PORTUGAL

ELECTRICITY AND HEATING

Portugal: a blazing energy transition hampered by the resilience of coal

THIS COUNTRY PROFILE IS AN EXTRACT FROM THE ANNUAL REPORT OF THE GLOBAL OBSERVATORY ON NON-STATE CLIMATE ACTION

→ DOWNLOAD THE COMPLETE REPORT ON **WWW.CLIMATE-CHANCE.ORG**

CLIMATE CHANCE

Portugal: a blazing energy transition hampered by the resilience of coal

Portugal, a country that is home to 10 million people, has become one of the European champions of renewable energies for electricity production, thanks to the growth of onshore wind, hydro-electricity, biomass and - more recently - solar energy. The spread of renewable energies also encourages new operators to emerge, both domestic and foreign, in a sector that is traditionally oligopolistic. However, the intense decarbonisation of the Portuguese electricity system has been faced with several challenges, requiring action from public and private operators at different levels. For example, the need for a rapid "exit" from coal, the physical interconnection with the rest of Europe, and the development of smart grids are some of the main challenges.

Head Editor • **GERMÁN BERSALLI** • *Researcher, Univ. Grenoble Alpes, CNRS, INRA, Grenoble INP, GAEL*

CONTENTS

1 • MOVING TOWARDS THE DECARBONISATION OF ELECTRICITY PRODUCTION?

Following the 2015 Paris Agreement, Portugal has been committed to achieving a carbon neutral economy by 2050. Since October 2017, the government has been working on a roadmap that aims to identify and analyse the implications of the trajectories that are most effective for pursuing the national goal of carbon neutrality. Despite an advance in renewable energies for generating electricity, continuing with coal prevents true decarbonisation of the sector.

• THE PORTUGUESE ELECTRICITY MIX: THE GROWTH OF WIND POWER VS THE RESILIENCE OF COAL • Despite significant investment in renewable energy over the past ten years, reducing CO_2 emissions from public electricity and heat production has proved to be a struggle (Figure 1). **On the one hand, we have seen an increase in electricity production, which pushes up the level of emissions, and, on the other hand, an opposite effect: a decrease in the carbon intensity of the electricity mix thanks to progress in renewable energies occurring at a faster rate than in fossil fuels. However, the second effect is barely enough to offset the first, which explains why the level of emissions only dropped very slightly over a ten year period**. Chart 1 also shows a large fluctuation in the level of emissions from one year to another. This can be explained by the significant variations in rainfall patterns and therefore hydro-electricity production, offset by increased use of fossil fuels. As such, CO_2 emissions decreased by 9% in 2016 but bounced back by 20% in 2017. Last year's emissions reached 17.1907 million tonnes of CO_2, 76% of which came from coal-powered power plants, 20% from gas-powered plants and 4% from diesel power plants.

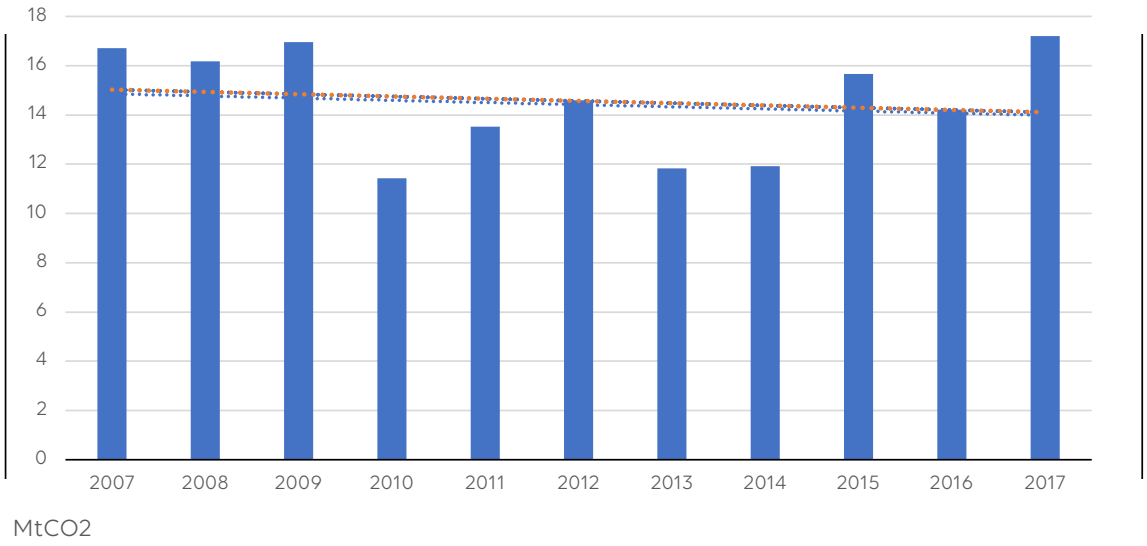


FIGURE 1. CO_2 EMISSIONS FROM THE PUBLIC PRODUCTION OF ELECTRICITY AND HEAT.

Source: Compiled by the author using data from ENERDATA

Public electricity generation in Portugal amounted to 49,447 gigawatt hours (GWh) in 2017, slightly lower than the record 51,983 GWh in 2016. The country has a fairly diversified electricity mix (Figure 2). In 2017, natural gas represented 32.9%, followed by coal (24.9%) and wind energy (20.3%). The remainder of the electricity mix was composed of: hydro-electricity (12.4%), biomass (5.7%), oil (1.9%), solar (1.4%) and geothermal (0.3%). Over the past decade, wind energy production has increased substantially; however, this has not been accompanied by a nominal decrease in production by coal-powered plants. As for gas-powered plants, their production levels vary from one year to the next to offset the fluctuations in hydro-electricity. The latter's share ranged from a maximum of 30.6% in 2010 to a minimum of 12.4% in 2017. **Finally, it should be noted that the share of**

wind energy in Portugal's electricity mix was the fourth highest in the world in 2016, behind Denmark, Lithuania and Uruguay. Solar energy, on the other hand, is still struggling to carve out its place in the Portuguese electricity mix.

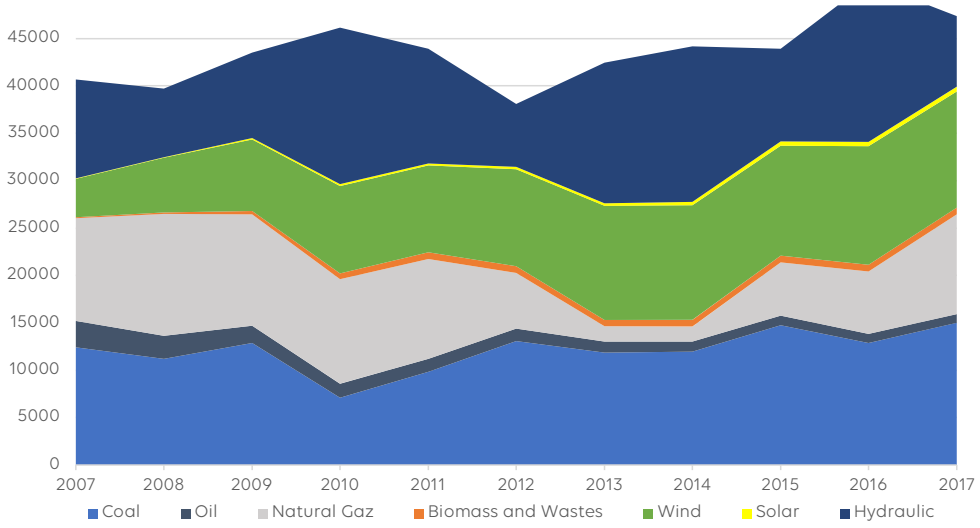


FIGURE 2. ELECTRICITY GENERATION BY SOURCE (GWH/YEAR)

Source: author's compilation using data from ENERDATA

Given the growth of wind power and the high variability of hydro-electricity production (from one year to another), the carbon intensity of Portugal's electricity mix (Figure 3) has experienced a slight downturn, but still demonstrates considerable fluctuations. With an intensity of around 300 grams of CO_2 per kWh, the country (like the majority of its European neighbours) still has a lot of work to do in order to achieve a fully-decarbonised electricity production sector.

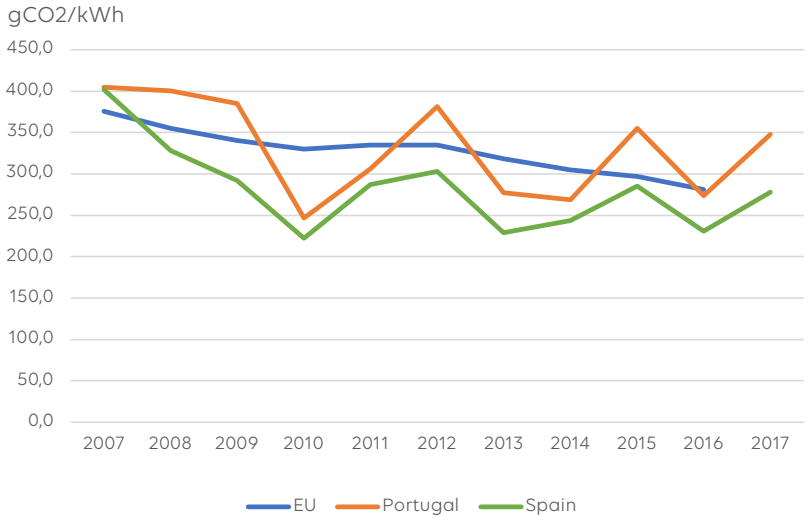


FIGURE 3. CARBON INTENSITY OF THE PORTUGUESE ELECTRICITY MIX.

Source: Compiled by the author using data from ENERDATA

• A SOMEWHAT AMBITIOUS NATIONAL POLICY FRAMEWORK • The purpose of the *Programa Nacional para as Alterações Climáticas 2020/2030* (National Climate Change Programme 2020/2030) is to ensure the reduction of greenhouse gas emissions, in order to achieve a goal of -18% to -23% in 2020 and -30% to -40% in 2030 compared to 2005 levels, ensuring compliance with national commitments in terms of mitigation and bringing Portugal in line with European objectives. It

sets specific targets for emissions reduction, and identifies a set of sectoral measures and policy options for development in the future. In this way, integrating mitigation objectives into sectoral policies is encouraged and a dynamic approach to planning is recommended, giving each sector (transport, energy, agriculture, forestry) greater autonomy in identifying policy tools.

As such, Portugal has adopted the 2020 target of sourcing 31% of its energy from renewable sources in final energy consumption, including 10% in transport; a general energy efficiency target of 25% for 2020 (more ambitious than the 20% target set by the EU) and a specific 30% energy efficiency target for public administration. Furthermore, in "*Compromisso para o Crescimento Verde*" the country committed to achieving 40% renewable energy in final energy consumption by 2030.

Given the strong potential of renewable energy in Portugal, the electricity sector, which includes dedicated production and cogeneration, is one of the main driving forces behind reducing national emissions. The most important way of encouraging renewable energy is a feed-in tariff for existing facilities. **A remuneration scheme came into force in 2015 for new small production facilities. Generally speaking, all technologies used in the generation of renewable electricity are eligible for support.** In addition, connections to the network are provided for renewable energy producers. Currently there is no direct assistance programme for renewable energies in the heating sector (in January 2017). Furthermore, Energy Efficiency Funds have provided grants for investments in solar water heaters through "Efficient Buildings 2016", which started in July 2016.

In November 2016, the Portuguese Minister of the Environment confirmed that the country's power plants would cease burning coal by 2030. This was reiterated when the roadmap for carbon neutrality by 2050 was launched in October 2017. The Sines power station in Portugal, inaugurated in 1985, is one of the EU's most climate-damaging coal-powered plants[1].

2 • THE DEVELOPMENT OF RENEWABLE ENERGIES AND THE DIVERSIFICATION OF OPERATORS

The development of renewable energies in Portugal has largely been led by EDP Renováveis (EDPR), which was established in 2007 as an independent company of the incumbent operator, EDP (Energias de Portugal). **By the end of 2017, EDPR was ranked fourth in the world in terms of wind energy production. Small start-ups have been emerging alongside this giant in a Portuguese electricity sector that is particularly dynamic in wind power and, more recently, solar power.**

• CONSOLIDATION OF ONSHORE WIND ENERGY • The power generation sector - which has long been oligopolistic - has four major players, including the EDP. **However, over the past decade this company has seen its market share decrease due to the emergence of several new renewable energy producers. In 2013, they already accounted for 40% of electricity on the wholesale market (IEA, 2016).**

Portugal has been experiencing spectacular development in onshore wind energy since the 2000s. **The country's installed capacity has grown from 100 MW in 2000 to 5,269 MW in 2017 (Figure 4), which has been made possible by a very generous feed-in tariff system (Figure 5).** A portion of the extra cost is passed on to electricity consumers, while another portion increases the deficit - and accumulated debt - of the electricity system. This prompted critical reactions (Peña et al., 2017), and the government decided to end this support system in late 2012. As such, plants put into operation from 2013 onwards could no longer receive these grants, which slowed down the sector's growth. However, a new promotion scheme came into force in 2015 for self-generators and small production facilities with a maximum installed capacity of 250 kW. As far as offshore wind power is concerned, there are as yet no turbines operating off the Portuguese coast because the ocean floor is too deep. Offshore wind power will be achieved via floating wind farms, a dozen of which are in the planning stage.

1 -Europe Beyond Coal Overview: National Coal Phase-Out Announcements in Europe, 2018

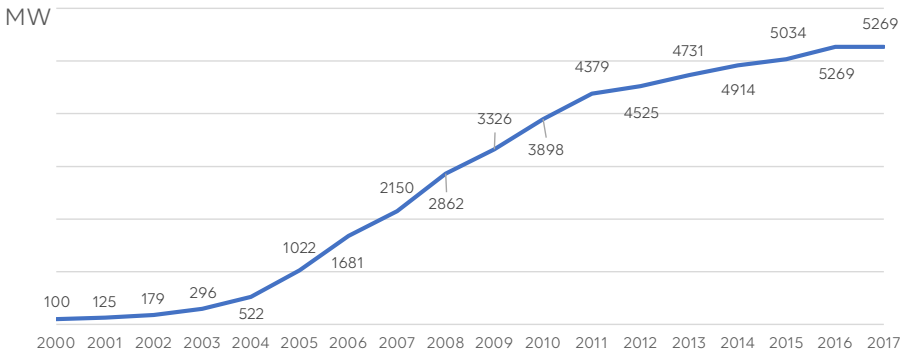


FIGURE4. INSTALLED WIND POWER CAPACITY, PORTUGAL.

Source: compiled by the author using data from ENERDATA

Three major operators dominate the wind energy market: ENEOP2, EDP Renováveis and Iberwind, who account for 45% of the total installed wind power capacity (Peña et al., 2017). In addition to these large operators, there are several hundred small renewable energy producers, the majority of which are part of the Portuguese Renewable Energy Association (APREN). The Omniflow scheme (see box 1) demonstrates the potential technological innovation of these small businesses, and is beginning to spread throughout Portugal and beyond.

According to APREN estimates (2018), renewable sources for electricity generation represented 1.8% of national GDP in 2017. **The technology which has contributed the most to this statistic is wind energy, due to the existence of a value chain that includes the production of industrial components as well as a range of R&D services. The sector accounts for 55,000 jobs, and there are 400 researchers working in this field.**

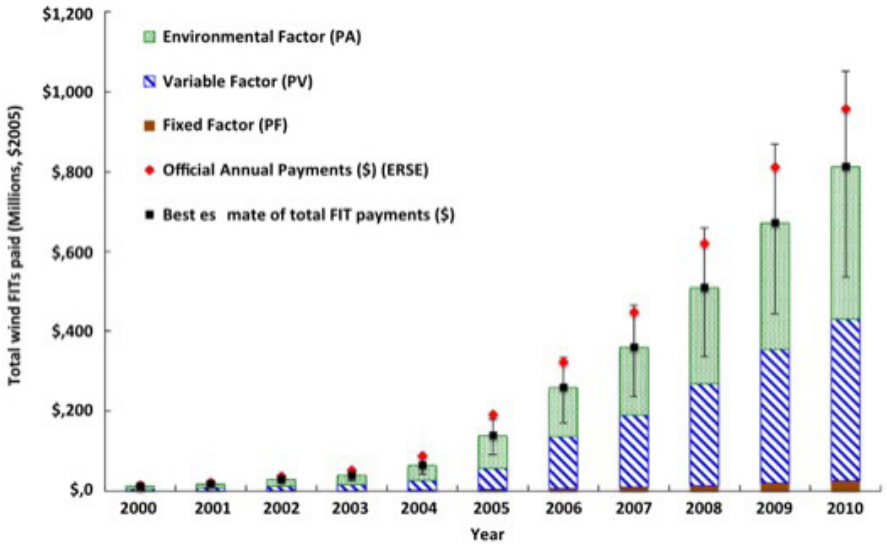


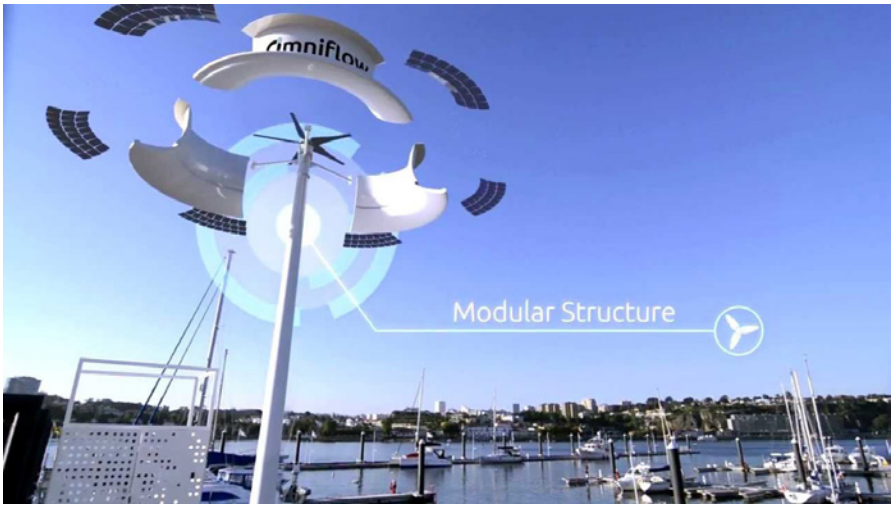
FIGURE 5. REMUNERATION PAID TO WIND ENERGY PRODUCERS

Source: Peña et al., 2017.

Omniflow, an innovative technology which combines wind and solar energy

Omniflow technology combines a vertical axis wind turbine with photovoltaic solar panels. This innovation was developed by a small Portuguese company which subsequently received financial support from the EU.

This technology has several innovative aspects: modular wing-shaped blades are integrated into a circular device which rests on a mast of varying size depending on the specific need. At its centre there is a mobile vertical axis which captures and accelerates wind coming from all directions, while the air above the turbine combines with the air coming directly from the turbine in an ascending cyclonic vortex. To complete the device, the surface is covered with solar cells. By combining these two energy sources, this hybrid technology increases total electricity generation and reduces storage needs thanks to the way solar and wind energy complement each other. As an energy source, the sun is usually more stable, but the turbine compensates for production losses in winter, as solar PV reaches peak production in summer while wind power experiences peak production in winter and can operate at night.



This start-up targets households as well as commercial buildings, and advises potential customers on the best solution for the site in question. It also offers a model that is suited to smart street lighting (Smart Street Lighting - Omnilight).

Source: Isento G. (10/11/2015) Omniflow é um gerador urbano com energia solar e eólica, publico.pt

TEXT BOX 1

• SOLAR PV TAKES OFF • The cost of solar PV has dropped significantly over the past few years, along with the price of storing electricity in batteries. In a sunny country such as Portugal, solar energy is a very appealing source of power to help balance the country's already impressive supply of hydraulic and wind energy. Portugal has invested in solar energy to take advantage of this potential, combining favourable conditions with technological progress and the government's stable regulatory framework. Recent investments have shown that Portugal can continue to play an active role in the deployment of renewable energies.

26 July 2018 marked the inauguration of a new solar facility in Ourique, Alentejo, in South-East Portugal. The *Ourika* plant has been operating since June, following 11 months of construction and 35 million euros of investment. **It is one of the largest solar power plants in Europe. Its 142,000 solar panels produce 80 GWh of energy per year, which is enough to power 23,000 households. In addition to its size, this power plant is the first on the Iberian Peninsula to be connected to the main power grid without a guaranteed tariff or other public subsidies.**

The Portuguese Minister of the Environment recently announced the planned instalment of 31 new

power stations in Portugal before 2021, which represents an additional production capacity of more than 1,000 MW. The total value of the projects has been estimated to be around 800 million euros. In 2021, the country will be able to triple its installed solar PV capacity from the current 572 MW to nearly 1,600 MW. The government even hopes to increase solar energy production sixfold before 2025.

A floating solar power plant in a hydroelectric dam

The company *EDP-Renovaveis*, which is associated with a French start-up, is testing a technology that is one of its kind in Europe: combining a hydroelectric dam and a floating solar power plant. The Alto *Rabagão* model, located in the north of the country, is small in size: 840 solar PV modules occupy a surface area half the size of a football pitch, submerged in a pool of water that is eight thousand times larger. With 220 kilowatts of power, they can only power around one hundred homes. But the test, which was launched in late 2016, at a cost of 450,000 euros, shows promise (Le Monde, 31/08/2018).

There are several advantages to installing panels in an aquatic environment: it cools the cells, which would increase their efficiency by 4 to 10%, and there is no need to use land or build additional power lines. Furthermore, the floating power station reduces evaporation from the reservoir and slows the growth of algae, according to those in charge of the EDPR projects.

If the test is successful, it will be followed by a project on a larger scale with 20 megawatts (MW). EDPR intends to develop the process on a larger Portuguese dam called Alqueva, which is located in Alentejo, in the south of the country, and to eventually export it to Brazil, where the energy company has a strong presence.

Photo: Rui Oliveira / Global Imagens

TEXT BOX 2

3 • THE CHALLENGES OF INTEGRATING A GROWING SHARE OF INTERMITTENT ENERGIES

The Iberian Peninsula is home to vast wind and solar resources, but it remains relatively isolated from the rest of Europe, which hinders the injection of renewable electricity into central European networks. Several projects are in progress with the aim of reversing this situation. At the same time, integrating intermittent energies creates new challenges for transport and distribution network operators. With this in mind, smart grids are being developed in several of the country's cities.

• THE PORTUGAL - SPAIN - FRANCE INTERCONNECTION • **In March 2018, Portugal produced more electricity from renewable energies than it actually needed. This marked the first time in the 21st century that the amount of electricity generated exceeded consumption.** However, the lack of energy connections with the rest of Europe remained a stumbling block. Without a properly connected electricity network or a well-developed storage system, some of this intermittent energy would be wasted. This is why interconnections are vital for EU energy union projects in order to create a

proper internal energy market, because they would enable surplus electricity to be transferred from one EU member state to another, depending on production and demand.

At the end of 2014, there were nine lines connecting Portugal and Spain: six were 400 kV and three were 220 kV, which meant there was a maximum exchange capacity of 2,800 MW from Portugal to Spain and 2,200 MW from Spain to Portugal. Despite this level of interconnection, sometimes there is still heavy traffic congestion between the two countries. Several investment projects are underway with the aim of remedying this issue, including two new 400 kV connections.

Furthermore, the EU has set the target of increasing the electricity interconnection capacity to 10% of the installed capacity in each country by 2020, and to 15% by 2030. In order to achieve this, special efforts need to be made to connect the Iberian Peninsula and integrate intermittent energies effectively. The completion of the planned interconnection projects between Portugal, Spain and France will help to increase electricity trading. Portugal and Spain will be in a position to export surplus renewable energy, particularly wind and hydraulic energy. Conversely, when wind energy generation is low or when hydroelectric resources are limited, more electricity from France could flow into the region.

In June 2015, the European Commission, France, Portugal and Spain signed a Memorandum of Understanding **for the creation of a High Level Group concerning interconnections for the South-Western region of Europe. Several projects are currently underway:**

• **Bay of Biscay line** Approved by the European Commission in January 2018, the project involves the installation of a 280 km long underwater line in the Capbreton Gulf (Landes). The French terrestrial portion will be entirely underground. This new line means that the interconnection capacity between the two countries will almost double from 2,800 to 5,000 MW. This will bring Spain closer to the interconnection target of 10% by 2025, the current level being 6%. This project received record EU funding of 578 million euros (Connecting Europe Facility-Energy).

-Santa Llogaia-Baixas Project (INELFE). The completion of the transformer in Arkale, Spain in June 2017 enabled full use of the Santa Llogaia-Baixas line between Spain and France, doubling the electricity interconnection capacity between the two countries, which rose from 1,400 to 2,800 MW. This line is 64.5 km long, with 33.5 km in France and 31 km in Spain. It connects the communes of Baixas in le Roussillon (France) and Santa Llogaia in Alt Empordà (Spain). The final route of the French portion was decided after 15 months of consultations with community representatives and local associations. One of the objectives of INELFE was to minimise the environmental impact of the interconnection, during both the design and implementation phases. The first step was to build the line underground and dig a utility tunnel to cross the Pyrenees. Although more costly, this solution helped to preserve, among other things, the forest tracks of the Albera mountain range[2].

• **Interconnection project between Spain and Portugal** (Ponte Lima - Vila Nova Famalicão - Recarei (Portugal) and Beariz - Fontefría (Spain)). This is a classic 400 kV aerial technology project which will connect Galicia with the Portuguese region of Minho, and will increase the exchange capacity between Spain and Portugal until it reaches the inter-governmental target of a 3.2 GW exchange capacity. The capacity will enable the full integration of the Iberian electricity market, as well as improving the management of renewable energy. The project is scheduled to be implemented in 2021. These projects, which are supported by the European Commission and the governments of Portugal, France and Spain, are an important step towards putting an end to the Iberian Peninsula's isolation from the rest of the European energy system.

• SMART GRIDS FOR SMART CITIES: EXAMPLE OF THE CITY OF ÉVORA • Évora is home to 56,596 inhabitants (2011), and is the capital of the Alentejo region, in south-central Portugal. It is the first city in the country to have tested certain smart grid technologies on a large scale through the *InovGrid* project. The *InovGrid project* has been developed by the energy company EDP in close

2 - inelfe.eu/fr/projets/baixas-santa-llogaia

collaboration with several organisations, including European research institutes and universities, industrial partners, local and national authorities, energy sector associations and regulators, the communities in question and other stakeholders. ***InovGrid* aims to transform the distribution network and provide a solution to a number of challenges in line with government policies: the need to increase energy efficiency, bring costs down, and to integrate intermittent energy producers as well as electric vehicles.**

An important component of *InovGrid* was the deployment of a smart grid infrastructure, which began in the municipality of Évora in 2011. The new infrastructure covers the whole of the city, reaching around 32,000 electricity consumers. Its main components are:

- smart boxes, installed in the homes of all low-voltage customers, which offer cutting-edge solutions such as real-time energy demand readings, load diagrams, voltage curves, etc.;
- distribution transformer controllers installed in each secondary substation, which act as data concentrators and as devices for local metering, supply quality monitoring and automation;
- a communication network based on powerline communication and radio service technologies, which connect computer housings and controllers to network headend systems;
- charging stations for electric vehicles;
- efficient street lighting systems, based on advanced control LED lighting.

Beyond implementing physical infrastructure, *InovCity* is seeking to improve communication between different stakeholders by offering various tools and services (displays, smartphone applications, etc.) and involving local authorities in a joint effort to improve energy efficiency.

The municipality of Évora has played an active role in this project, participating financially and allowing the first tests to be carried out in the city's public buildings. This project was guided by the city's 2012 action plan for sustainable energy[3], which aimed to reduce GHG emissions by 20% by 2020.

The Évora project highlighted several benefits of smart grids, including: an improvement in energy efficiency (3.9% reduction in electricity consumption); an increase in service quality (detection and handling of faults, monitoring supply quality); reduced energy losses, resulting from a drop in demand and better management of the network; reduced fraud, improved integration capacities of distributed energy resources and electric vehicles.

Currently, the project is expanding to other Portuguese towns, including Guimarães, Lamego, Batalha/Marinha Grande, Alcochete, Algarve and São João Madeira, reaching in excess of 150,000 consumers by the end of 2014. Furthermore, as of 2015, all new establishments use digital boxes, making this technology standard in Portugal[4].

Brain-e, a social network for better electricity consumption

The Brain-e platform helps users reduce their energy consumption in a simple and interactive way. "The energy market is booming, yet there is a real lack of consumer awareness." This was the idea that brought about Brain-e, a smart platform for managing energy consumption. "Not many consumers know how much they are consuming, what they are consuming, what prices are being charged by the market or how to make savings," explains Luis Guerreiro, one of the young people involved in the project (publico.pt/2015/09/22).

Brain-e collects energy consumption information in digital format and presents information to users in a simple way. The platform provides consumers with suggestions on how to save energy, information on market prices and forecasts for energy consumption and production potential. Users can also cooperate with their friends and neighbours to manage their consumption across communities.

Simple actions can help to save energy; for example, washing clothes one hour later than usual or switching off certain appliances at night. This social network wants to help people change their daily energy consumption patterns by

3 - cm-evora.pt/pt/site viver/Habitar/ambiente/PublishingImages/Paginas/Evoracarbonozero/PAES_Evora2012.pdf
4 - http://www.gridinnovation-on-line.eu/articles/library/inovgrid-project---edp-distribuicao-portugal.kl

providing consumers with information that will help them monitor their consumption. This project also seeks to forge energy management communities, which create incentives to jointly reduce the consumption of a certain location. Brain-e is free for users, who can save energy, save money and help to reduce CO_2 emissions. It is the result of work by a team of six entrepreneurs - four engineers, a social sciences researcher and a designer. The team has two important objectives at present: to launch a 1.0 version of the platform which can be tested by a limited number of users, and to find a commercial partner who is looking to break new ground in the services that they provide to their customers (publico.pt/2015/09/22).

"The biggest hurdle will be the limited number of digital devices that are capable of reading energy consumption in Portugal. This is why we are looking at other markets at international level, where these devices are more commonplace", explains Luis Guerreiro.

Source: www.publico.pt/2015/09/22/p3/noticia/uma-rede-social-de-poupanca-de-energia-1824238

TEXT BOX 3

CONCLUSION

Portugal has been experiencing steady growth in the use of renewable energies for electricity generation in recent years. This transition is guided by proactive policies - European and, above all, national - but also by the actions of various operators, be it a long-established energy company or new innovative enterprises. In addition, actions by some cities such as Évora demonstrate the importance of the role played by local authorities. Despite this progress, the country still has a long way to go before it achieves a completely decarbonised electricity mix.

PLEASE DO NOT HESITATE TO REACT TO THIS STUDY, AND NOTIFY US COMPLEMENTARY REPORTS AND DATA VIA THIS ADDRESS: CONTRIBUTION@CLIMATE-CHANCE.ORG

REFERENCES

REPORTS AND DATABASES:

• Portugal - Energy system Overview, International Energy Agency (chiffres 2016)

• Energy Policies of IEA Countries - Portugal 2016 Review, International Energy Agency (last update)

• Energy and Climate, Relatorio do Estado do Ambiante - State of the Environment Portal (chiffres 2016, last update mai 2018)

• APREN (Associação de Energias Renováveis), Renewable Electricity in Portugal (Décembre 2017)

GREY LITERATURE:

• CCS Institute (01/04/2015) CO_2 Capture and Storage in Portugal: A bridge to a low-carbon economy

• Europe Beyond Coal (22/06/2018) Overview: National coal phase-out announcements in Europe

• ProgRESsHeat (21/11/2017) Local heating and cooling strategy recommendations for Matosinhos – Deliverable 5.4

SCIENTIFIC LITERATURE:

• Nunes L.J.R. & al. (2017) Biomass in the generation of electricity in Portugal: A Review, Renewable and Sustainable Energy Reviews 71, Mai 207

• Prata R. & al. (2018) Distributional costs of wind energy production in Portugal under the liberalized Iberian market regime, Energy Policy 113, Février 2018, pp. 500-512.

• Peña I. & al. (2017) Lessons from wind policy in Portugal, Energy Policy 103, Avril 2017, pp. 193-202

• Delgado J. & al. (2018) Impacts of plug-in electric vehicles in the portuguese

PRESS:

• Isento G. (10/11/2015) Omniflow é um gerador urbano com energia solar e eólica, publico.pt

• Neslen A. (18/05/2016) Portugal runs for four days straight on renewable energy alone, The Guardian

• Morgan S. (04/05/2018) Le Portugal dépasse les 100% d'énergie renouvelable, Euractiv

• Stefanini S. (22/08/2016) Portugal's clean-power problem, Politico

• Collet S. (25/01/2018) L'interconnexion entre la France et l'Espagne reçoit une subvention européenne record, actu-environnement.com

• (27/07/2018) European solidarity on Energy: Better integration of the Iberian Peninsula into the EU energy market, europa.eu

• (22/02/2018) Portugal extends area of pilot floating wind turbine project, theportugalnews.com