric vehicles in Norway was of 22%, where its authorities follow a "polluter pays principle" in the car tax system (Norwegian EV Policy, 2018) so that consumers have economic incentives to buy zero emission cars. One of the goals that the Norwegian Parliament has adopted is that all new cars sold by 2025 should be zero (electric or hydrogen) or low (plug-in hybrids) emission, although without any explicit prohibition but through high taxes to polluter cars.

Also, authorities plan to help consumers in the choice of zero emission cars through the increase of public available charging points. Norway complies with the European regulation of a public available charging point every 10 electric cars, and by 2020, Norwegian market share of these cars might reach 30%. In that line, Norway is promoting and financing the existence of at least two multi standard fast charging stations every 50 km on main roads (Norwegian EV policy, 2018).

Finally, energy consumption at the industry sector decreased in the period 2000 to 2015 from 7,15 MTOE to 5,42 MTOE, and as a result, the Technical Energy Efficiency Index has been reduced by 20,5%. In Norway, the economic activities within the industry sector with highest use of energy are the production of metals, chemicals, pulp & paper and non-metallic minerals, which together consume about 80% of all the energy used in the industry. Different programs have been implemented in order to increase the role and weight of renewable energy use in the industry. They are aimed to facilitate the introduction of full-scale innovative green energy technology in the production process. Also, other type of program provides investment support to increase efficiency in the use of energy, that is, to reduce energy use per unit of output (Norwegian EV policy, 2018).

4. Conclusions

The objective of this paper was to understand the policy and regulation changes in Uruguay and the European Union that led to the adoption of renewable sources of energy.

Uruguay is a unique example of the construction of a solid political consensus that modified in a very short period of time the energy matrix of a country. Wind, biomass and solar installed power went from 1% of the total installed capacity in 2005 to almost 50% in the year 2017. Uruguay became one of only 3 countries in the world with more than 90% of the electricity coming from renewable sources and where non-conventional renewables provide a significant contribution to it.

Still, the country faces many challenges in the regulation front. For example, even when in the generation and commercialization stages the regulation allows free entrance of companies, these markets are not operating in competence. In the case of commercialization, there are no companies competing with the state-owned UTE. In the generation stage, although the entry of new generators is growing, the market continues showing a strong concentration. Moreover, the regulator shows different weaknesses at the time of enforcing the regulation. Contributing to the limited regulatory control exerted by the URSEA over UTE is the fact that the set of regulations that UTE has a Constitutional rank. This implies that in practice there is little room for URSEA to regulate other that the quality of the electricity service and some other very specific aspects of the business.

New or updated regulations of the Uruguayan electricity sector should take into consideration the particular characteristics of this market. There are at least two important aspects: UTE, the state owned monopoly currently in charge of the transmission and distribution of electricity has multiple objectives other than just profit maximization (namely, the provision of electricity to all households at the same price, regardless of its location, and other distributive concerns); the electricity sector in Uruguay has been able to build a strong and durable political consensus that has been fundamental to achieve the recent transformation of the energy matrix in this country.

Based on these previous considerations, as technological improvements allow prosumers to increase their independence from the grid (e.g. either through efficiency gains in PV panels, or a price decrease in batteries), regulations should try to avoid a regressive distribution effect in which UTE has to increase prices to compensate the loss in revenue from prosumers´ activities.

Uruguay is a very interesting case in terms of its energy policy but it faces important shortcomings and challenges in the regulation front.

New or updated regulations have to be discussed and agreed upon in such a way that the existing consensus is preserved. In this way, the country can keep moving towards the inclusion of renewables sources of energy and the promotion of energy efficiency that has made it an example in Latin America.

The European Union and particularly, countries such as Norway in the European Economic Area, are good examples of regulation of the electricity market with the aim of promoting efficiency in the use for final consumers, but also an appropriate level of competition and incentives for efficiency in the electricity chain and investments for research and development and innovation with the aim of incentivize the production and storage of green energy.

In order to achieve this type of market, it is necessary to promote the active role of all the society and in particular, to let consumers to become prosumers and participate in the production of renewable energy.

With respect to prosumers, regulators should guarantee their access to the grid, and provide them with the right incentives for getting into the market and invest in the production of renewable electricity, and the right incentives to be efficient in the consumption and maximize self-consumption.

The experience of European countries, and especially Norway and other Nordic countries of the Nord Pool is that there should be complete roll-out of smart meters, allowing for at least hourly measure of both production and consumption. Net-metering in processing and estimating the bill within a variable contract helps promoting efficient self-consumption.

The sector of economic activity that constitutes the major concern with respect to the increase in use of energy in the EU is transport, and within transport, the use of energy by road transport as cars or trucks. Norway is the leading country in promoting incentives to reduce the CO2 emissions and from there we can learn some policy initiatives to expand the use of electric vehicles.

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Appendix 1. List of Acronyms

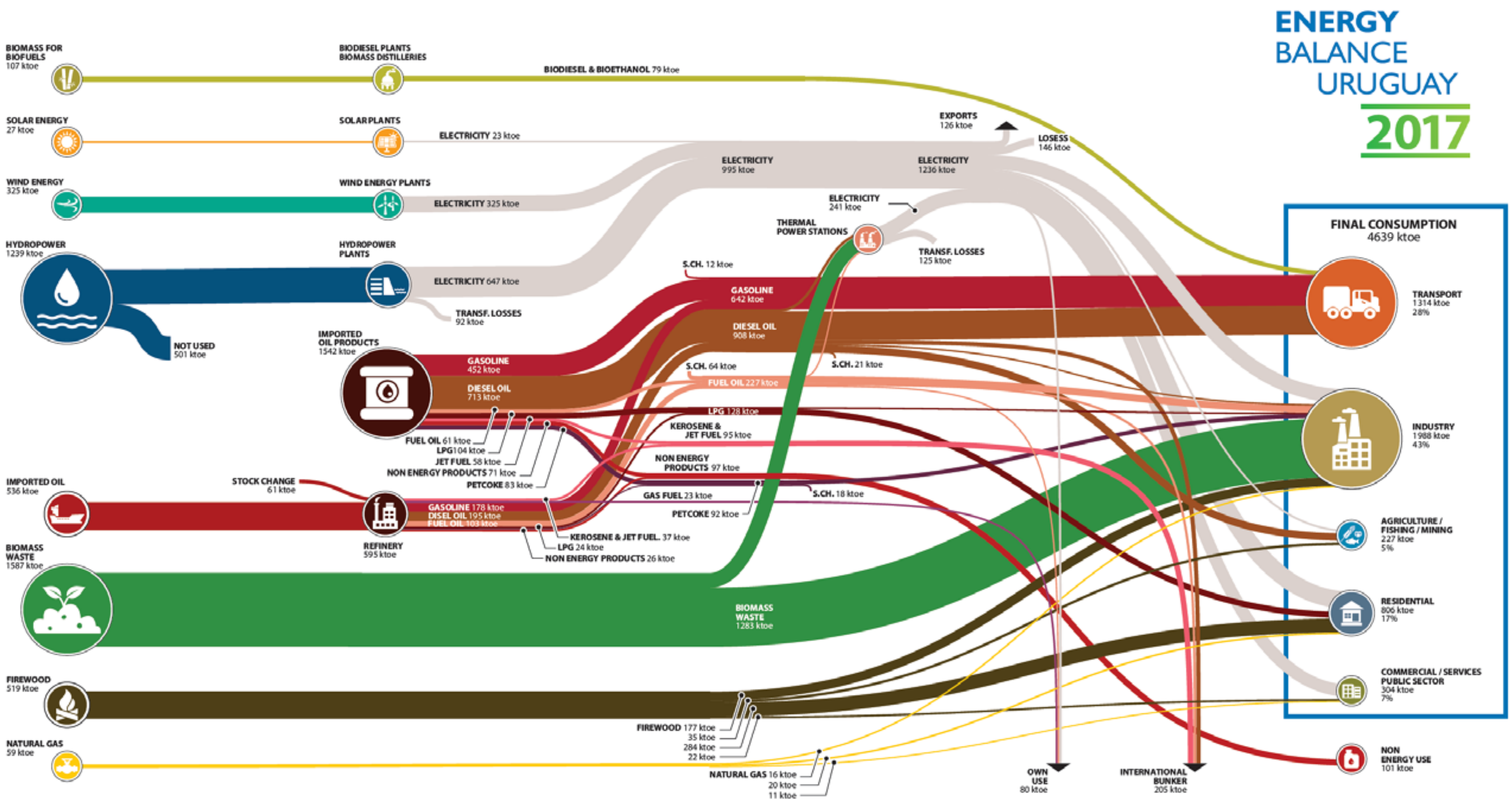
In English

DSO	Distribution System Operator
EPC	Engineering, Procurement and Commissioning
NCRS	Non-Conventional Renewables Sources
TSO	Transmission System Operator
SOE(s)	State Owned Enterprise(s)

In Spanish

ADME	Administración del Mercado Eléctrico
DNC	Despacho Nacional de Cargas
DNE	Dirección Nacional de Energía
MIEM	Ministerio de Industria, Energía y Minería
MMEE	Mercado Mayorista de Energía Eléctrica
MEF	Ministerio de Economía y Finanzas
OPP	Oficina de Planeamiento y Prespuesto
PE	Política Energética 2005 - 2030
UREE	Unidad Reguladora de Energía Eléctrica
URSEA	Unidad Reguladora de los Servicios de Electricidad y Agua
UTE	Administración Nacional de Usinas y Transmisiones Eléctricas
SIN	Sistema Interconectado Nacional

Appendix 2. Energy Balance of Uruguay



Source: Ministry of Industry, Energy and Mining of Uruguay.

Note: Only main flows are depicted.