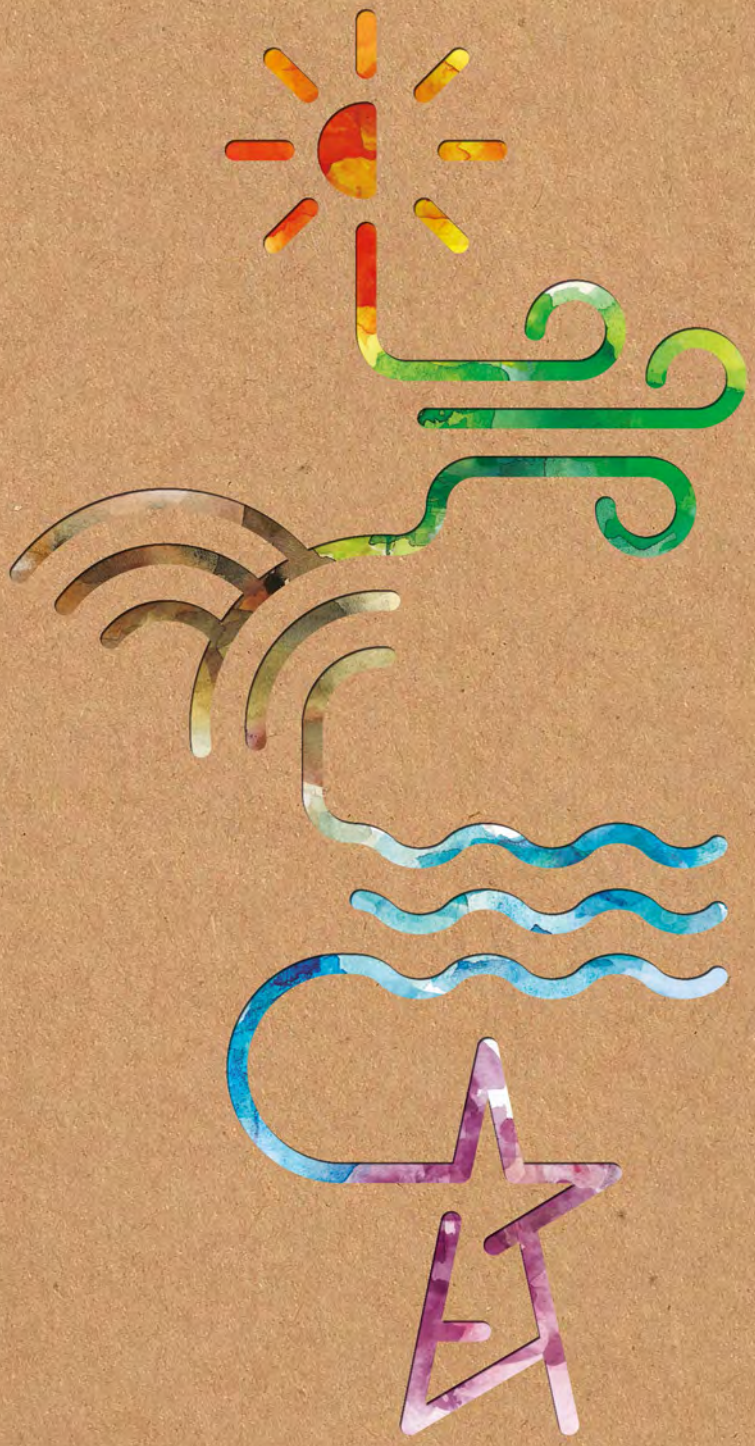
Renewable energy
in the Spanish
electricity system

2016



RED ELÉCTRICA DE ESPAÑA

Renewable energy in the Spanish electricity system

2016

RED ELÉCTRICA DE ESPAÑA

Introduction

The development of renewable energy is one of the objectives of the Clean Energy package proposed by the European Commission in order to move towards a decarbonised energy model. However, the integration of renewable energy due to it being intermittent, variable and highly unpredictable represents an enormous challenge for system operation due to the special nature associated to its control and generation.

Red Eléctrica de España (REE), as transmission agent and operator of the Spanish electricity system, makes a significant effort to integrate renewable energy into the system. The Control Centre of Renewable Energies (CECRE), is the pioneering technological tool that has been facing up to the challenge of incorporating this type of energy into the operation of the electricity system under reliable and safe conditions.

More than ten years ago, renewable energies started to play an important role in the electricity generation structure and nowadays they represent one of the main sources of energy in the entire set of electricity generating facilities not only in Spain, but also in many other countries.

It is not surprising, therefore, that there is significant public interest in knowing the statistical data regarding its evolution and how it works. In response to this interest, Red Eléctrica has decided to publish the first edition of this report entitled 'Renewable energy in the Spanish electricity system 2016', with the objective of ratifying REE's role as a point of reference regarding information about the Spanish electricity system.

The report presents an overview of the role of renewable energy in Spain in 2016 and how it has evolved over recent years. It is divided into four main chapters: Energy from the wind, Energy from water, Energy from the sun and Energy from the Earth and sea, and a fifth one that consolidates the data included in the aforementioned chapters and which is entitled 'Renewable energy in 2016'. The latter has been included at the beginning of the report as the first chapter in order to provide the reader with an initial overview of the behaviour of renewable energy during the year.

In addition, the digital version of this report is supplemented by Excel files that allow detailed data to be displayed and downloaded. This information is available on the corporate website **www.ree.es,** along with other publications and statistics that REE periodically makes available to the public.

As part of its continued effort to improve, REE's aim is to offer a quality service for all users. To this end the following e-mail address redelectrica@ree.es is made available to the public, as a channel through which suggestions and observations may be submitted.

Renewable energy in 2016

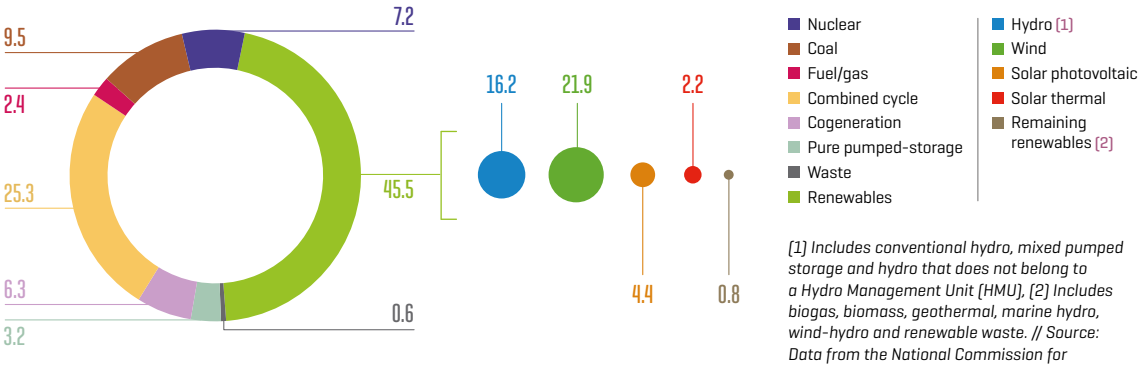
01

Renewable energy in Spain **represented more than 45% of the installed power capacity in 2016 and almost 39% of national generation.** The share of renewables reached almost 41% in the Spanish peninsular system, which accounts for about 95% of national generation.

(%)

BREAKDOWN OF INSTALLED POWER CAPACITY STRUCTURE

NATIONAL ELECTRICITY SYSTEM AS AT 31-12-2016 (105,279 MW)

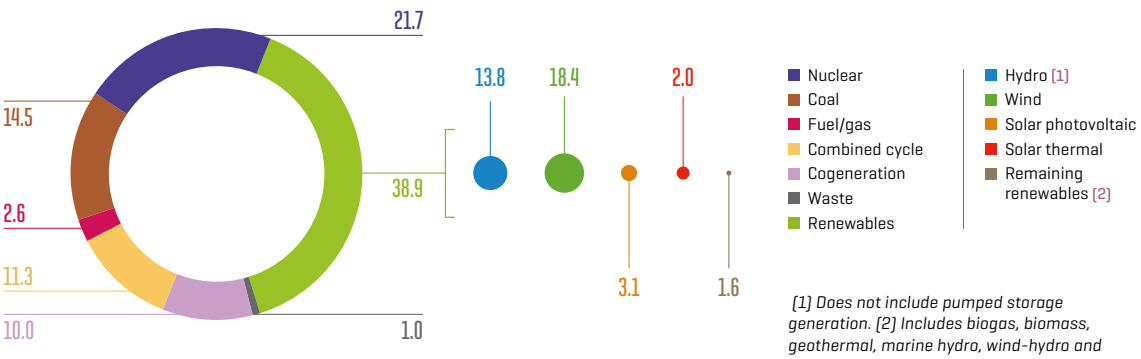


(1) Includes conventional hydro, mixed pumped storage and hydro that does not belong to a Hydro Management Unit (HMU), (2) Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. // Source: Data from the National Commission for Markets and Competition (CNMC) and REE.

(%)

ELECTRICITY GENERATION MIX IN 2016

NATIONAL ELECTRICITY SYSTEM (258,787 GWh)



(1) Does not include pumped storage generation. (2) Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. // Source: REE.

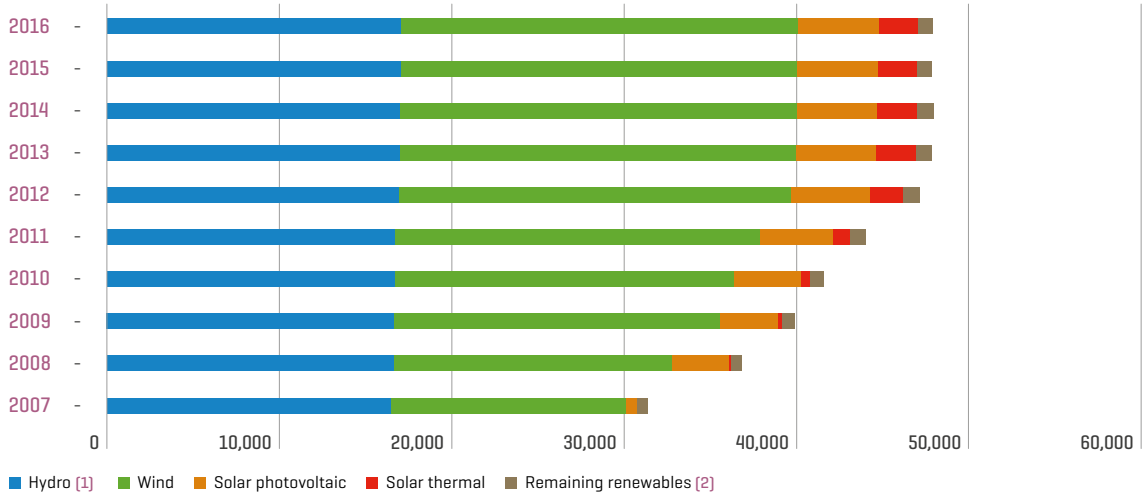
The evolution of installed renewable power capacity in Spain over the last ten years shows that wind and solar technologies have been the drivers of the huge increase seen over this period, a growth of almost 70 % compared to the figure for 2007.

Renewable energies have increased their relevance in the overall national electricity generation mix with a share of almost 39 %

[MW]

EVOLUTION OF INSTALLED RENEWABLE POWER CAPACITY

NATIONAL ELECTRICITY SYSTEM

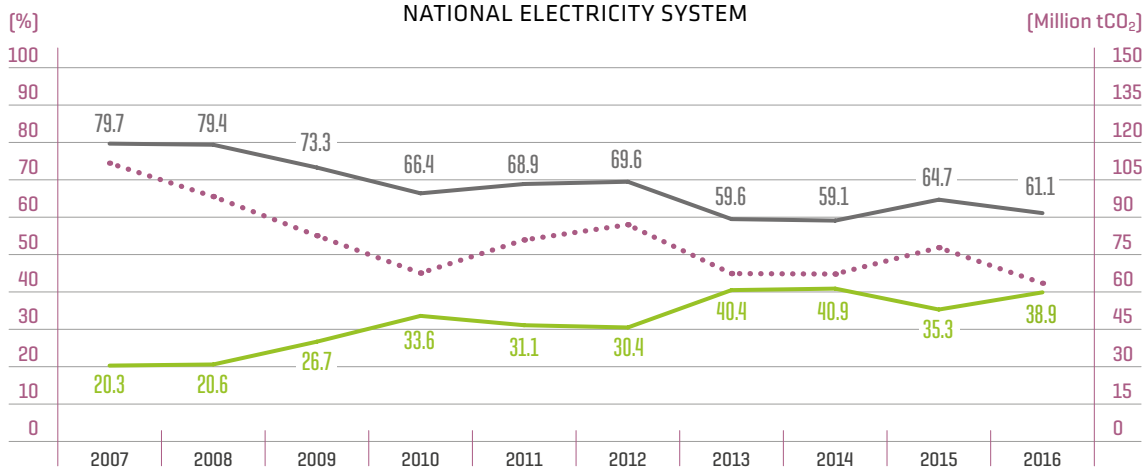


(1) Includes conventional hydro, mixed pumped storage and hydro that does not belong to a Hydro Management Unit (HMU), (2) Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. // Source: Data from the National Commission for Markets and Competition (CNMC) and REE.

[%] [$MtCO_2$]

EVOLUTION OF RENEWABLE/NON-RENEWABLE GENERATION AND CO_2 EMISSIONS ASSOCIATED WITH ELECTRICITY GENERATION

NATIONAL ELECTRICITY SYSTEM



Renewables: hydro, wind, solar photovoltaic, solar thermal and remaining renewables.
Non-renewables: nuclear, coal, fuel/gas, combined cycle, cogeneration and waste.
Emissions (Million tCO_2)

Source: REE.

in 2016, almost twice as much as ten years ago. In the Spanish peninsular system, which represents around 95% of all national production, the share of renewables in the generation mix reached 40.8%.

This progressive increase in renewables has led to a decrease in CO_2 emissions as these energies have been replacing the use of fossil fuels in electricity production. Specifically, the level of emissions from electricity generation in 2016 stood at 63.5 million tonnes of CO_2, 18.3% below the 2015 level and 43.1% lower than the level registered in 2007.

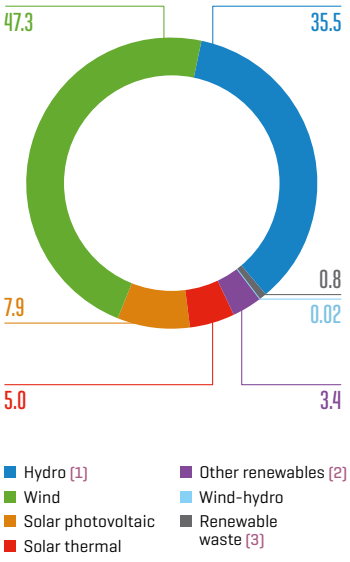
Wind energy is the most relevant renewable technology and also plays a prominent role in the electricity generation mix, ranking as the second source in 2016 with a share of 18.4% of the total national production. Regarding renewable sources, wind energy alone accounted for 47.3% of all renewable generation in 2016.

Since 2007, wind energy has been the main source of renewable generation, due to its regularity and more importantly to the fact that installed wind power capacity has grown year on year. In fact, unlike hydropower, whose dependence on meteorological conditions is extremely high, wind energy is much more constant in its production, although it also has a certain degree of dependence on meteorological conditions.

[%]

ANNUAL RENEWABLE ENERGY GENERATION STRUCTURE IN 2016

NATIONAL ELECTRICITY SYSTEM (100,748 GWh)

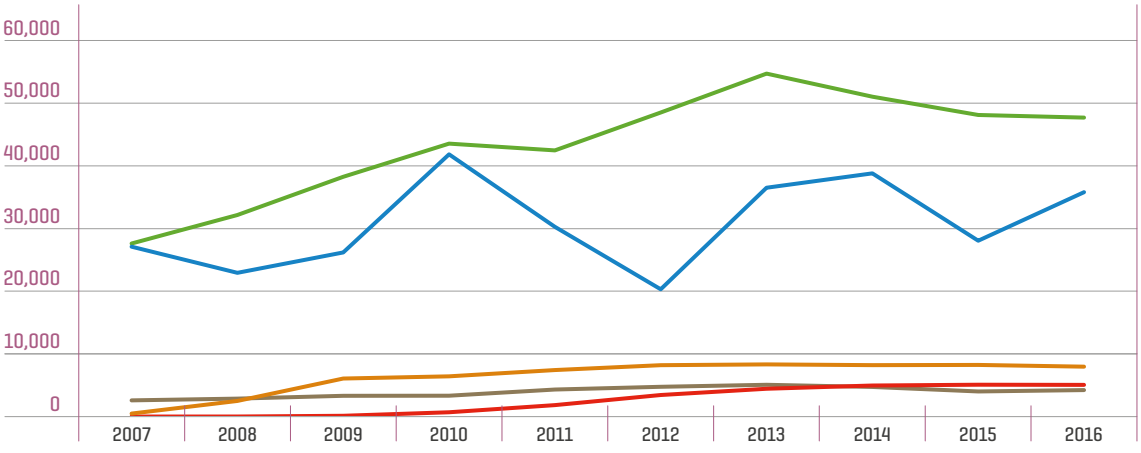


(1) Does not include pumped storage generation. (2) Includes biogas, biomass, marine hydro and geothermal. (3) 50% of generation obtained using urban solid waste is considered as renewable.

[GWh]

EVOLUTION OF RENEWABLE ENERGY GENERATION

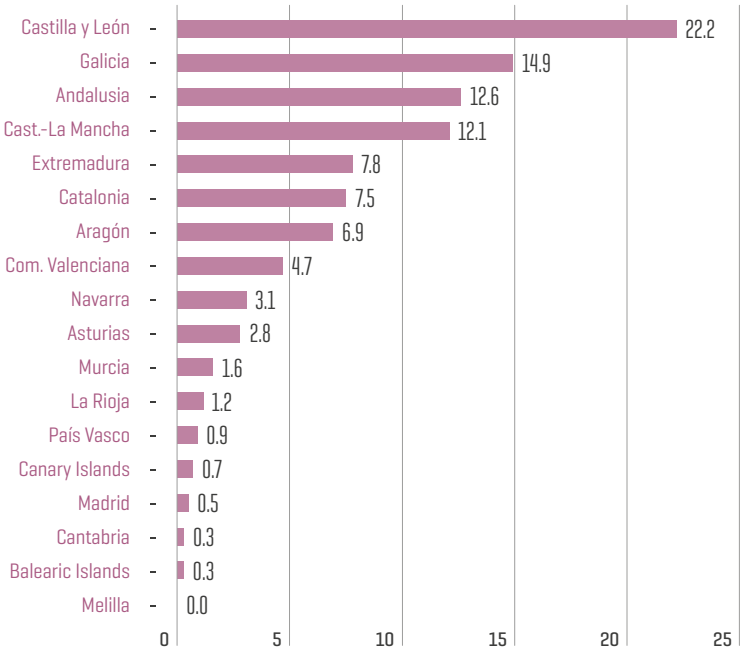
NATIONAL ELECTRICITY SYSTEM



(1) Does not include pumped storage generation. (2) Includes biogas, biomass, geothermal, marine hydro and renewable waste. // Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Melilla since 2007.

SHARE OF INSTALLED RENEWABLE POWER CAPACITY

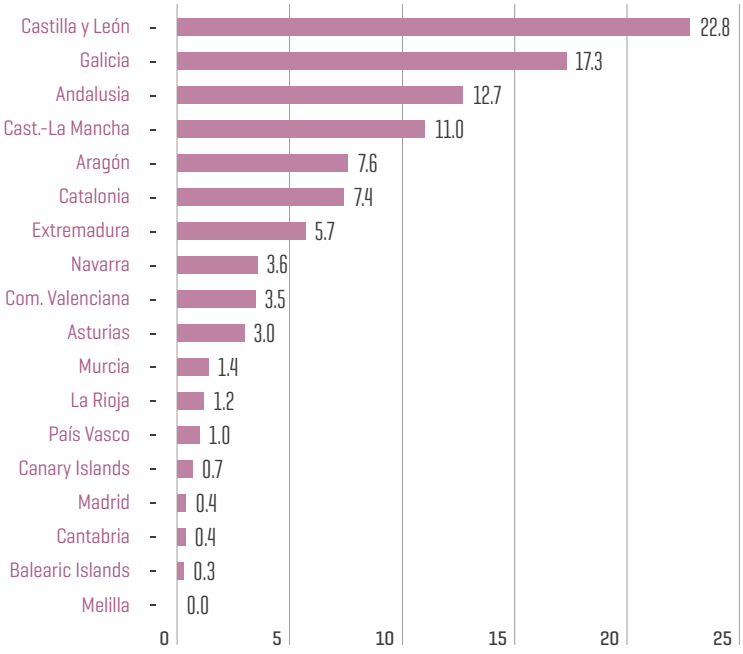
PER AUTONOMOUS COMMUNITY IN RELATION TO NATIONAL RENEWABLE POWER CAPACITY AS AT 31-12-2016



Source: Data from the National Commission for Markets and Competition (CNMC) and REE.

SHARE OF RENEWABLE GENERATION

PER AUTONOMOUS COMMUNITY IN RELATION TO NATIONAL RENEWABLE GENERATION AS AT 31-12-2016



Source: REE.

By autonomous community, most of the installed renewable power capacity is located in Castilla y León, Galicia, Andalusia and Castilla-La Mancha, which together account for almost 62 % of the installed renewable power capacity nationwide.

In five autonomous communities, more than half of the installed power capacity is renewable. Of these, head and shoulders above the rest is Castilla y León as 74 % of its power capacity is renewable, also making it the community with more megawatts of installed renewable generation capacity.

By technology, Castilla y León leads the four autonomous communities with the greatest amount of installed wind power capacity, followed by Castilla-La Mancha, Galicia and Andalusia. Regarding hydro, Castilla y León and Galicia stand out and a bit further down in the ranking is Extremadura, which is a region that stands out for its installed power capacity based on solar technologies. Andalusia is the region with the highest installed power capacity of solar photovoltaic and solar thermal.

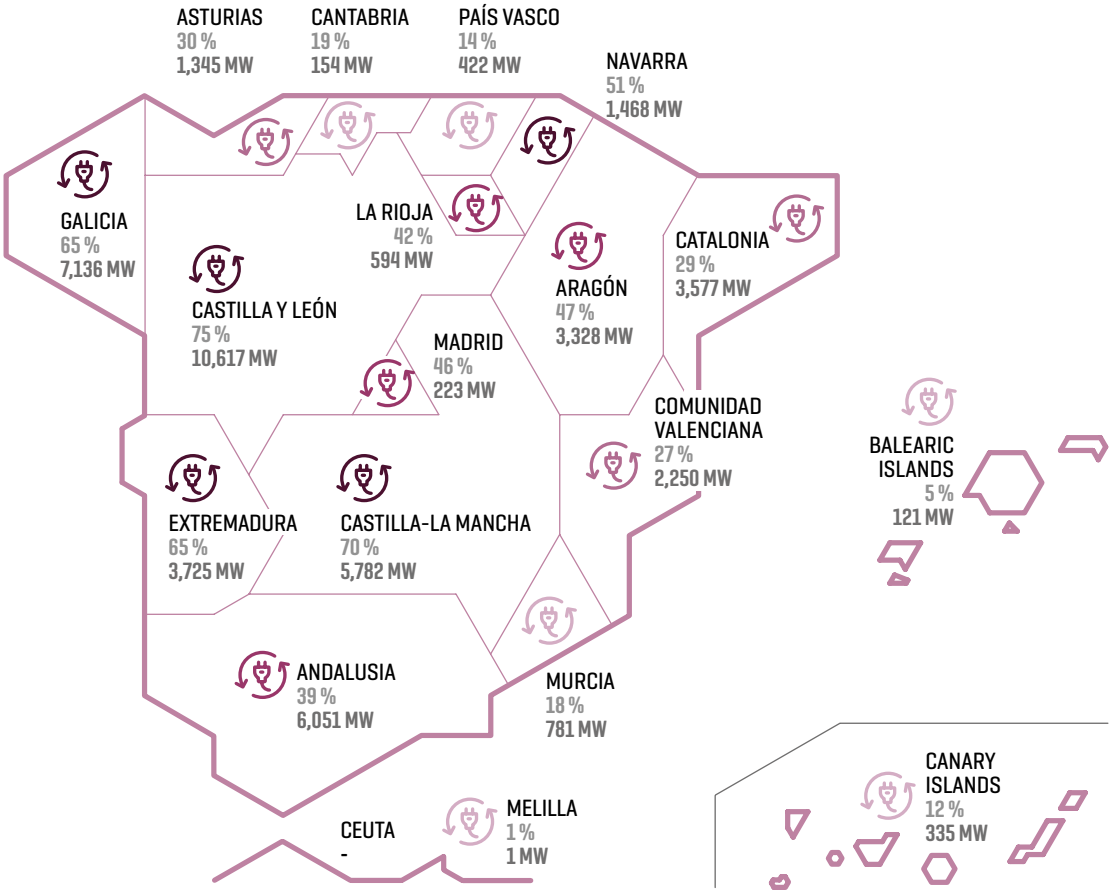
As for the contribution of renewable generation to the total energy generated, in 2016 five autonomous communities registered figures in excess of 50 %, led by Navarra with more than 70 % of its total generation being of renewable origin.

Castilla y León is the region with the most installed renewable capacity, representing just over 22 % of the installed renewable power capacity in Spain in 2016; Galicia, Andalusia and Castilla-La Mancha follow. Together these four regions account for nearly 62 % of total renewable power capacity nationwide.

[%] [MW]

RENEWABLE POWER/TOTAL INSTALLED CAPACITY RATIO AND RENEWABLE POWER CAPACITY

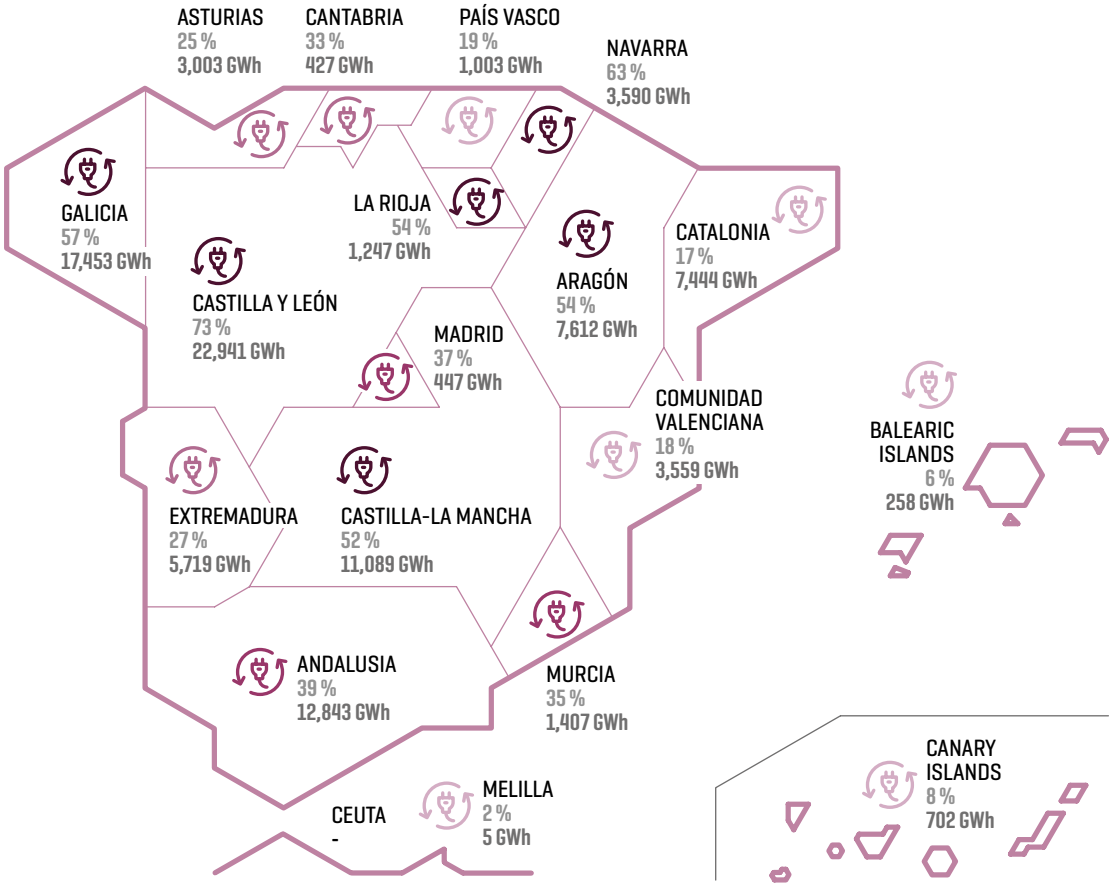
AS AT 31-12-2016



Source: Data from the National Commission for Markets and Competition (CNMC) and REE.

[%] [GWh]

RENEWABLE GENERATION/TOTAL GENERATION RATIO AND RENEWABLE GENERATION IN 2016

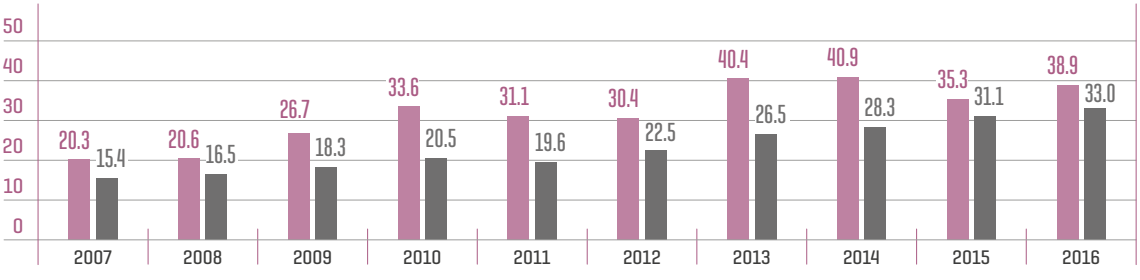


Source: REE.

[%]

RENEWABLE GENERATION REGARDING TOTAL GENERATION IN SPAIN

AND THE AVERAGE OF A SELECTION OF ENTSO-E MEMBER COUNTRIES



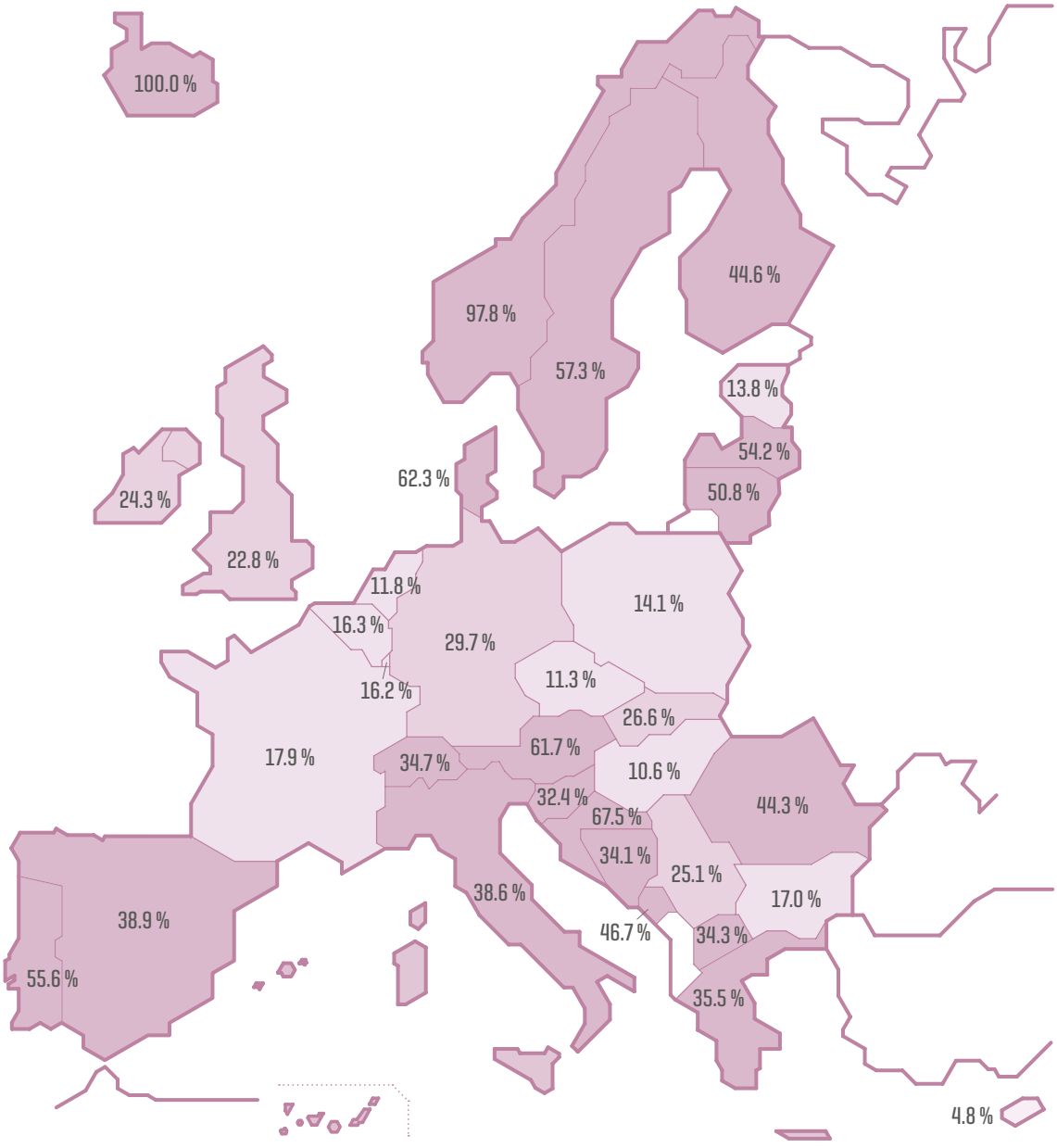
(1) Due to the unavailability of data for the whole series of some countries, the evolution chart contains information only from: Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Denmark, Czech Republic, France, FYROM (Macedonia), Greece, Holland, Hungary, Italy, Luxembourg, Poland, Portugal, Czech Republic, Romania and Switzerland. Pumped storage generation is not included in Spain's data.

In comparison with the rest of the European countries, Spain ranks fourth in volume of renewable generation. Regarding the contribution of renewable energy to total generation, Spain always has figures above the European average, which has also seen a positive evolution in recent years due to the renewable energy and CO_2 emissions targets set by the European Union.

[%]

RENEWABLE ENERGY IN RELATION TO TOTAL PRODUCTION

IN ENTSO-E MEMBER COUNTRIES IN 2016



< 10 % ≥ 10 % and < 20 % ≥ 20 % and < 30 % ≥ 30 %

Source: ENTSO-E. Data portal 24 May 2017. Great Britain includes data for Northern Ireland. Spain REE.

Energy from the **wind**

02

Wind power is the main source of renewable electricity generation in Spain, **with 23,057 MW of installed power capacity by the end of 2016.** Although this figure has remained practically unaltered over the last three years, Spain continues to be among the European leaders and currently **is ranked second in regard to installed wind power capacity.**

Wind power in Spain accounts for 21.9% of the installed power capacity in the entire set of generation facilities, standing at 23,057 MW by the end of 2016. This figure is the result of more than a decade of ongoing and increased growth in wind power capacity, despite the fact that this value has remained virtually unchanged over the last three years.

In 2016, wind energy was the second source of generation, accounting for 18.4% of the total annual national generation. Compared to 2015, wind energy generation registered a slight decrease of 0.9%.

With regard to the entire set of renewable technologies, wind energy is the most relevant in both installed power capacity and generation. Specifically, it accounts for almost half of the total installed renewable power capacity, and represented 47.3% of the total renewable energy generated on the Spanish peninsula in 2016.

February was the month in which more wind energy was generated, almost 2% above the monthly maximum value of the previous year which was also registered in February. In addition, it was the technology that contributed most to national production in the months of January (25.5%), February (28.8%) and March (24.0%).

During 2016, all-time records for hourly and daily wind energy production were set: on 11 January, the maximum hourly energy generation was recorded at 17,390 MWh between 1:00 pm and 2:00 pm, 1% more than the all-time high of 17,213 MWh, registered on 19 January 2015. On 12 February 2016, the annual daily wind power energy record was recorded with a value that was 3.6% higher than that registered in January 2015.

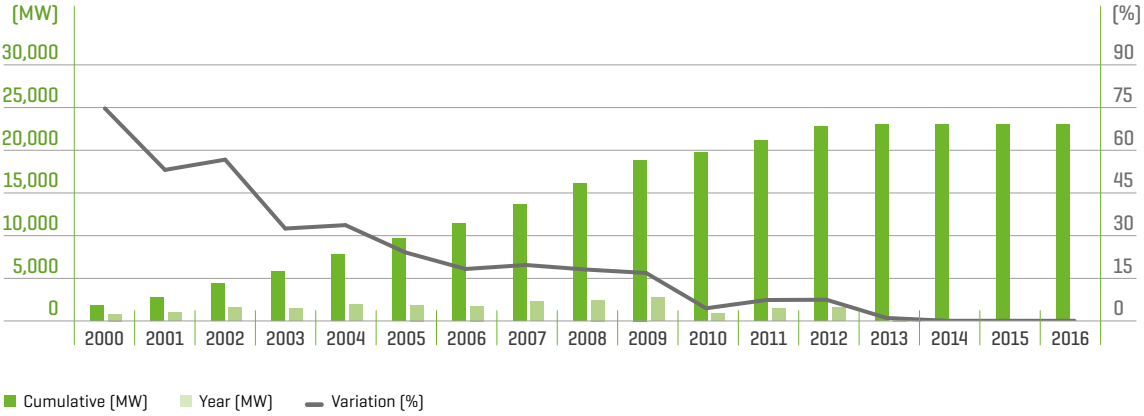
By autonomous community, Castilla y León is the region with more installed wind power capacity, representing almost 25% of the national total, followed by Castilla-La Mancha, Galicia and Andalusia. These four autonomous communities alone account for 70% of the installed wind power capacity in Spain.

Compared with other European countries, Spain is the country with the second highest installed wind power capacity behind Germany, which is clearly the leader with just over 49 GW of installed capacity. In terms of generation share, the clear leader is Denmark, where wind energy accounts for more than 44% of its electricity production, with Spain currently ranking fifth among ENTSO-E member states.

[MW] [%]

INSTALLED WIND POWER CAPACITY

NATIONAL ELECTRICITY SYSTEM

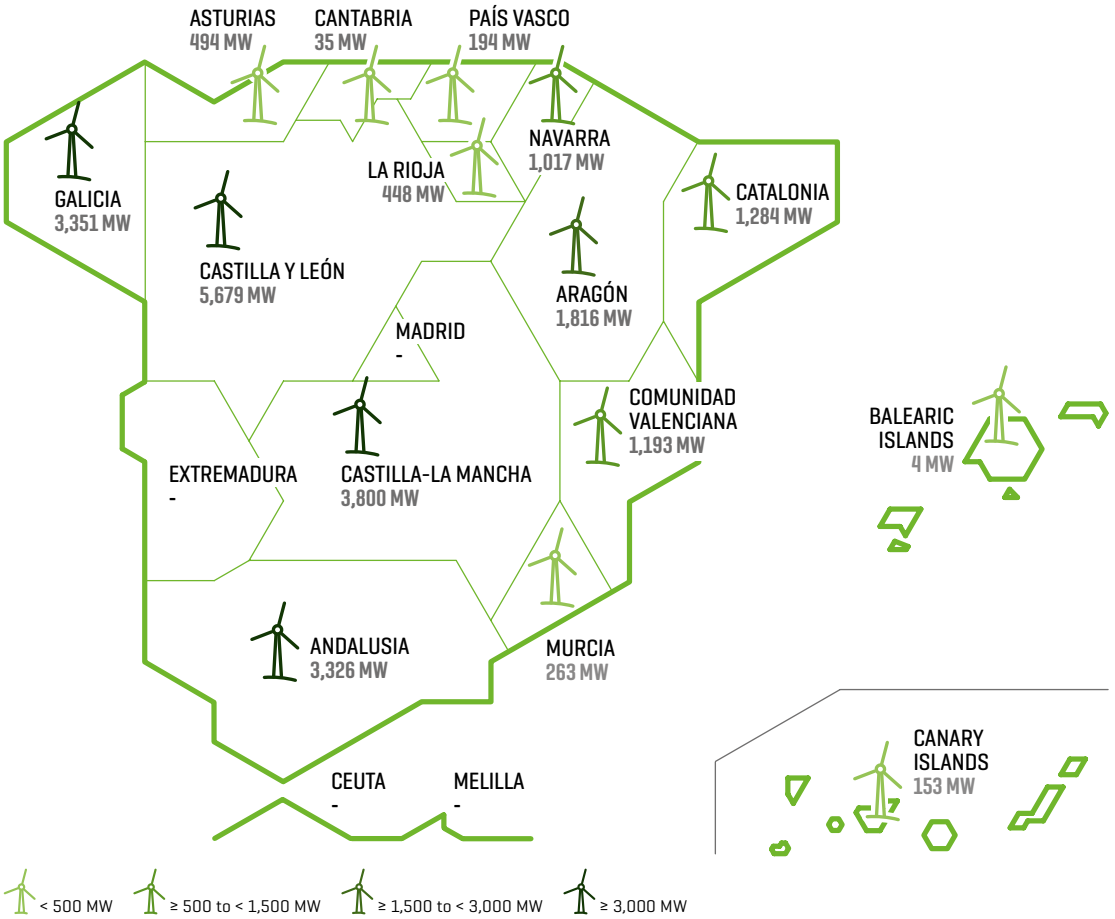


Source: Data from the National Commission for Markets and Competition (CNMC). Data regarding the Balearic Islands and the Canary Islands available as of 2006.

[MW]

INSTALLED WIND POWER CAPACITY

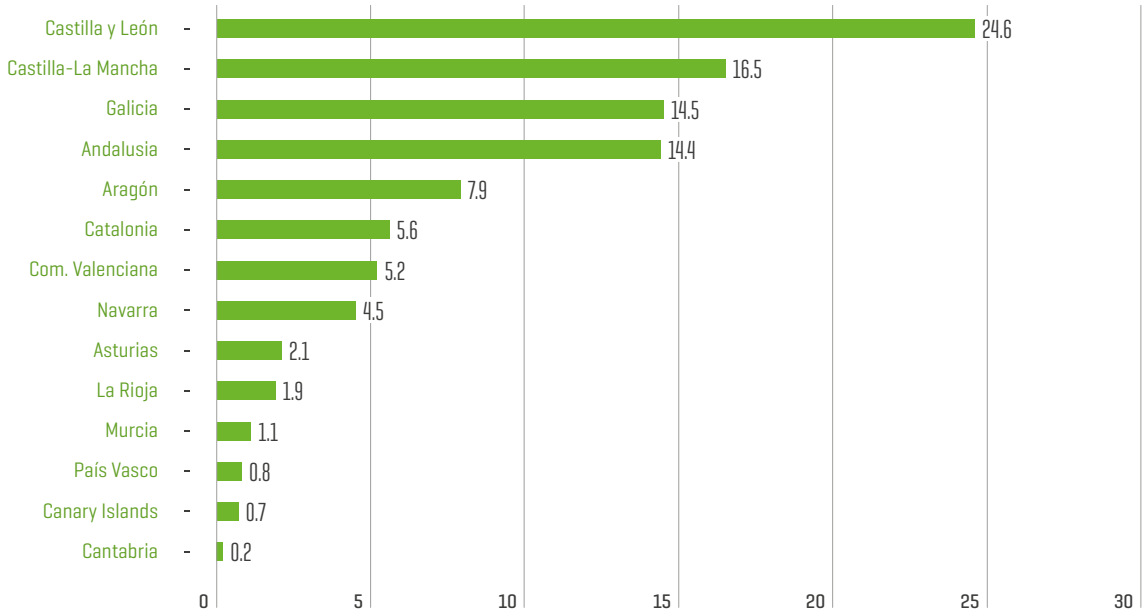
PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM AS AT 31-12-2016



Source: Data from the National Commission for Markets and Competition (CNMC).

SHARE OF INSTALLED WIND POWER CAPACITY

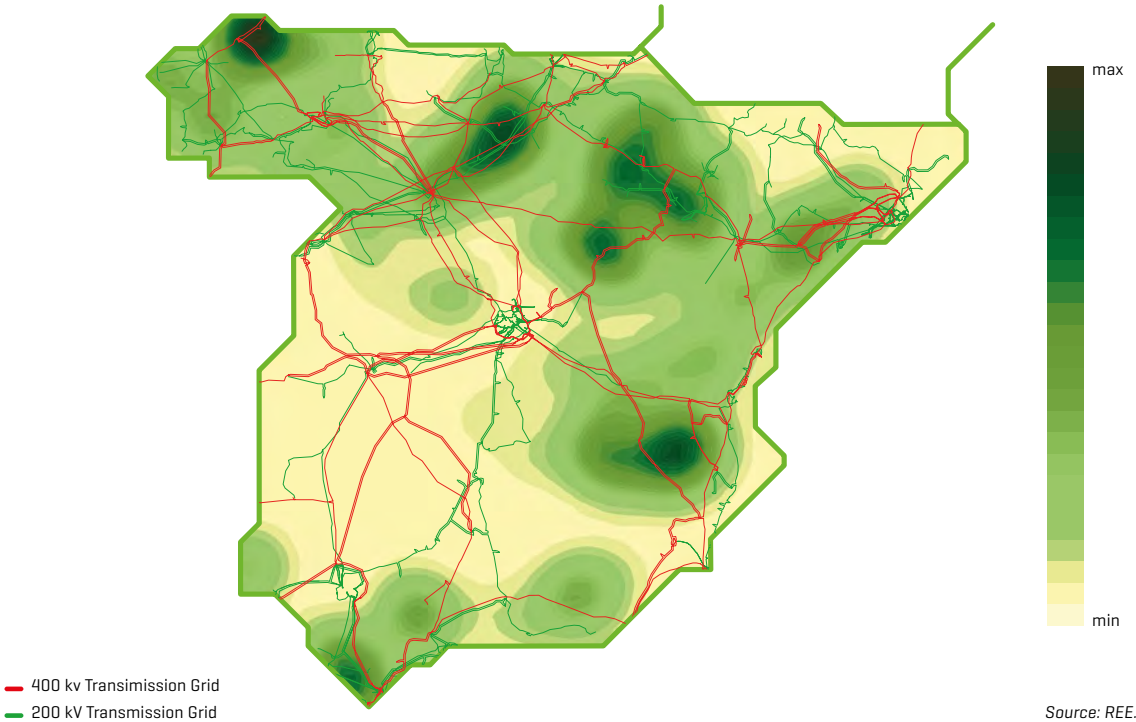
IN RELATION TO THE NATIONAL TOTAL AS AT 31-12-2016



Source: Data from the National Commission for Markets and Competition (CNMC).

GEOGRAPHICAL DISTRIBUTION OF WIND ENERGY FACILITIES ON THE SPANISH PENINSULA

AS AT 31-12-2016



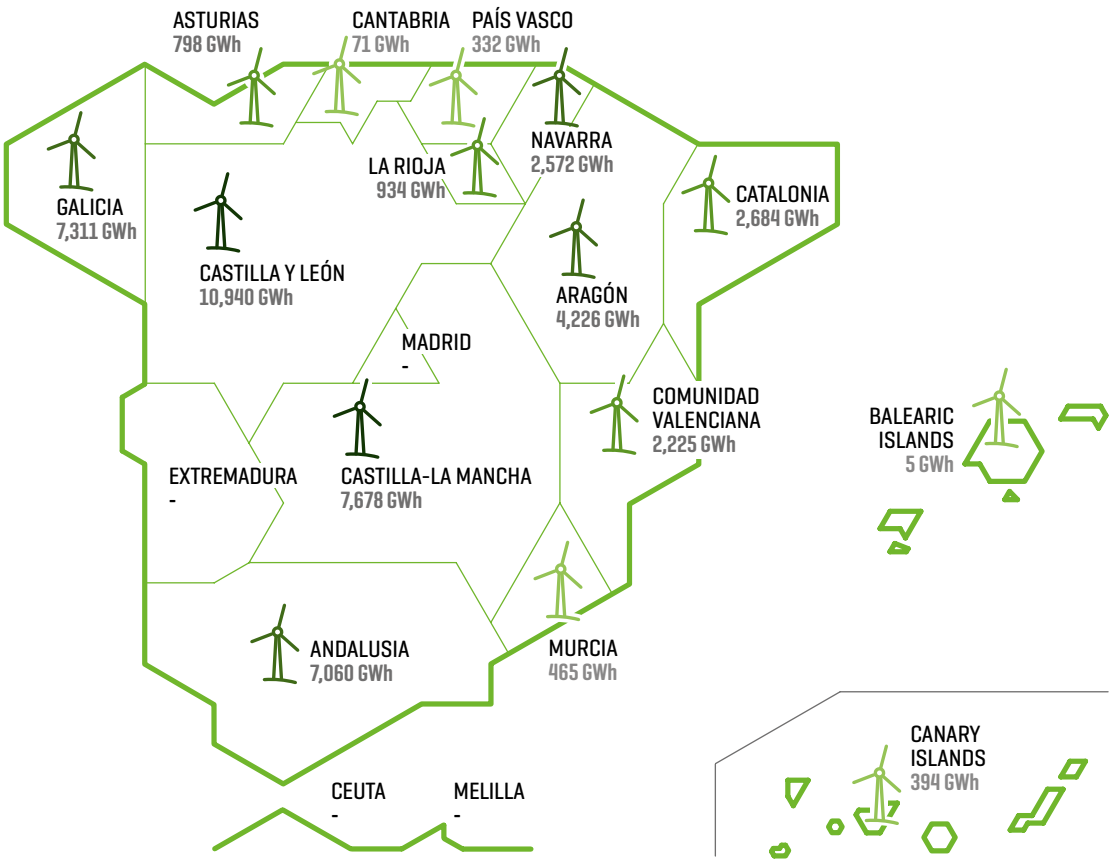
Source: REE.

Castilla y León is the **region with the highest share of wind power generation,** reaching a peak of 23 % of wind energy produced in Spain in 2016; followed by Castilla-La Mancha, Galicia and Andalusia. Together, **these four regions alone accounted for 70 %** of the total wind energy generated in 2016.

(GWh)

WIND ENERGY GENERATION IN 2016

PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM

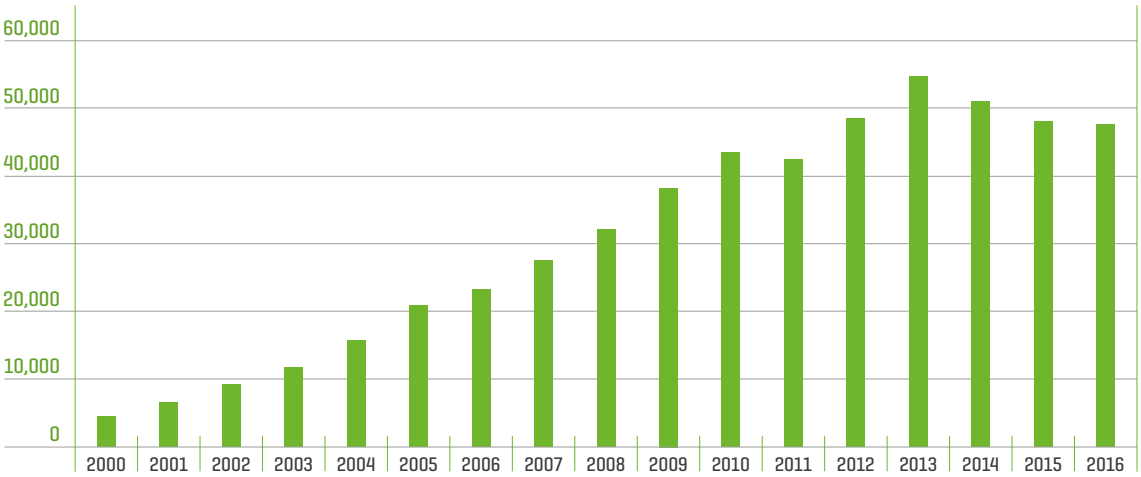


Source: REE.

[GWh]

WIND ENERGY GENERATION

NATIONAL ELECTRICITY SYSTEM

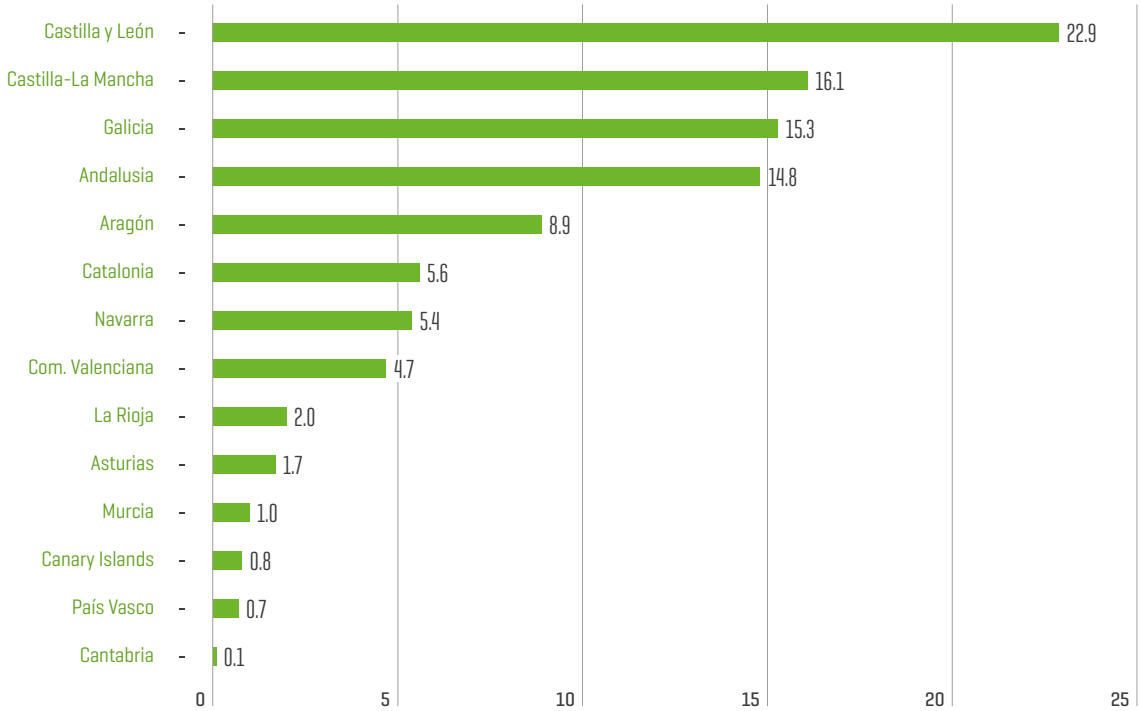


Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006.

[%]

SHARE OF WIND ENERGY GENERATION

PER AUTONOMOUS COMMUNITY IN RELATION TO TOTAL NATIONAL WIND GENERATION IN 2016

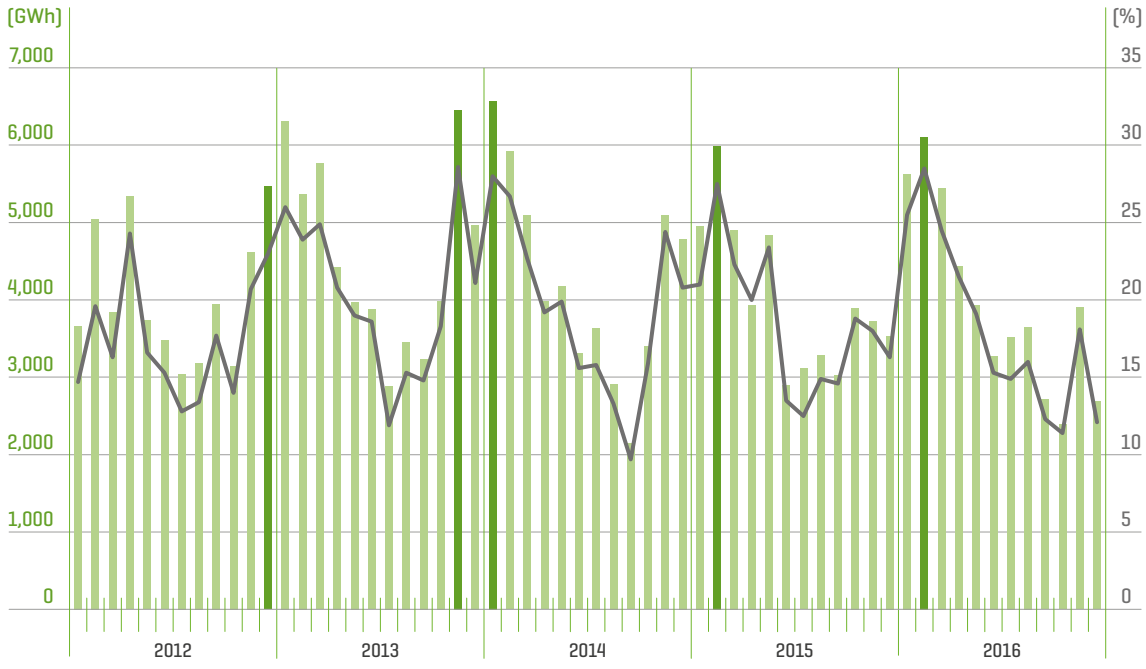


Source: REE.

In 2016, wind energy was the second source of electricity generation in Spain, slightly over 18 % of the total, and in the first three months of the year **it was the main technology in the overall generation mix,** noteworthy was February, in which wind energy, with more than 6,000 GWh, covered almost 29 % of the total generation of that month.

NATIONAL WIND ENERGY GENERATION, MONTHLY MAXIMUM VALUES AND SHARE IN THE TOTAL GENERATION MIX

NATIONAL ELECTRICITY SYSTEM

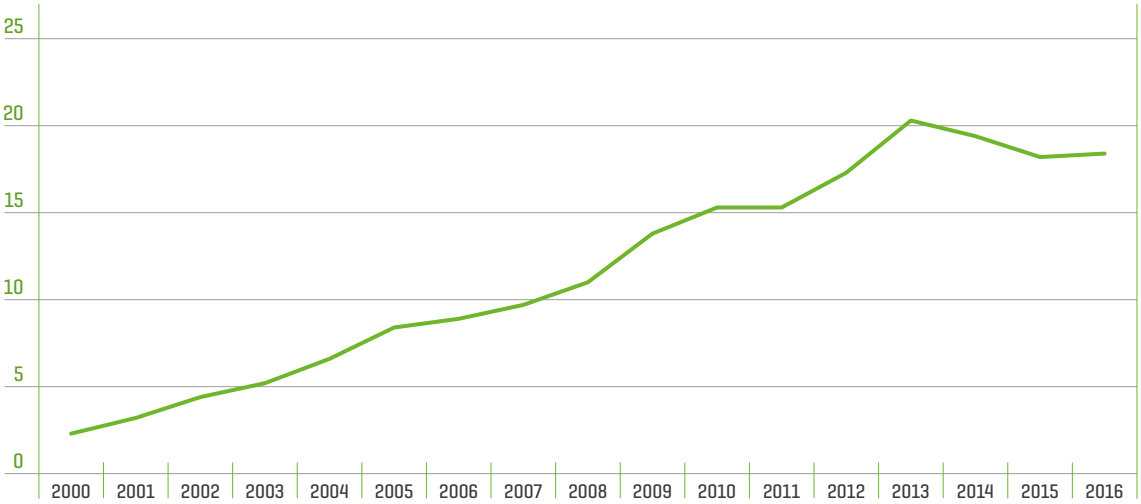


Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Ceuta and Melilla since 2007.

[%]

SHARE OF WIND ENERGY GENERATION IN THE TOTAL GENERATION MIX

NATIONAL ELECTRICITY SYSTEM

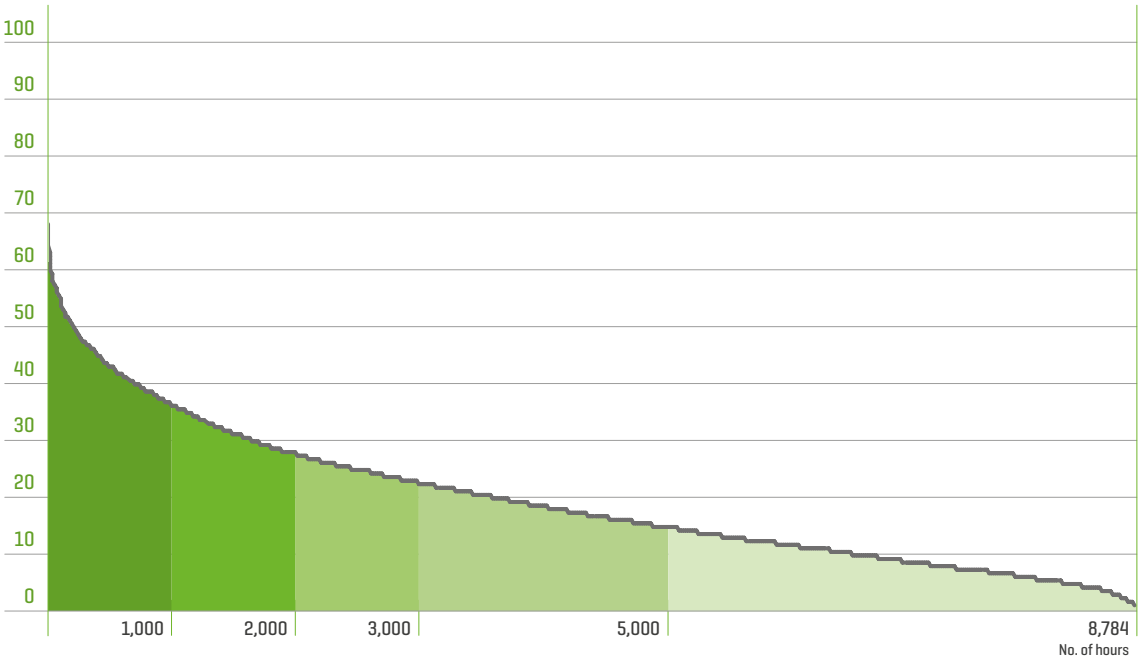


Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Ceuta and Melilla since 2007.

[%]

MONOTONOUS CURVE OF THE SHARE OF WIND ENERGY GENERATION IN DEMAND COVERAGE

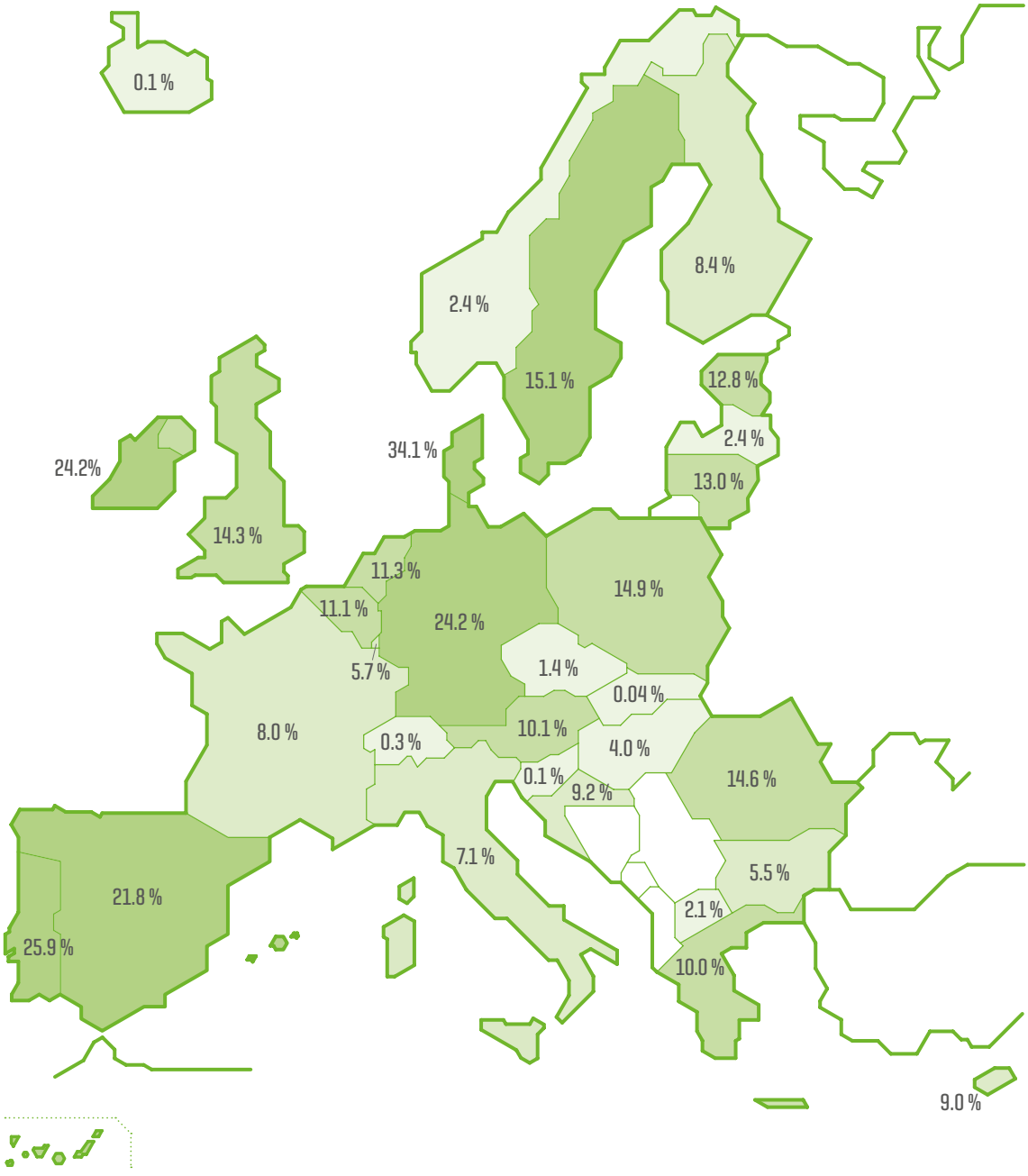
SPANISH PENINSULAR ELECTRICITY SYSTEM



Representation of the share of wind energy generation in demand coverage throughout the whole of the year divided in hourly periods and sorted by its greater to lesser share in the generation mix. // Source: REE.

INSTALLED WIND POWER CAPACITY IN RELATION TO TOTAL POWER CAPACITY

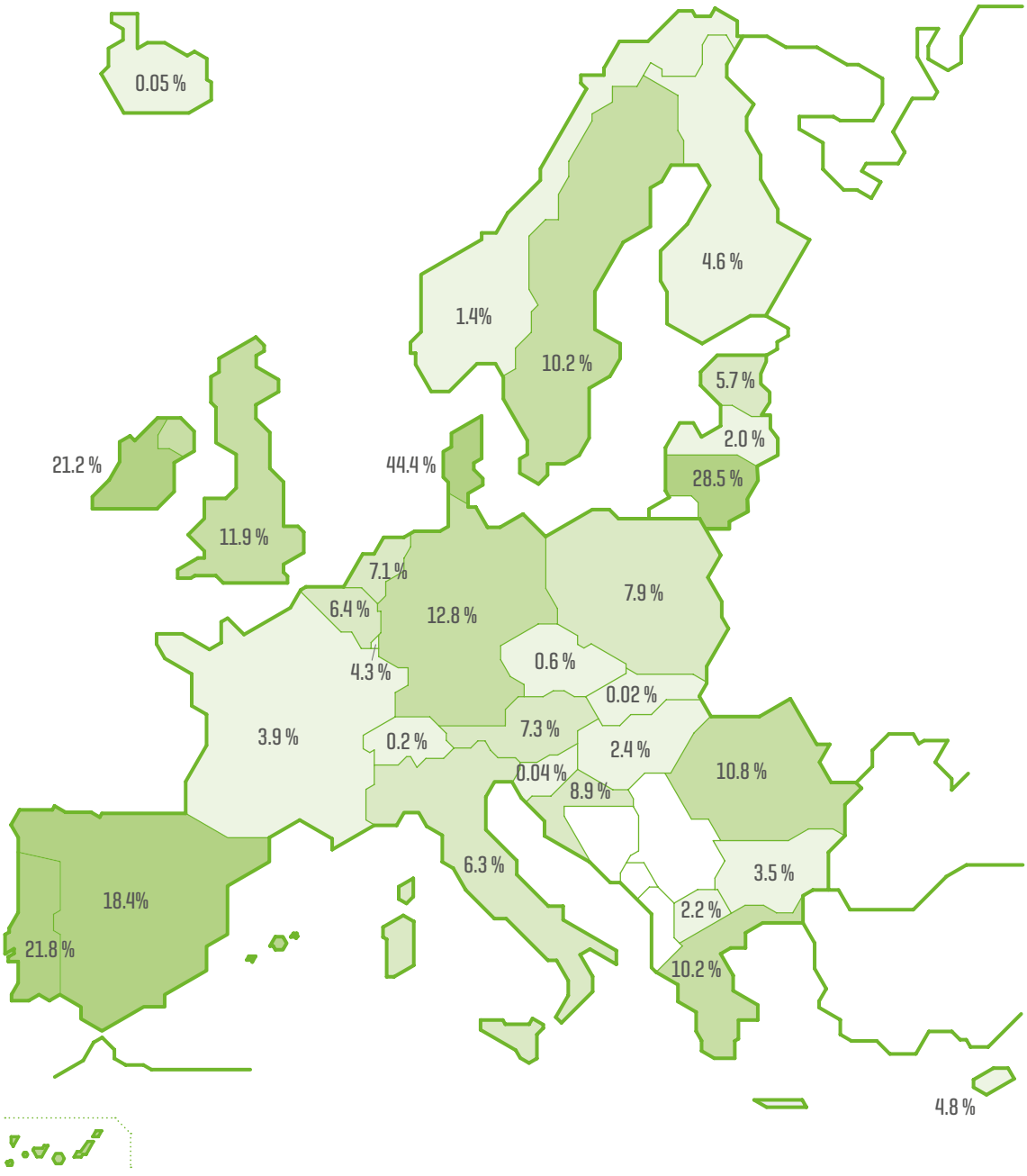
IN ENTSO-E MEMBER COUNTRIES AS AT 31-12-2016



Source: ENTSO-E. Data portal 24 May 2017. Great Britain includes data for Northern Ireland. Spain REE. // Note: data for Slovakia, Slovenia, France, FYROM (Macedonia), Great Britain, Greece, Holland, Hungary, Ireland, Sweden and Switzerland correspond to 2015, data for 2016 was not available at the close of this report.

WIND ENERGY GENERATION IN RELATION TO TOTAL GENERATION

IN ENTSO-E MEMBER COUNTRIES AS AT 31-12-2016



< 5% ≥ 5% to < 10% ≥ 10% to < 15% ≥ 15%

Source: ENTSO-E. Data portal 24 May 2017. Great Britain includes data for Northern Ireland. Spain REE.

Energy from **water**

03

Hydropower is the second source of renewable electricity generation in Spain **with 17,025 MW of installed power capacity by the end of 2016.** Although this technology has shown constant growth for over a century, **in the last decade it has been losing ground to wind energy,** which has consolidated itself as a leader among renewable energy sources.

Hydropower was traditionally the main renewable source in Spain, until 2009 when it was overtaken by wind energy. Since then, it has clearly remained the second renewable source of energy registering a total of 17,025 MW of installed power capacity by the end of 2016 (without considering pure pumped storage).

Regarding total national installed capacity, hydropower represents 16.2%, which ranks it as the third renewable technology behind combined cycle and wind.

Hydropower generation in Spain is extremely variable, reaching over 40,000 GWh in wet years, while in dry years said volume is reduced by almost half. On average, 2016 was a wet year, with hydropower production standing at 35,798 GWh, a value that is almost 28% more than in 2015. In this regard, hydropower contributed 13.8% to the total national electricity production, ranking fourth among generation technologies, up from 10.6% last year.

With regard to the entire set of renewable technologies available, hydropower ranked second behind wind with 35.5% of the total renewable energy generated nationwide.

Historically, the final months of winter and the first months of spring are periods in which there is a greater contribution of hydroelectric generation due mainly to the snow-melt and also to the greater rainfall registered in these months.

In 2016, April was the month in which more hydroelectric generation was produced with just over 5,200 GWh (36.8% higher than the previous year's maximum value) and May was the month in which this technology contributed the most to the total generation mix, reaching almost 25% of the total generation of said month.

One of the main advantages of this technology compared to other renewable energy sources is its manageability, which is evidenced by observing the average daily curve of hydropower share in relation to the total generation. This shows how the greatest contribution of this technology coincides with the demand peaks that occur in the morning and the late-evening.

Hydroelectric reserves closed 2016 with values below their statistical average level, despite the fact it was a wet year in hydrological terms (rainfall). Reserves were above the statistical average in the first nine months of the year and below it in the last quarter, with the complete set of reservoirs closing the year with a fill level a little over 39%, which means seven percentage points less than at the end of 2015.

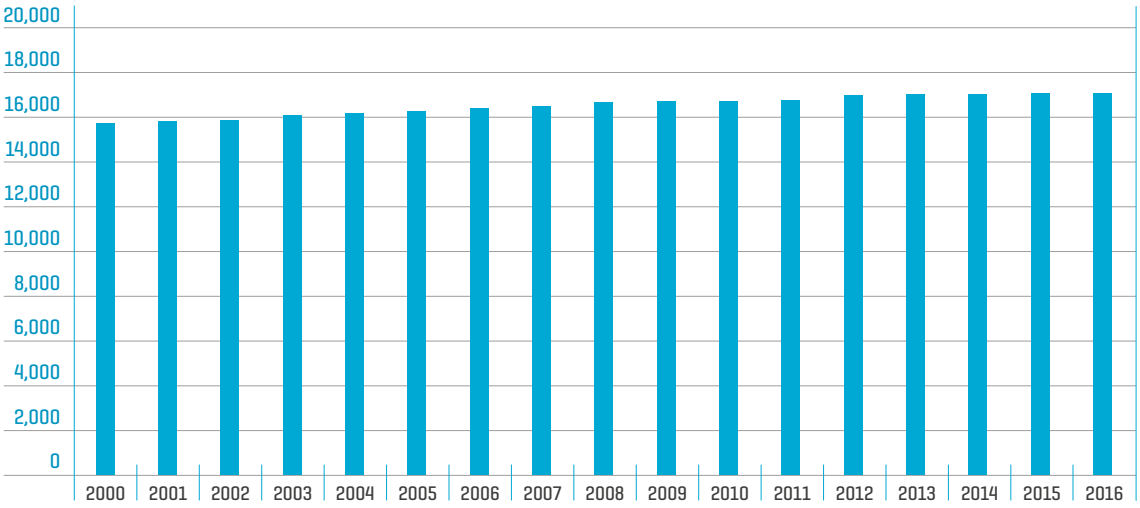
By autonomous community, Castilla y León is the community with the most installed hydropower capacity, almost 26% of the national total. This is due to the fact that the Duero basin, the second most important basin on the Iberian Peninsula, lies exclusively in this region. It is followed by Galicia with about 22% of the national total, a region that holds much of the northern basin, which is the most important in installed power capacity terms and that also includes Asturias, Cantabria and part of the Basque Country. Five autonomous communities together account for 80% of the total installed hydropower capacity: Castilla y León, Galicia, Extremadura, Catalonia and Aragón.

In comparison with other European countries, in 2016 Spain was ranked fourth in installed hydropower capacity and fifth, behind Norway, Sweden, France and Italy, in the amount of energy generated using this technology.

[MW]

INSTALLED HYDROPOWER CAPACITY [1]

NATIONAL ELECTRICITY SYSTEM



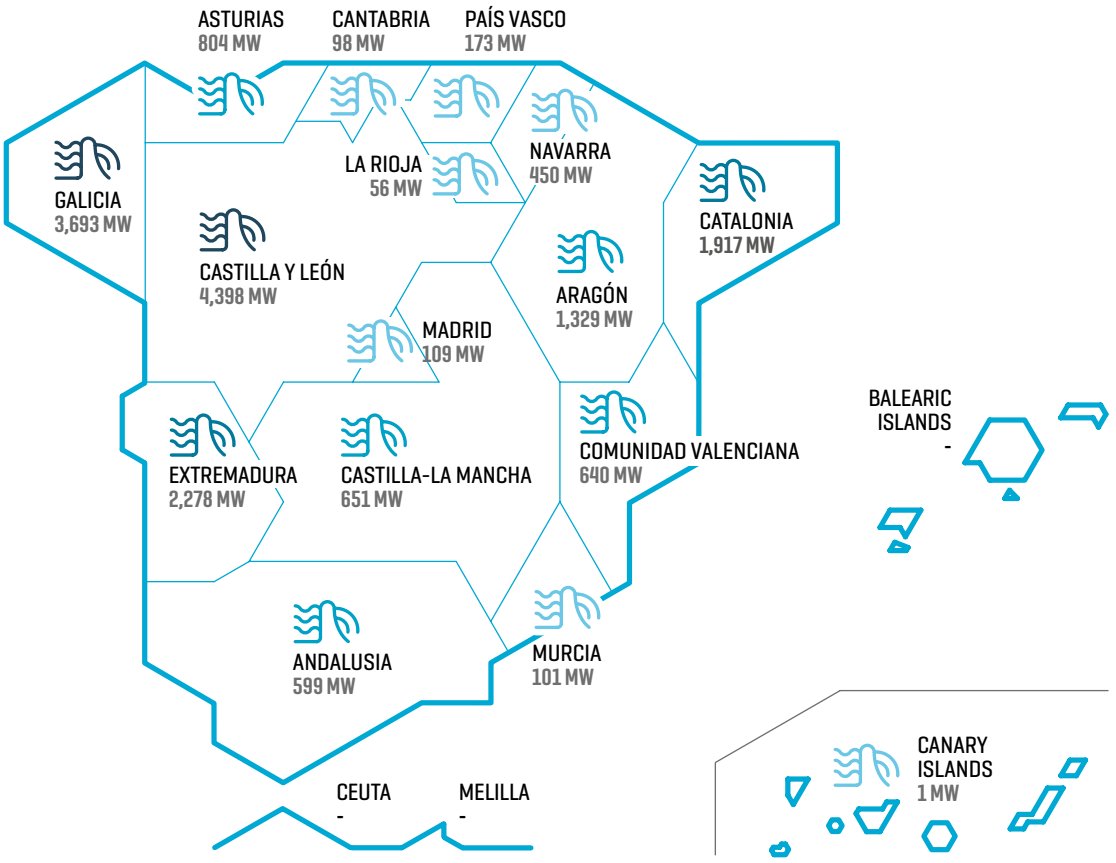
[1] Includes conventional hydro, mixed pumped storage and hydro that does not belong to a Hydro Management Unit (HMU) // Source: Data from the National Commission for Markets and Competition (CNMC) and REE.

Five autonomous communities account for 80 % of Spain's installed hydropower capacity, led by Castilla y León with the Duero basin, which with a total of 4,398 MW of installed power capacity by the end of 2016, represents almost 26 % of the total national hydropower capacity.

(MW)

INSTALLED HYDROPOWER CAPACITY (1)

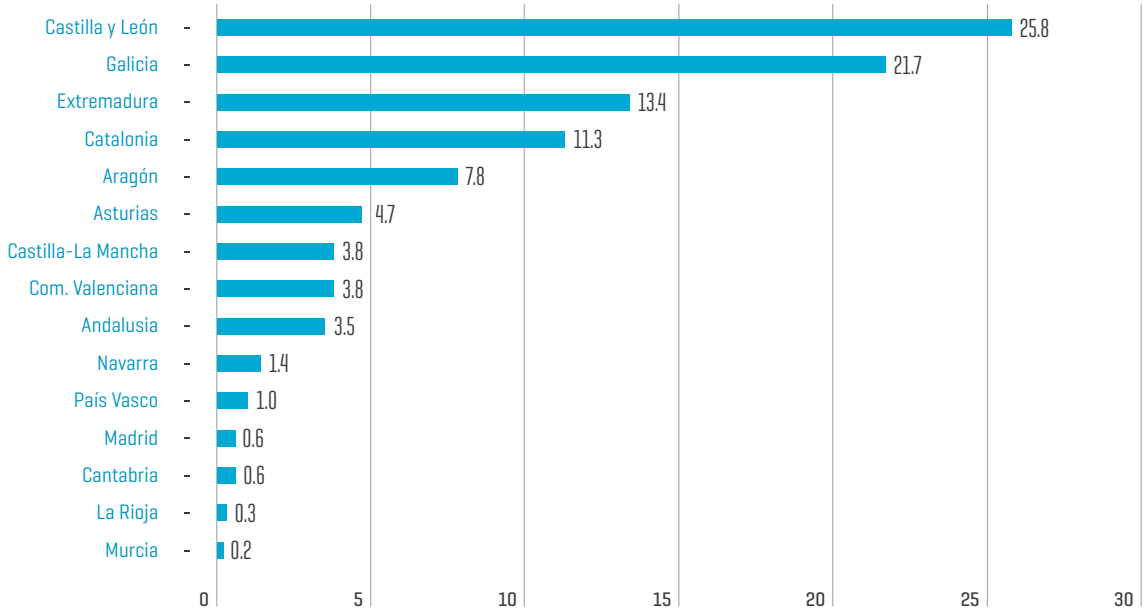
PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM AS AT 31-12-2016



(1) Includes conventional hydro, mixed pumped storage and hydro that does not belong to a Hydro Management Unit (HMU) // Source: Data from the National Commission for Markets and Competition (CNMC) and REE.

SHARE OF INSTALLED HYDROPOWER CAPACITY [1] PER AUTONOMOUS COMMUNITY

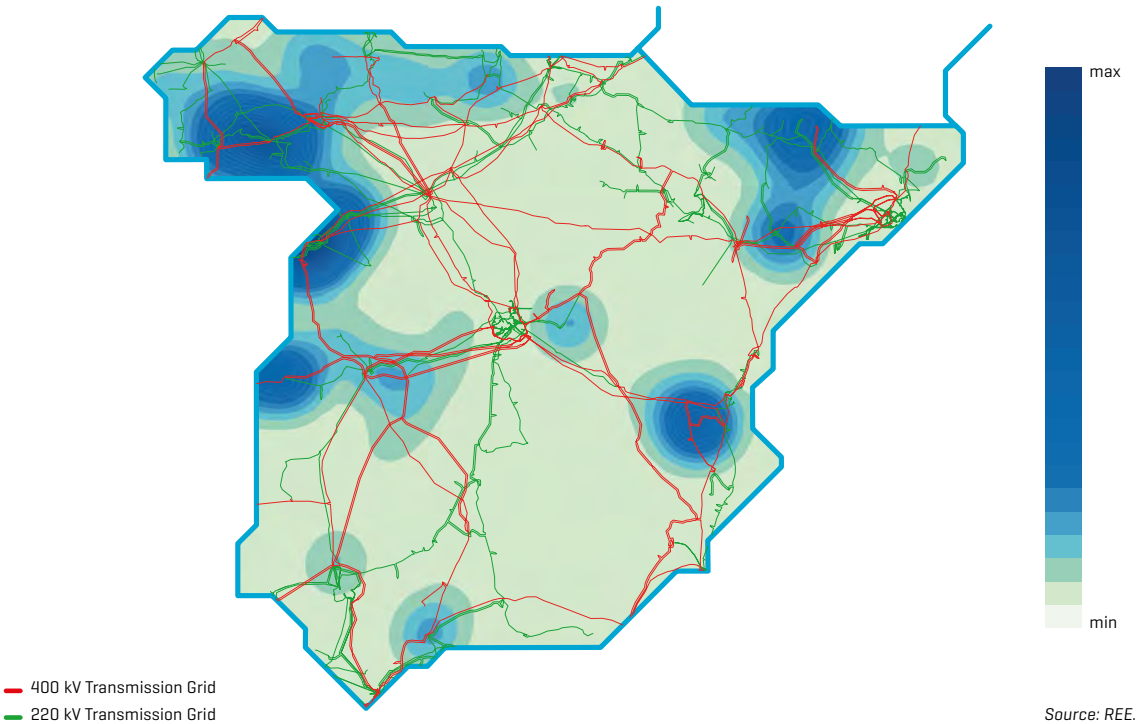
IN RELATION TO THE NATIONAL TOTAL. NATIONAL ELECTRICITY SYSTEM AS AT 31-12-2016



[1] Includes conventional hydro, mixed pumped storage and hydro that does not belong to a Hydro Management Unit (HMU) // Source: Data from the National Commission for Markets and Competition (CNMC) and REE. Does not include pure pumped storage capacity.

GEOGRAPHICAL DISTRIBUTION OF HYDROELECTRIC POWER STATIONS ON THE PENINSULA

AS AT 31-12-2016

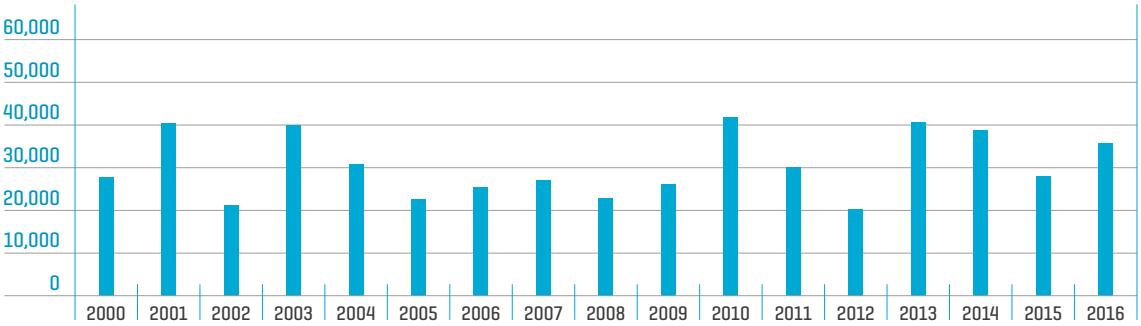


Source: REE.

[GWh]

HYDROELECTRIC POWER GENERATION

NATIONAL ELECTRICITY SYSTEM

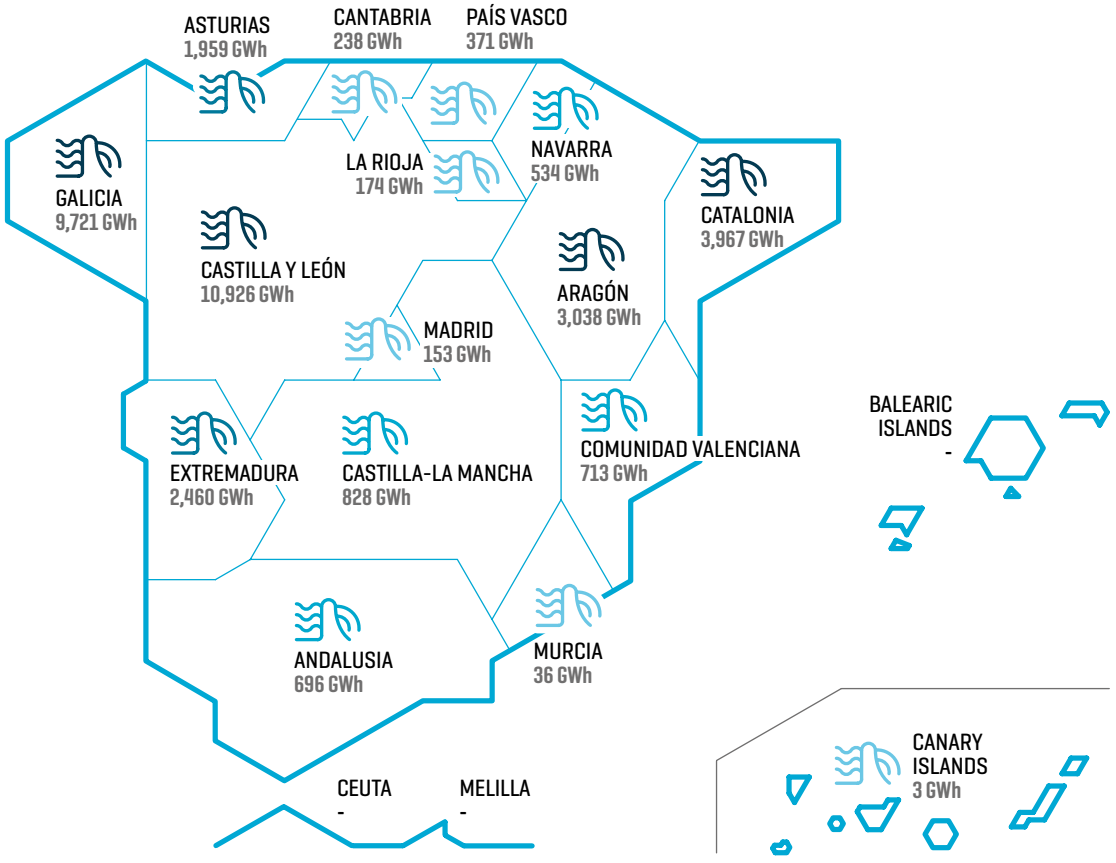


Source: REE. Does not include pumped storage generation. Data regarding the Canary Islands available as of 2006.

[GWh]

HYDROELECTRIC POWER GENERATION AS AT 31-12-2016

PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM

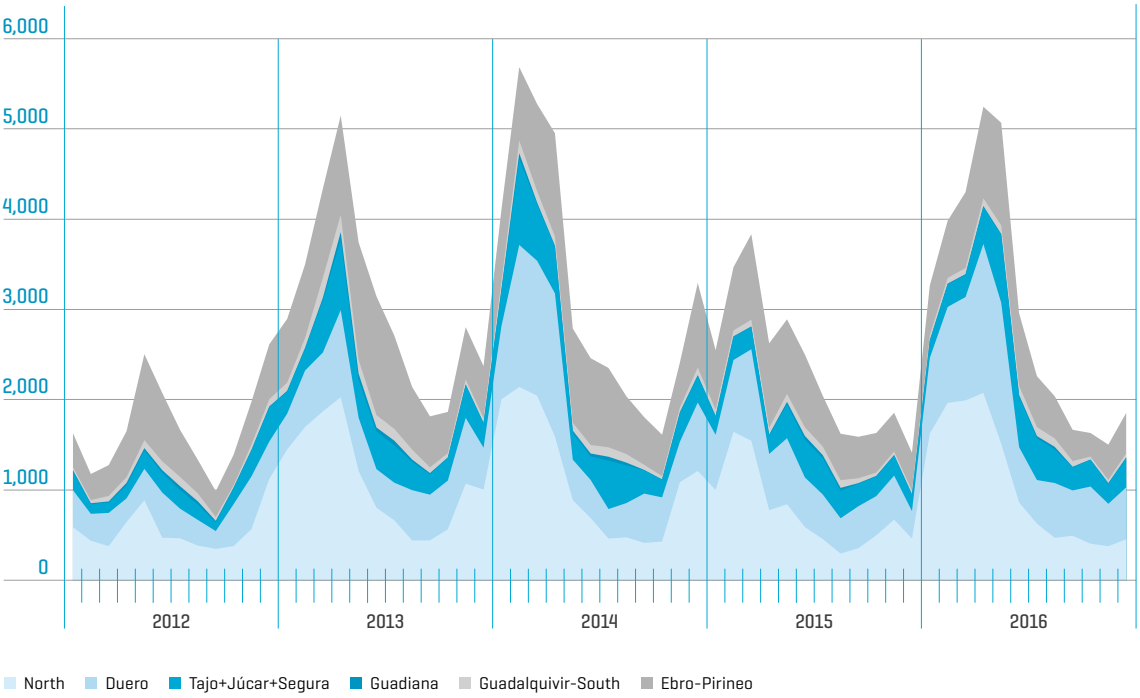


Source: REE. Does not include pumped storage generation.

[GWh]

HYDROELECTRIC POWER GENERATION BY HYDROGRAPHIC BASIN

PENINSULAR ELECTRICITY SYSTEM

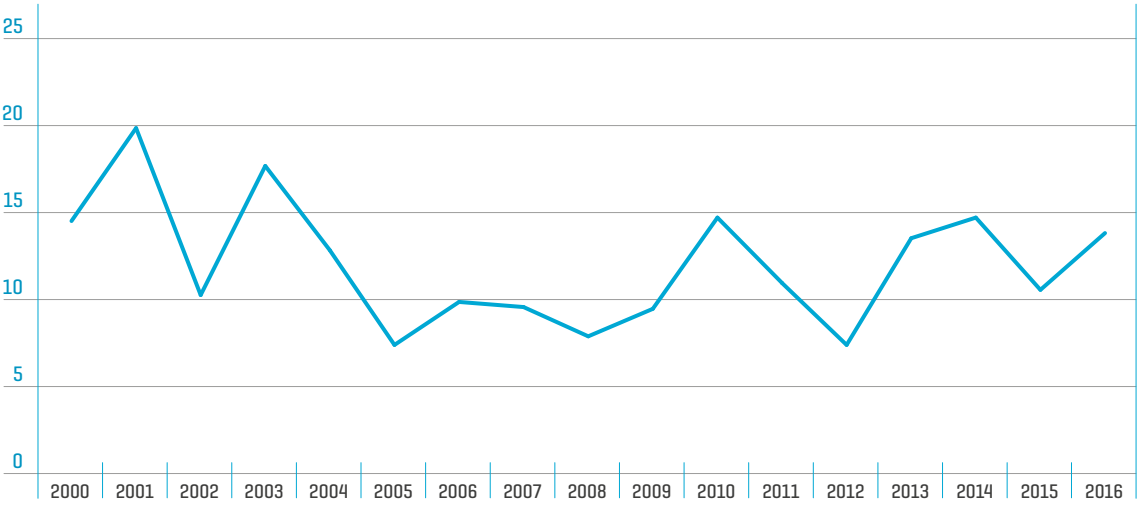


Source: REE. Does not include pumped storage generation.

[%]

SHARE OF HYDROPOWER IN THE TOTAL GENERATION MIX

NATIONAL ELECTRICITY SYSTEM

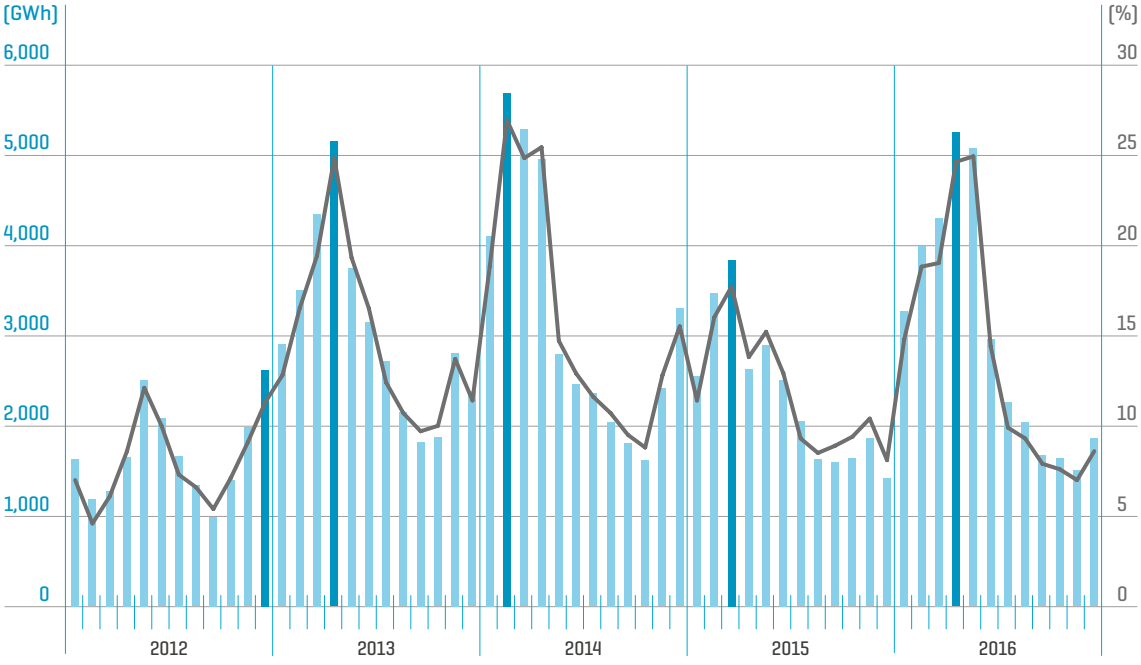


Source: REE. Data regarding the Canary Islands available as of 2006. Does not include pumped storage generation.

[GWh] [%]

NATIONAL HYDROELECTRIC POWER GENERATION, MONTHLY MAXIMUM VALUES AND SHARE IN THE TOTAL GENERATION MIX

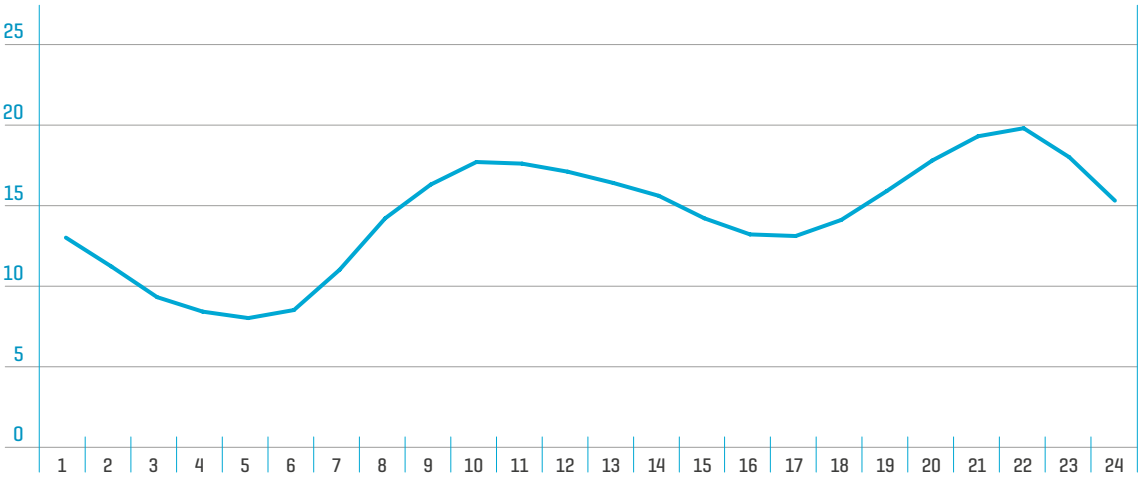
NATIONAL ELECTRICITY SYSTEM



Source: REE. Data regarding the Canary Islands available as of 2006. Does not include pumped storage generation.

[%]

AVERAGE SHARE OF HYDROPOWER IN RELATION TO TOTAL GENERATION THROUGHOUT THE DAY

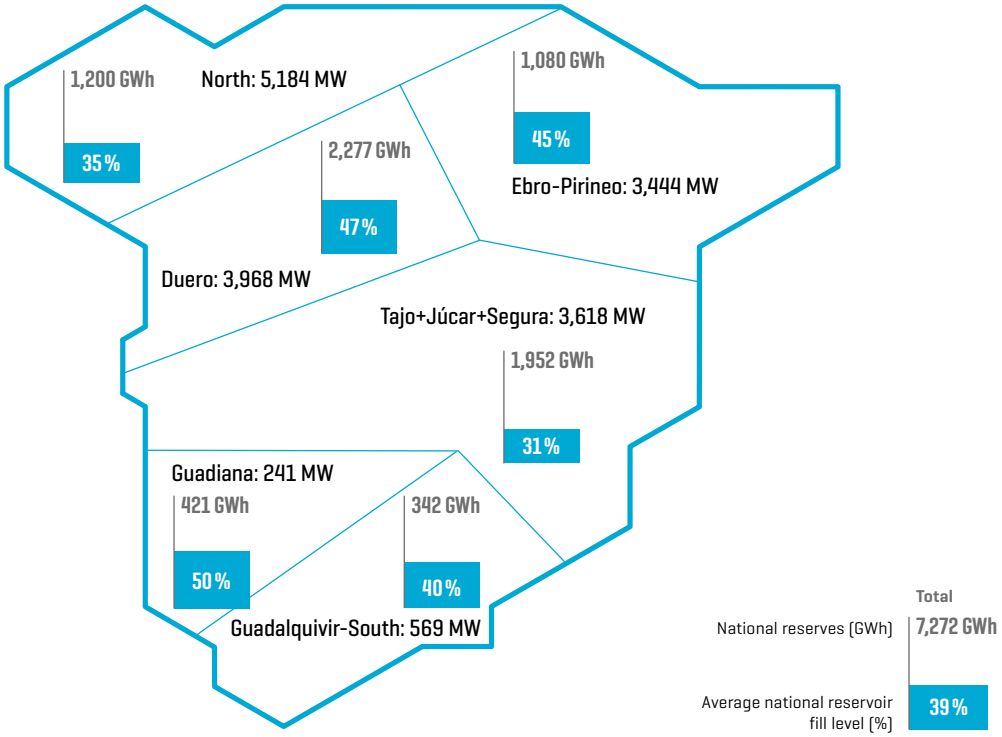


Source: REE. Does not include pumped storage generation.

[GWh] [%]

INSTALLED HYDROPOWER CAPACITY [1] AND HYDROELECTRIC RESERVES

BY HYDROGRAPHIC BASIN AS AT 31 DECEMBER



[1] Includes conventional hydro, mixed pumped storage and hydro that does not belong to a Hydro Management Unit (HMU) // Source: REE.

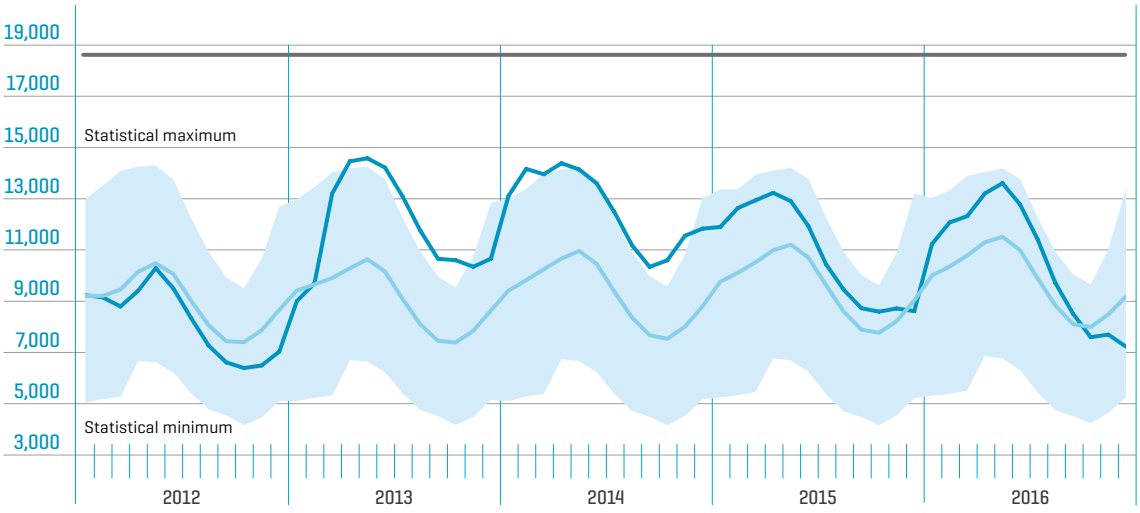
[GWh] [%]

EXTREME VALUES OF PENINSULAR HYDROELECTRIC RESERVES

		2016			Historical values	
		GWh	Date	%	Date	%
Maximum	Annual	7,219	May 17	80.5	May 1969	92.0
	Hyper-annual	6,490	May 22	67.8	April 1979	91.1
	Overall total	**13,705**	**May 17**	**73.9**	**April 1979**	**86.6**
Minimum	Annual	2,274	Nov 2	28.0	January 1976	24.9
	Hyper-annual	3,843	Dec 31	40.2	November 1983	17.6
	Overall total	**6,168**	**Nov 2**	**38.1**	**October 1995**	**23.6**

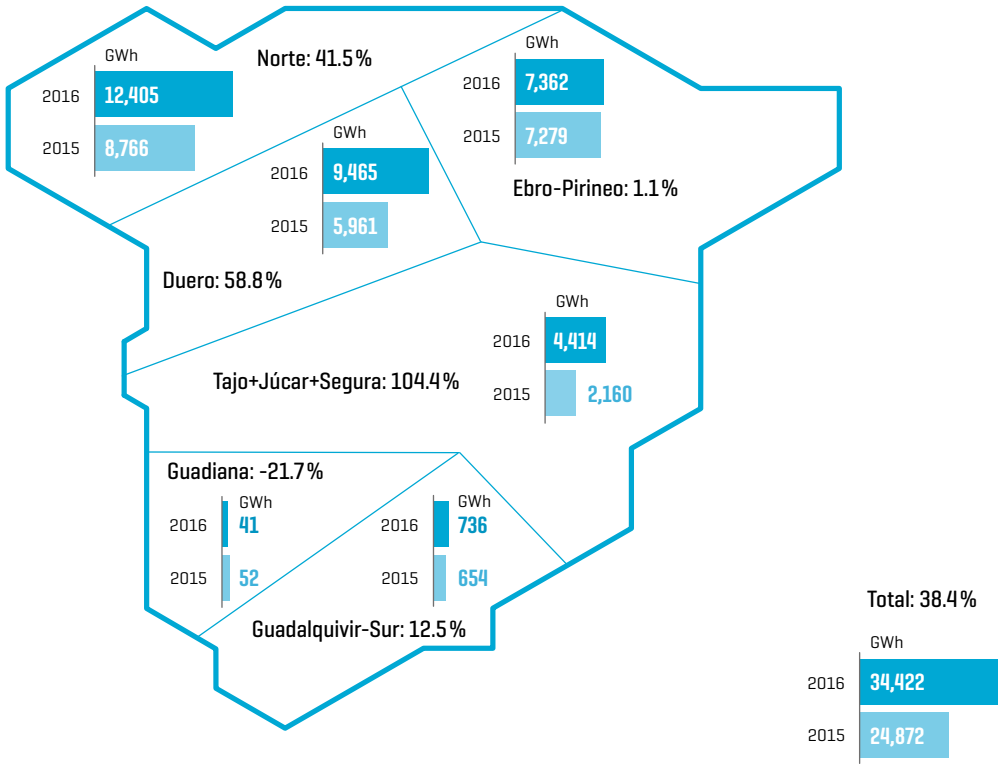
Source: REE.

[GWh]
TOTAL HYDROELECTRIC RESERVES



Statistical maximum and minimum levels: average of the maximum and minimum values for the last 20 years. // Source: REE.

[GWh] [%]
PRODUCIBLE HYDROELECTRIC ENERGY BY HYDROGRAPHIC BASIN AND ANNUAL

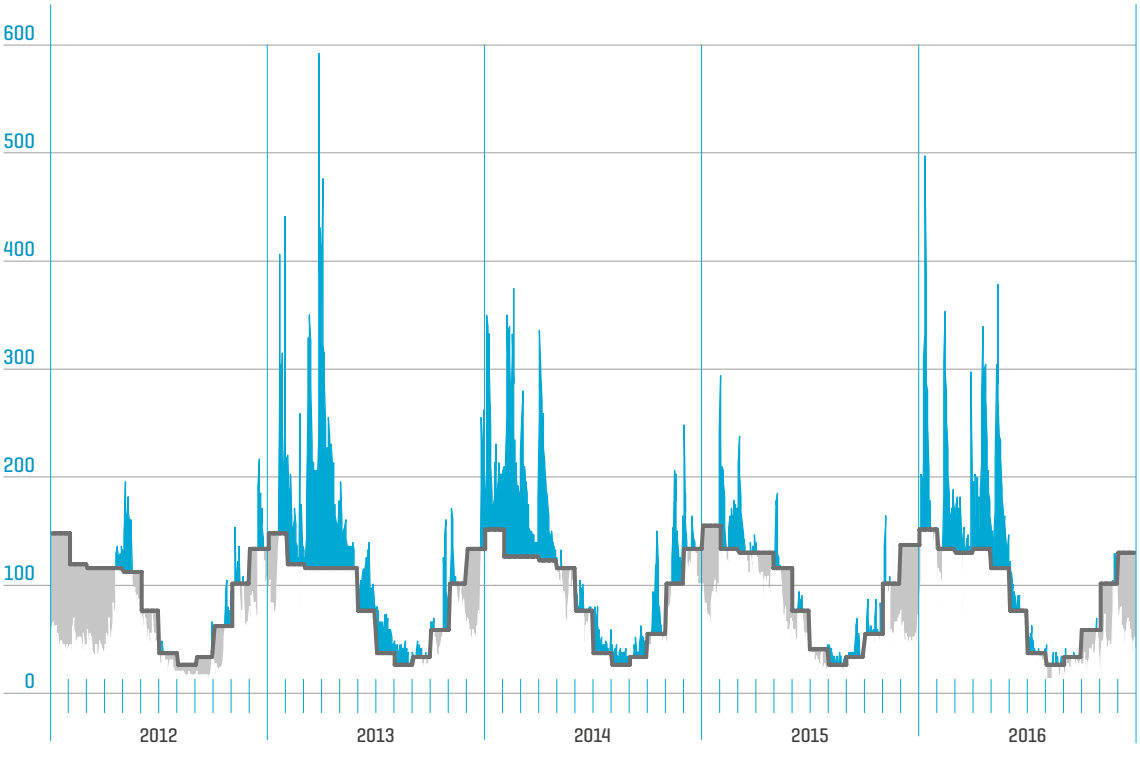


Source: REE.

In 2016, Spain was the fourth European country in terms of installed hydropower capacity and the fifth, behind Norway, Sweden, France and Italy, in energy generated using this technology. However, in terms of generation share, while Spanish hydropower accounted for about 14 % of the national generation, in ten European countries that percentage exceeded 30 %.

[GWh]

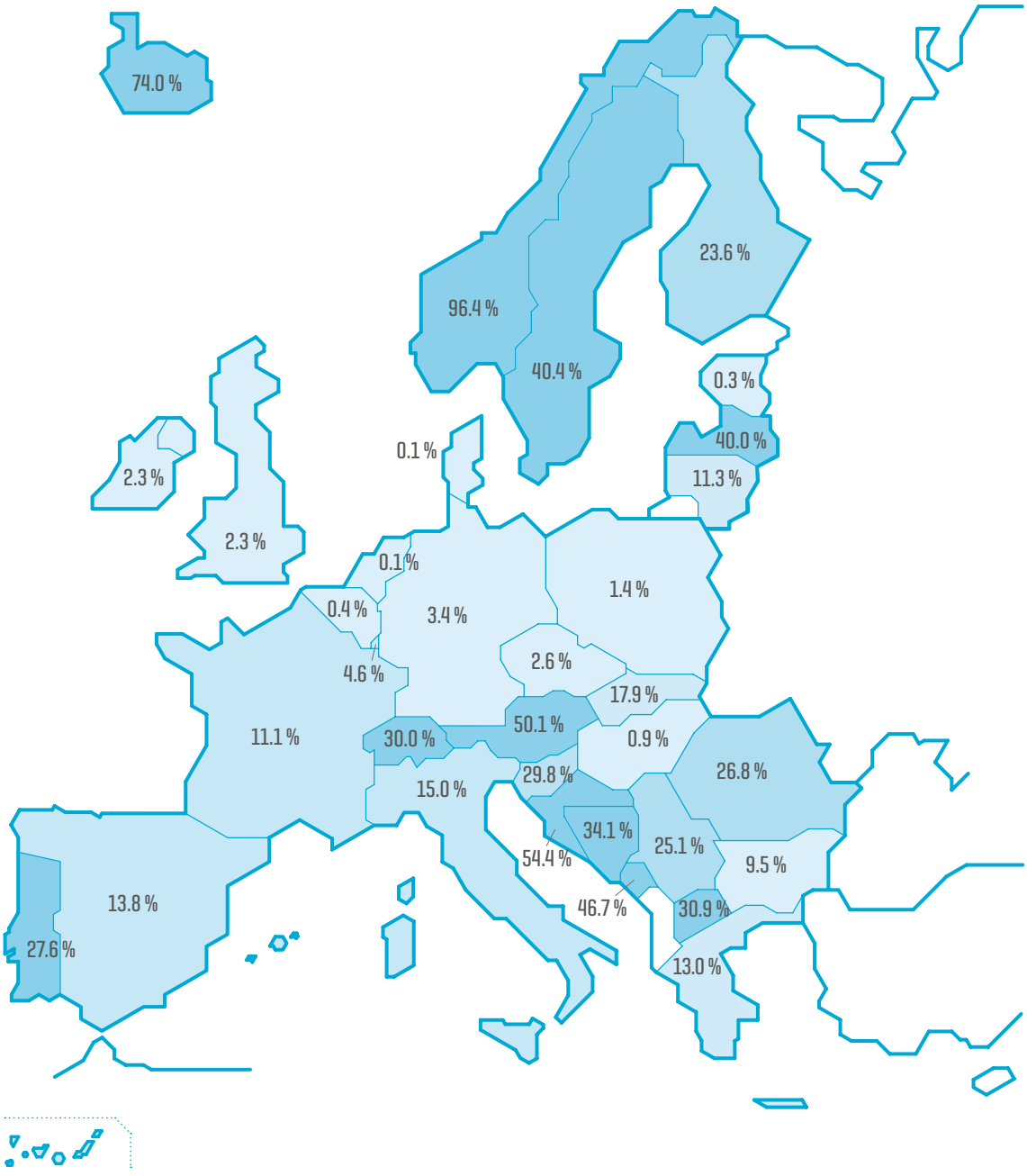
DAILY PRODUCIBLE HYDROELECTRIC ENERGY
COMPARED WITH THE HISTORICAL AVERAGE PRODUCIBLE



Source: REE.

HYDROELECTRIC POWER GENERATION IN RELATION TO TOTAL GENERATION

IN ENTSO-E MEMBER COUNTRIES IN 2016



< 10% ≥ 10% to < 20% ≥ 20% to < 30% ≥ 30%

Source: ENTSO-E. Data portal 24 May 2017. Great Britain includes data for Northern Ireland. Spain REE.

Energy from the **sun**

04

Solar energy is the third renewable source of electricity generation in Spain with 6,973 MW of installed power capacity by the end of 2016. This technology **represents 7% of the installed power capacity nationwide** and about 5% of the total generation.

Installed solar power capacity by the end of 2016 stood at 6,973 MW (4,774 MW correspond to solar photovoltaic and 2,299 MW to solar thermal), which represents about 7% of the total installed power capacity in Spain.

As with wind power, growth in solar power capacity has stabilised in the last three years following a long period of continued growth. Photovoltaic began to emerge in 2000 with 1 GW of installed capacity, reaching an annual record growth in 2008 with 2,733 MW of new installed power capacity, a growth that continued until 2012 with more than 250 MW installed each year on average, but which has remained virtually unchanged since then.

As for solar thermal, the largest increases in installed power capacity occurred between 2009 and 2013, but since 2013 it has remained stable.

As with installed solar power capacity, solar power generation in Spain went through a period of significant growth up until recently when it then became more moderate, reaching 13,026 GWh in 2016. This represented 5.1% of the total electricity generation in 2016; 3.1% was solar photovoltaic and the remaining 2% was solar thermal.

The summer months are clearly the periods of highest production for both technologies. During 2016, the monthly maximum value of solar photovoltaic generation occurred in June and was only 1% lower than the value registered in June the previous year.

Seasonality is an important factor for this technology and greatly conditions solar energy generation levels throughout the year. As such, generation from May to August registers fairly similar values, while these values fall between November and February by almost half.

In the case of solar thermal, something similar happened, with July being the month of highest generation, although in 2016 the monthly maximum for July fell by 7.2% compared to that registered in 2015. The seasonality of this technology is similar to that of solar photovoltaic, although its daily production is distributed more evenly throughout the day due to the ability of these power stations to store some of the heat they get from the sun and to use it in the hours following its capture.

By autonomous community, the distribution of both solar technologies is very different. Castilla-La Mancha is the region with more installed solar PV (photovoltaic) power capacity, almost 20% of the national total, closely followed by Andalusia and a little further away Extremadura and Castilla y León. Together, these four autonomous communities represent 61% of the installed solar PV power capacity in Spain. On the other hand, the autonomous communities of the Cantabrian coast stand out due to the fact that all of them are below 1% of the overall national total.

In the case of solar thermal, only six autonomous communities have this type of facility, with Andalusia being the region with the highest installed power capacity followed by Extremadura; with 80% of the total power capacity of this technology currently installed in these two regions.

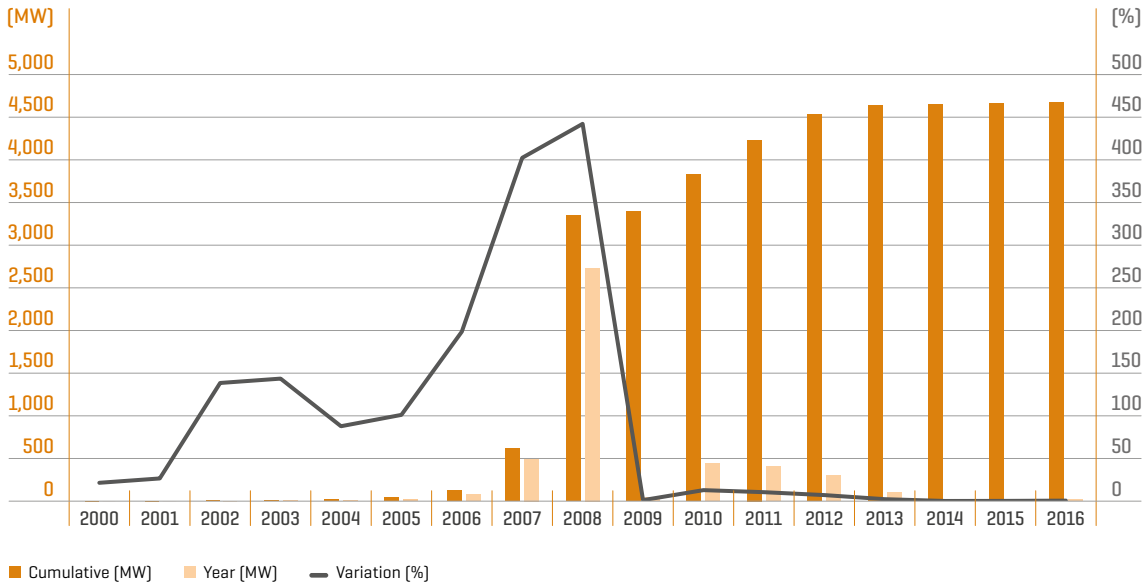
As for the situation of solar technology in Europe, Spain is ranked fourth regarding installed solar power capacity, far behind Germany which is the undisputed leader with almost 40 GW of installed solar power capacity. However, if we measure the weight of this technology in the total installed power capacity in each country, Spain would fall to ninth place.

However, in spite of Germany's greater installed power capacity, the fact that there are fewer hours of sunshine in comparison with the countries of southern Europe means that in the ranking regarding the contribution of solar energy to the total generation of each country, it is those countries in the south that show better figures in relation to their installed solar power capacity. In this regard, Greece and Italy are the countries with the greatest contribution of solar energy. Spain is ranked fourth behind Germany.

[MW] [%]

INSTALLED SOLAR PHOTOVOLTAIC (PV) POWER CAPACITY

NATIONAL ELECTRICITY SYSTEM



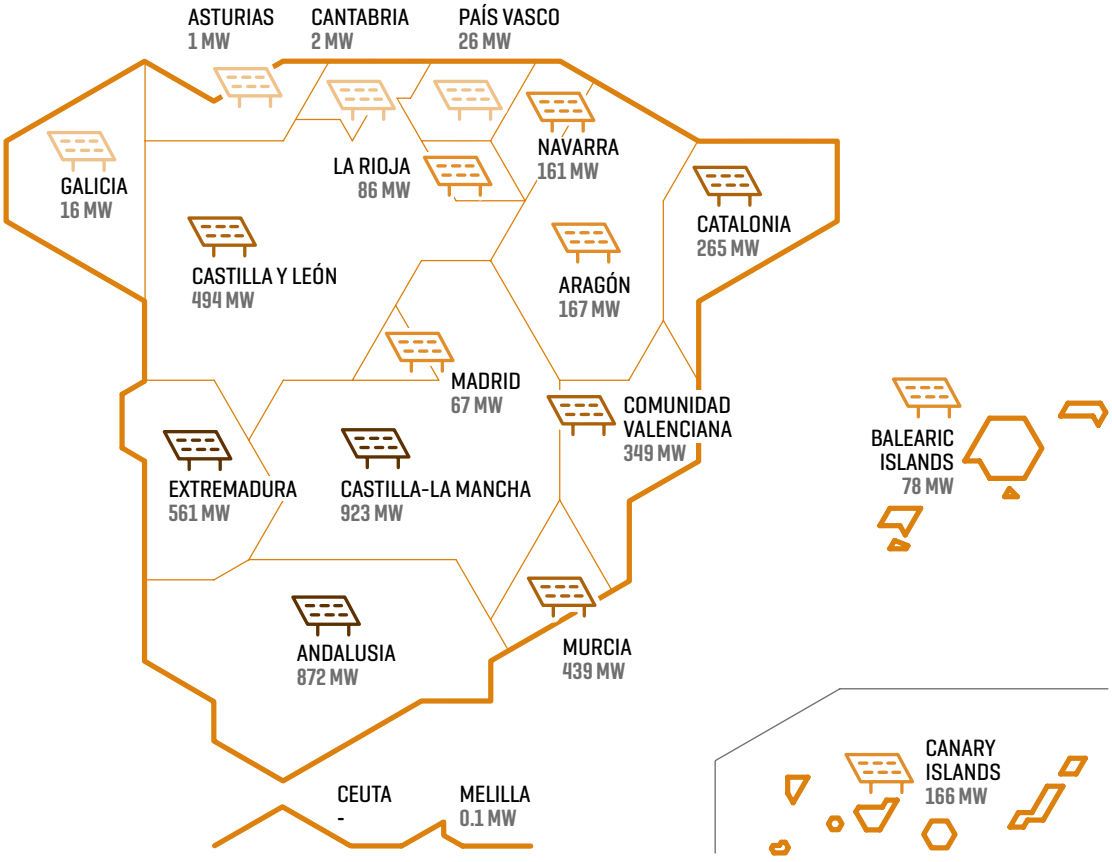
Source: Data from the National Commission for Markets and Competition (CNMC). Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Melilla since 2007.

With almost 20% of the national total, **Castilla-La Mancha is the region with the highest solar photovoltaic power capacity,** followed by Andalusia, Extremadura and Castilla y León. This contrasts sharply with the autonomous communities of the Cantabrian coast which have less than 1% of the overall national total.

(MW)

INSTALLED SOLAR PHOTOVOLTAIC (PV) POWER CAPACITY

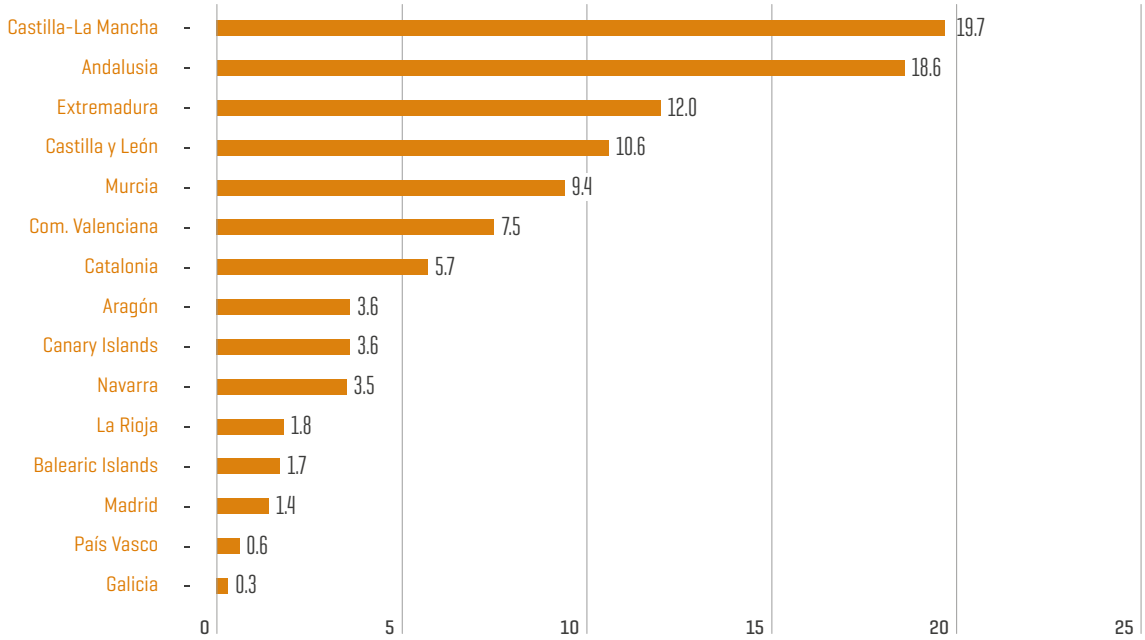
PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM AS AT 31-12-2016



Source: Data from the National Commission for Markets and Competition (CNMC).

SHARE OF SOLAR PV POWER CAPACITY PER AUTONOMOUS COMMUNITY

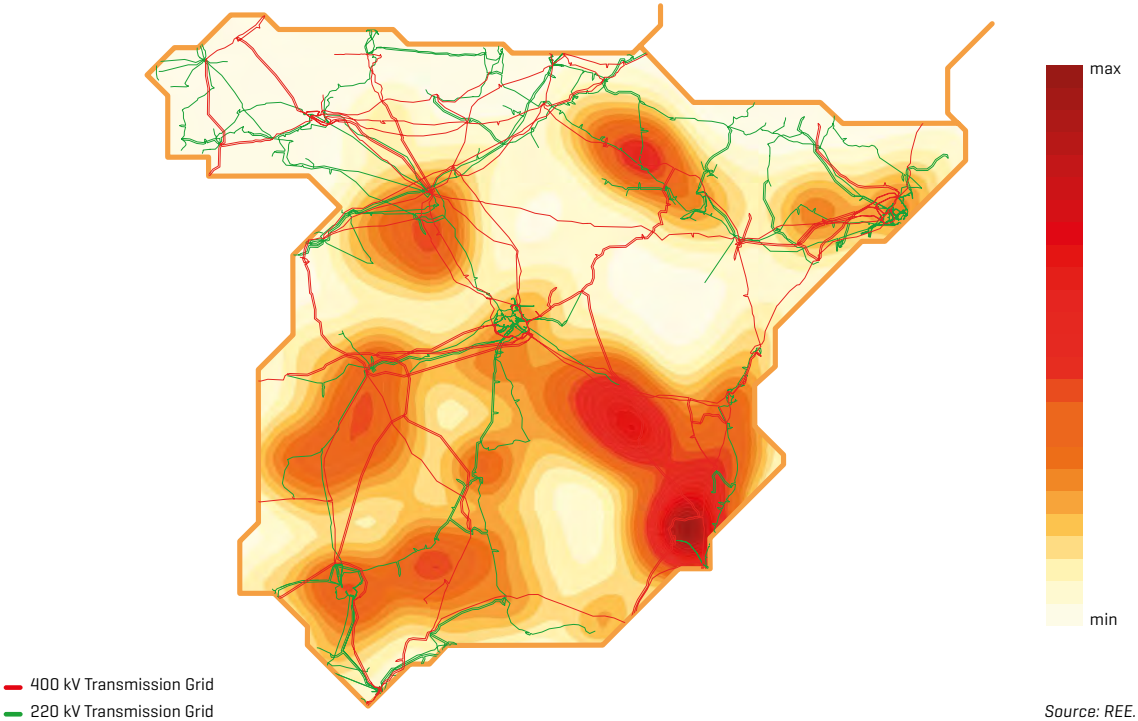
IN RELATION TO THE NATIONAL TOTAL AS AT 31-12-2016



Source: Data from the National Commission for Markets and Competition (CNMC). // Note: Cantabria, Asturias and Melilla are not included as their share of this technology is very small and would not be easily seen in the graph.

GEOGRAPHICAL DISTRIBUTION OF SOLAR PHOTOVOLTAIC FACILITIES ON THE PENINSULA

AS AT 31-12-2016

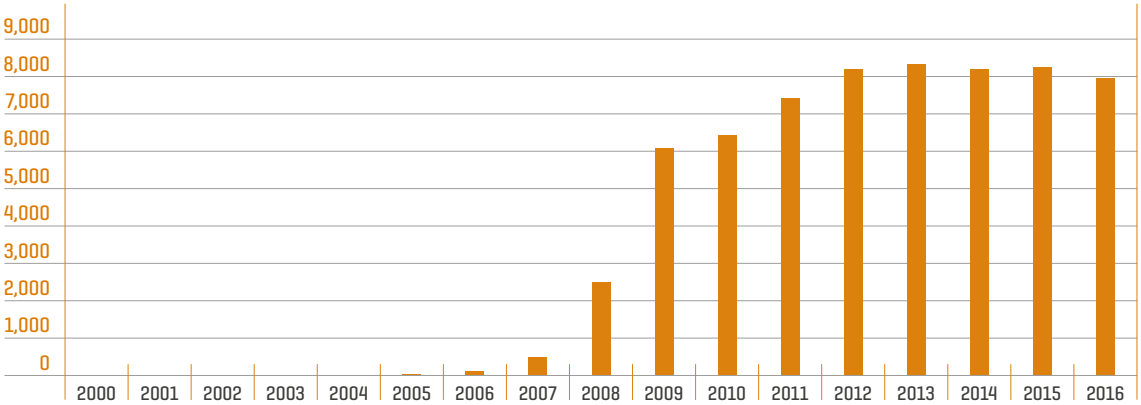


Source: REE.

[GWh]

SOLAR PV ENERGY GENERATION

NATIONAL ELECTRICITY SYSTEM



Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Melilla since 2007.

[GWh]

SOLAR PV ENERGY GENERATION IN 2016

PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM

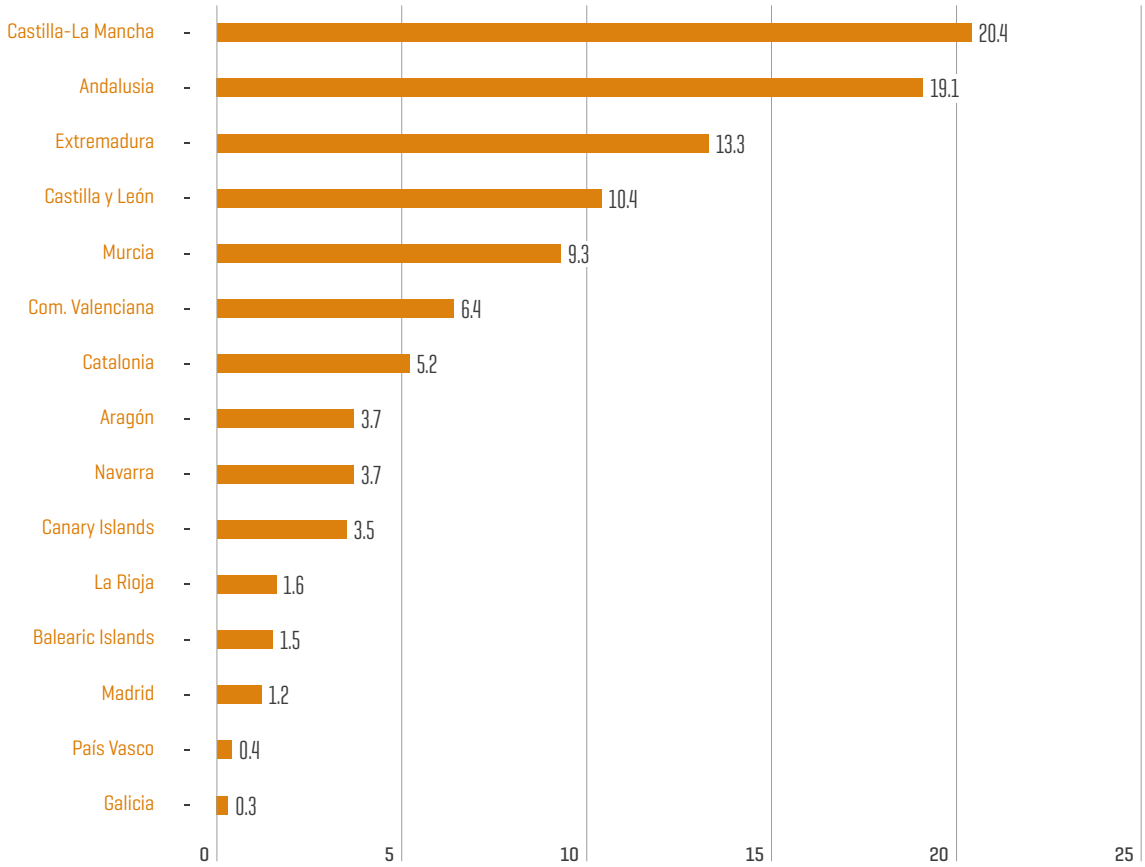
< 50 GWh ≥ 50 to < 300 GWh ≥ 300 to < 900 GWh ≥ 900 GWh

Source: REE.

Four autonomous communities account for more than 60 % of the solar photovoltaic energy generated in Spain in 2016, led by Castilla-La Mancha and Andalusia whose **production exceeded 1,500 GWh in both regions.**

(%)

SHARE OF SOLAR PV ENERGY GENERATION PER AUTONOMOUS COMMUNITY IN RELATION TO THE NATIONAL TOTAL

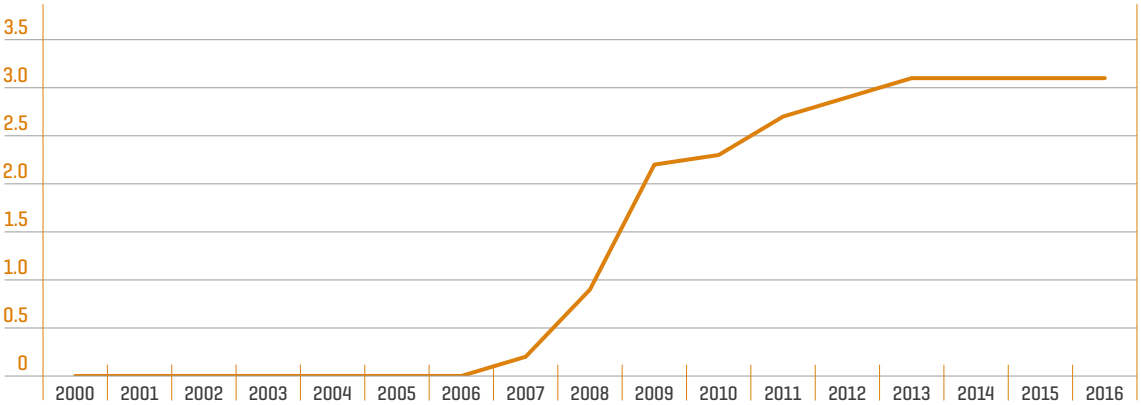


Source: REE. // Note: Cantabria, Asturias and Melilla are not included as their share of this technology is very small and would not be easily seen in the graph.

[%]

SHARE OF SOLAR PV ENERGY GENERATION IN THE TOTAL GENERATION MIX

NATIONAL ELECTRICITY SYSTEM

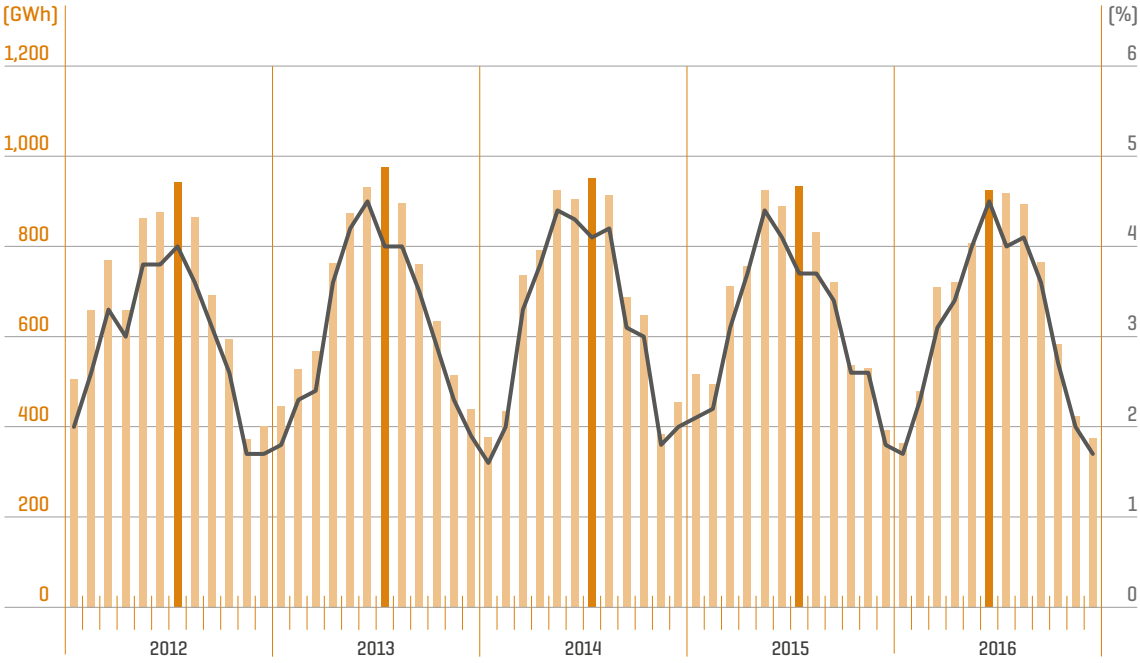


Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Melilla since 2007.

[GWh] [%]

SOLAR PV ENERGY GENERATION, MONTHLY MAXIMUM VALUES AND SHARE IN THE TOTAL GENERATION MIX

NATIONAL ELECTRICITY SYSTEM



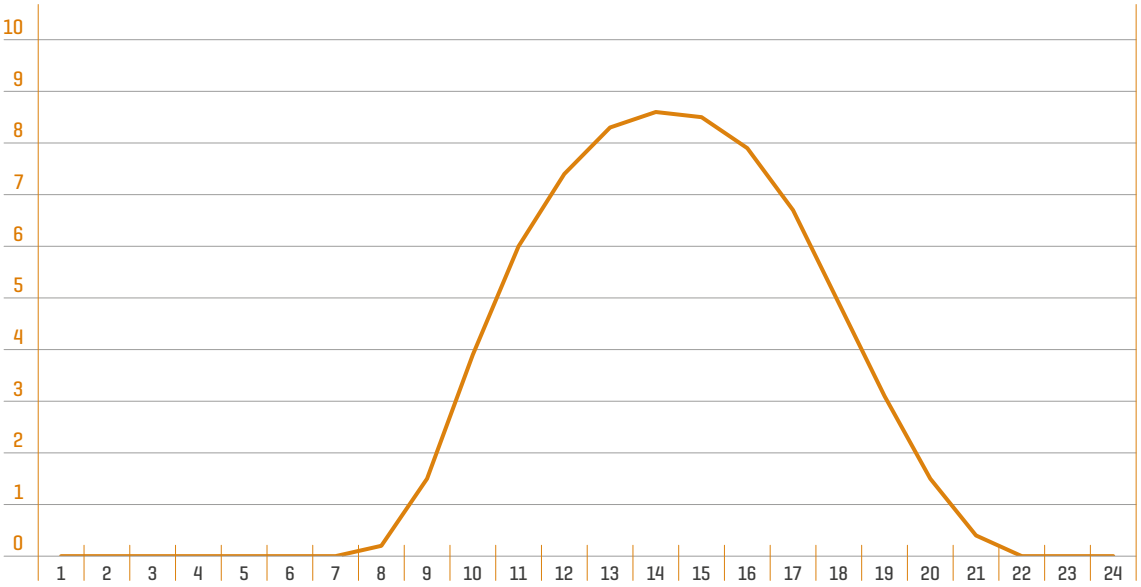
Solar photovoltaic energy generation [GWh] Monthly maximum [GWh] Solar photovoltaic energy generation/Total generation [%]

Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Melilla since 2007.

[%]

AVERAGE SHARE OF SOLAR PV IN RELATION TO GENERATION THROUGHOUT THE DAY

PENINSULAR ELECTRICITY SYSTEM

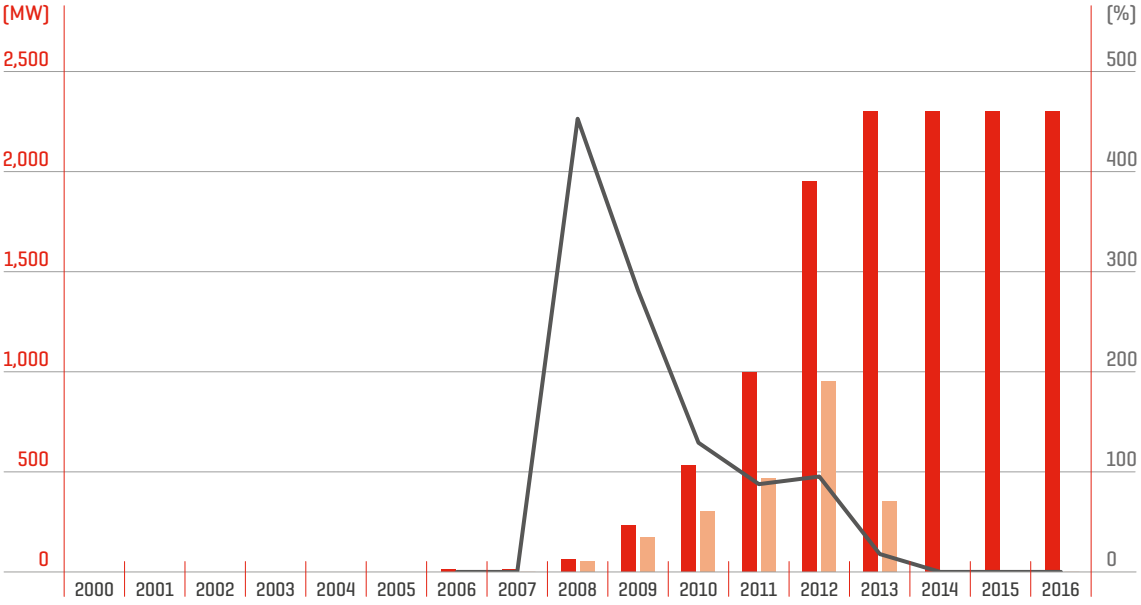


Source: REE.

[MW] [%]

INSTALLED SOLAR THERMAL POWER CAPACITY

NATIONAL ELECTRICITY SYSTEM



Source: Data from the National Commission for Markets and Competition (CNMC).

[MW]

INSTALLED SOLAR THERMAL POWER CAPACITY

PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM AS AT 31-12-2016

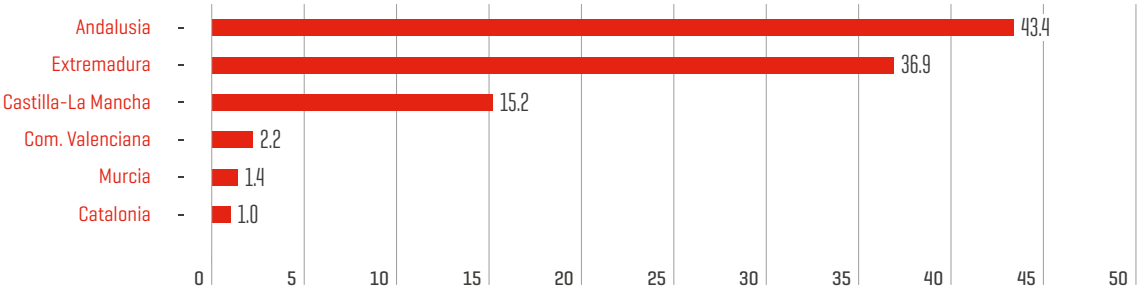
< 50 MW ≥ 50 to < 250 MW ≥ 250 to < 500 MW ≥ 500 MW

Source: Data from the National Commission for Markets and Competition (CNMC).

[%]

SHARE OF SOLAR THERMAL POWER CAPACITY PER AUTONOMOUS COMMUNITY

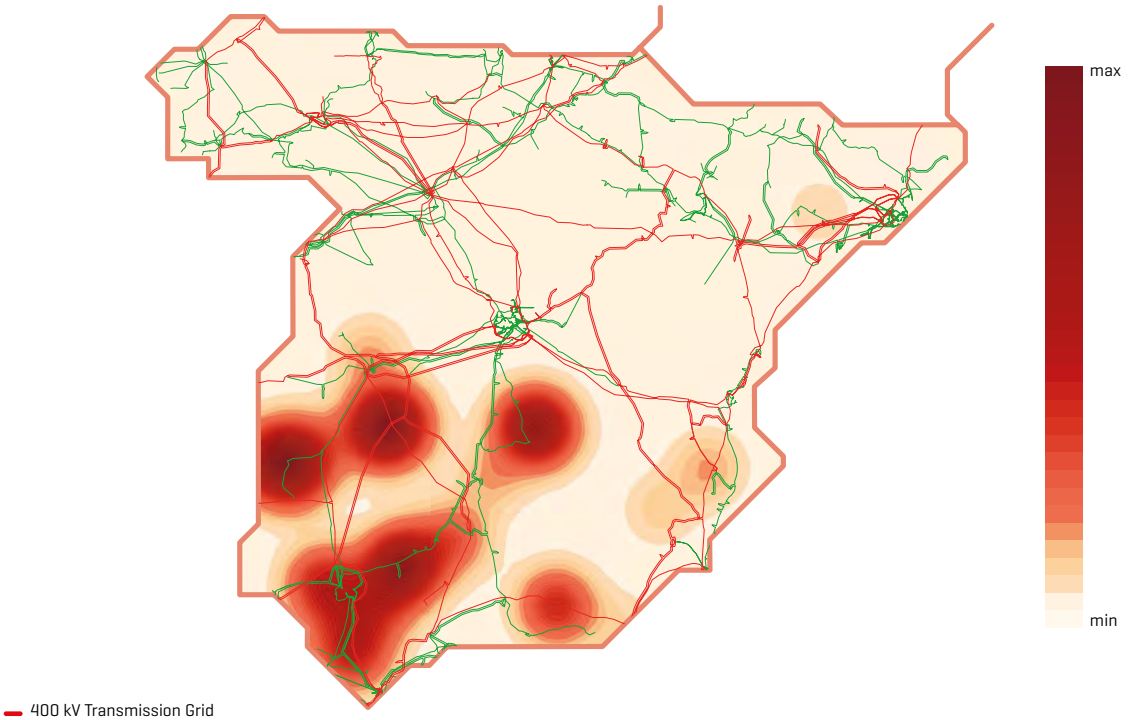
IN RELATION TO THE NATIONAL TOTAL AS AT 31-12-2016



Source: Data from the National Commission for Markets and Competition (CNMC).

GEOGRAPHICAL DISTRIBUTION OF SOLAR THERMAL FACILITIES ON THE PENINSULA

AS AT 31-12-2016

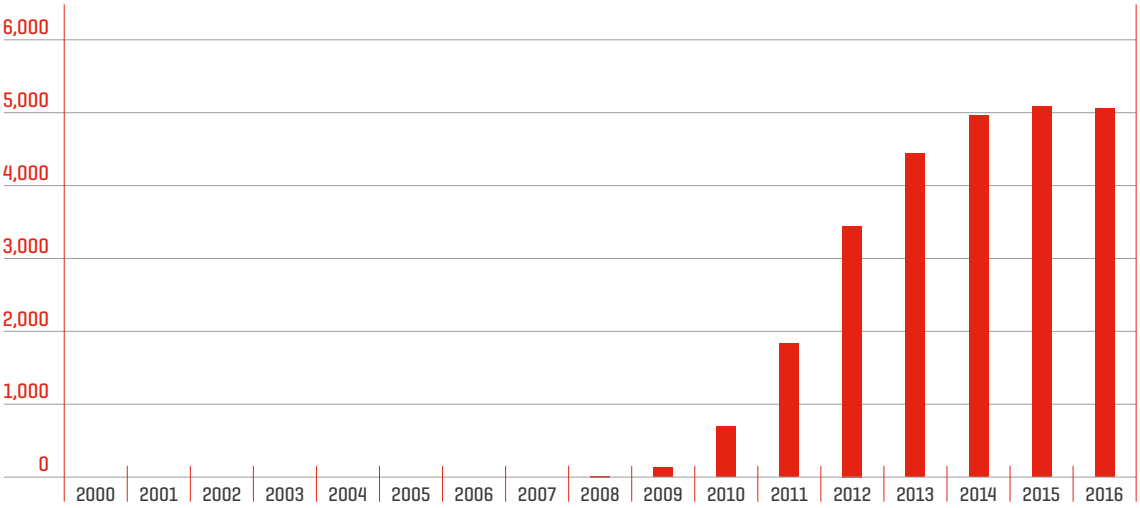


Source: REE.

SOLAR THERMAL ENERGY GENERATION

NATIONAL ELECTRICITY SYSTEM

[GWh]



Source: REE.

Andalusia is the region with more installed solar thermal power capacity with a total of 997 MW, and the one with the highest solar thermal energy produced, with 2,195 GWh in 2016, **followed in both cases by Extremadura.** These two regions account for 80 % of the total installed power capacity of this technology in Spain.

(GWh)

SOLAR THERMAL ENERGY GENERATION IN 2016

PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM AS AT 31-12-2016.

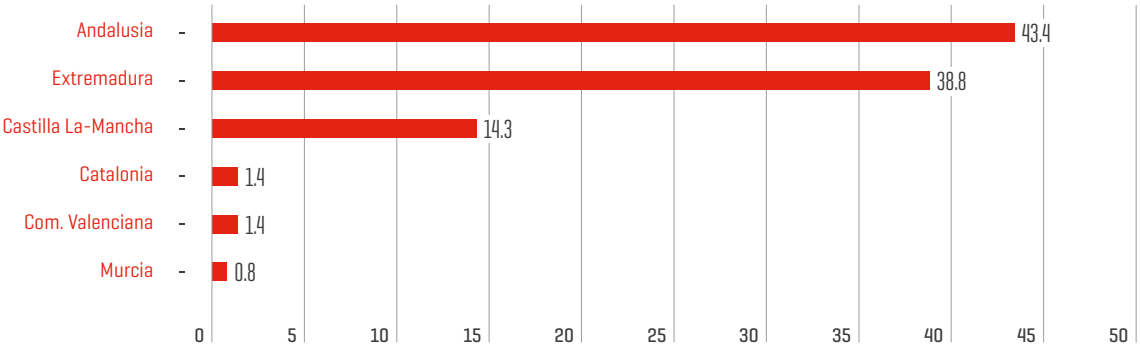
< 50 GWh ≥ 50 to < 500 GWh ≥ 500 to < 1.000 GWh ≥ 1.000 GWh

Source: REE.

In Spain, only six regions have solar thermal facilities, and of these, **Andalusia and Extremadura alone account for more than 80 % of all solar thermal energy generated nationally in 2016.**

[%]

SHARE OF THERMAL SOLAR ENERGY GENERATION COMMUNITY IN RELATION TO THE NATIONAL TOTAL IN 2016

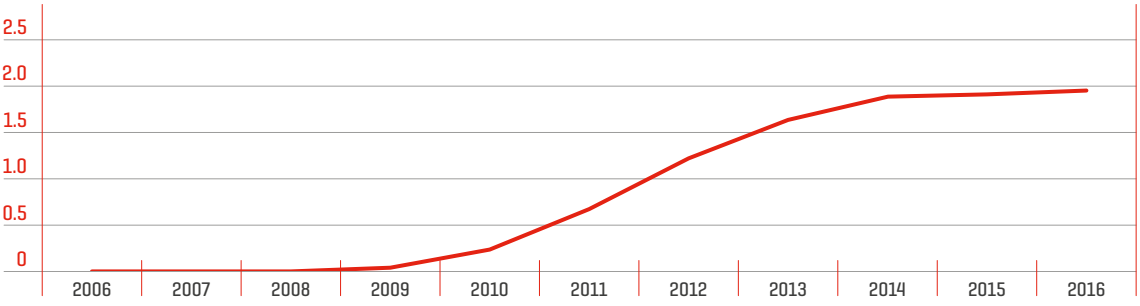


Source: REE

[%]

SHARE OF SOLAR THERMAL ENERGY GENERATION IN THE TOTAL GENERATION MIX

NATIONAL ELECTRICITY SYSTEM

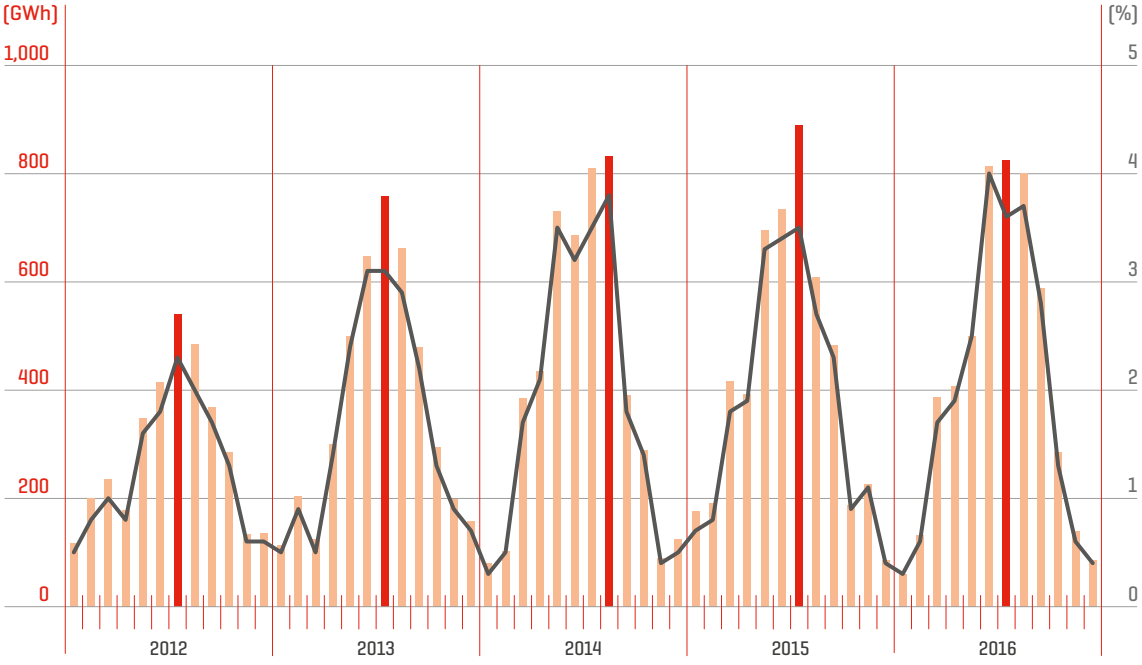


Source: REE

[GWh] [%]

NATIONAL SOLAR THERMAL ENERGY GENERATION, MONTHLY MAXIMUM VALUES AND SHARE IN THE TOTAL GENERATION MIX

NATIONAL ELECTRICITY SYSTEM

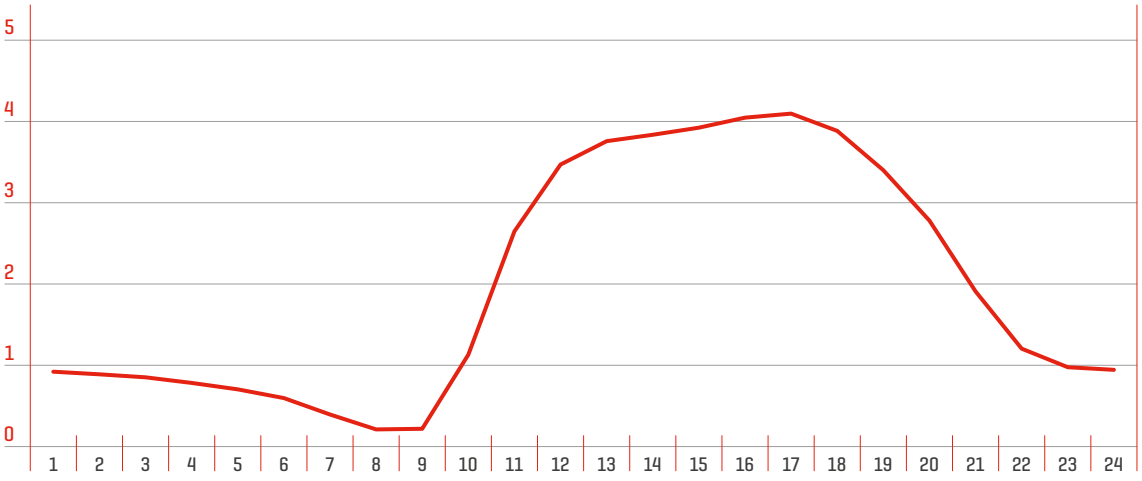


Source: REE.

[%]

AVERAGE SHARE OF SOLAR THERMAL IN RELATION TO GENERATION THROUGHOUT THE DAY

PENINSULAR ELECTRICITY SYSTEM

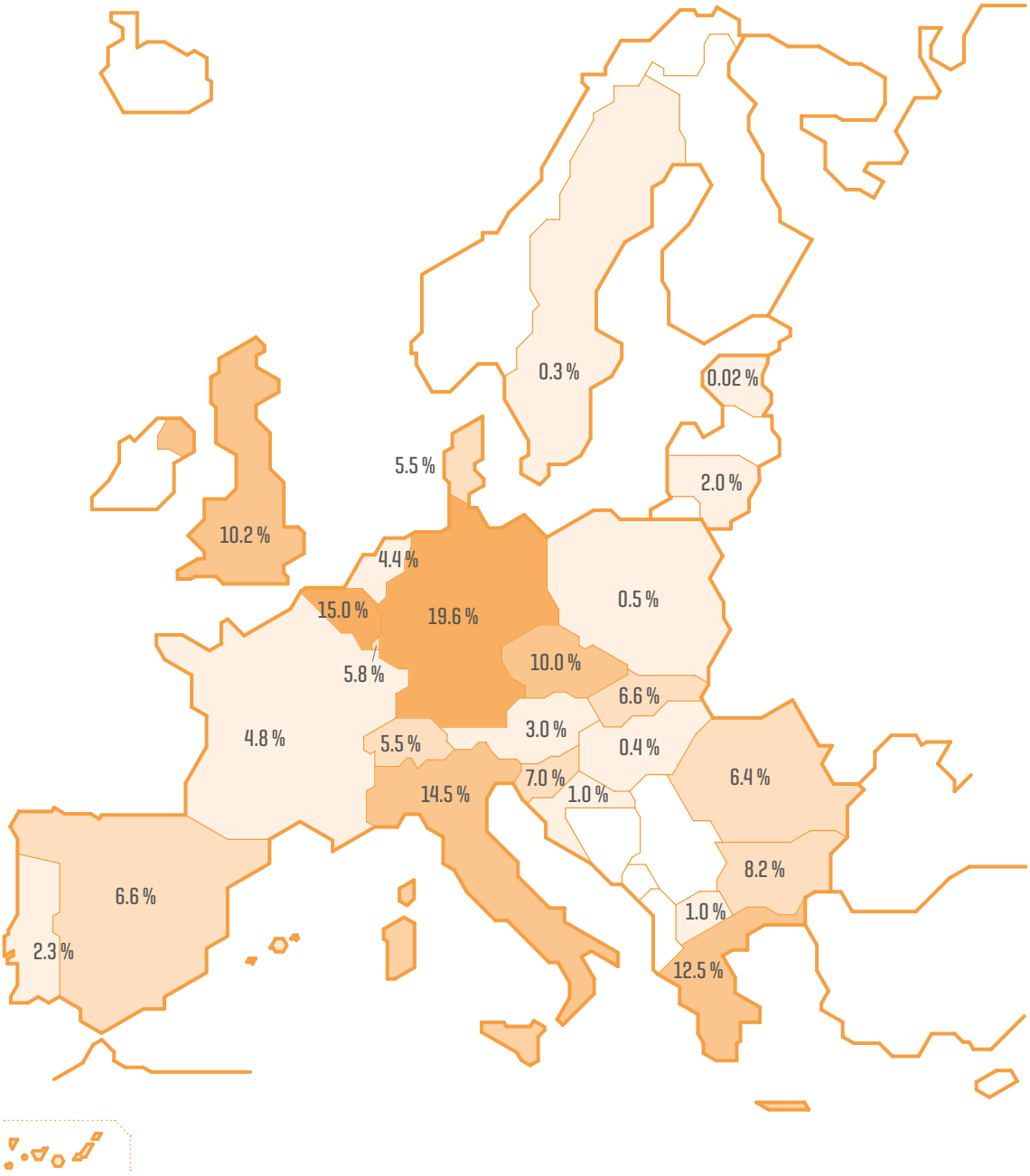


Source: REE.

[%]

SOLAR POWER CAPACITY IN RELATION TO TOTAL POWER CAPACITY

IN ENTSO-E MEMBER COUNTRIES AS AT 31-12-2016

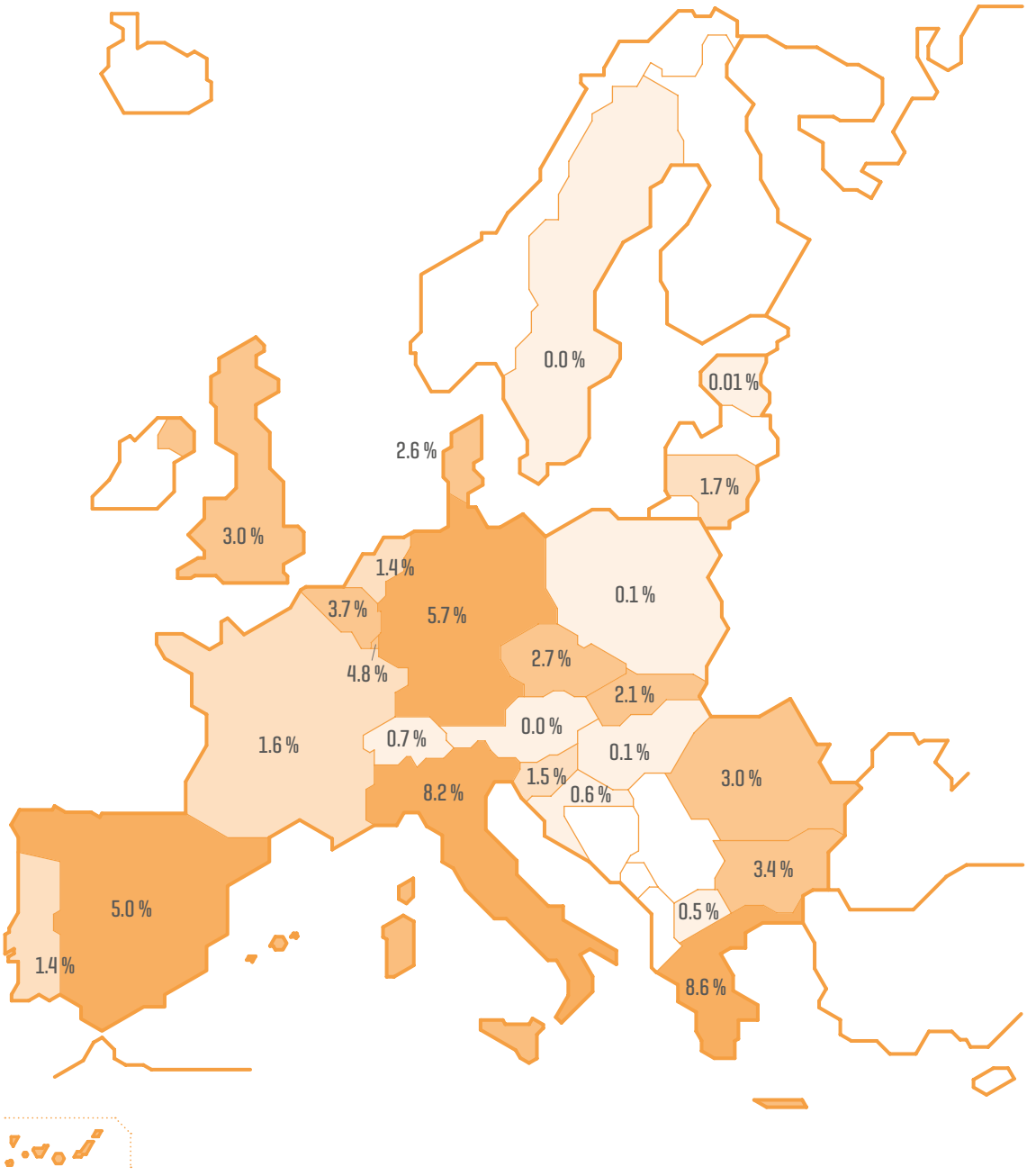


< 5 % ≥ 5 % to < 10 % ≥ 10 % to < 15 % ≥ 15 %

Source: ENTSO-E. Data portal 24 May 2017. Great Britain includes data for Northern Ireland. Spain REE. // Note: data for Slovakia, Slovenia, France, FYROM (Macedonia), Great Britain, Greece, Holland, Hungary, Ireland, Sweden and Switzerland correspond to 2015, the 2016 data was not available at the close of this report.

SOLAR ENERGY GENERATION IN RELATION TO TOTAL GENERATION

IN ENTSO-E MEMBER COUNTRIES IN 2016



< 1% ≥ 1% to < 2% ≥ 2% to < 5% ≥ 5%

Source: ENTSO-E. Data portal 24 May 2017. Great Britain includes data for Northern Ireland. Spain REE.

Energy from the **earth** and the **sea**

05

By the end of 2016, the set of renewable energies obtained from a wide range of other sources, **led by biomass, represented 0.8% of the installed power capacity in Spain** and around 2% of overall production.

This section contains aggregated information on a group of renewable energy technologies from a wide range of other sources, which together account for 1.8% of installed renewable power capacity and just 0.8% of the total installed power capacity in Spain at the end of 2016.

This group of technologies, known as 'remaining renewables', we can clearly identify four main subgroups: biomass and biogas (744 MW); renewable waste - identified as 50% of the urban/municipal solid waste (107 MW); the wind-hydro power station installed on the island of El Hierro (11.4 MW); and 5 MW of marine hydro.

It should be noted that the evolution of these aggregated energies has been constant for more than a decade[1], with installed capacity going from 215 MW in 2000 to 867 MW in 2016. However, its share in the Spanish generation mix is still minimal, not exceeding 2% in any of the years in the aforementioned period.

Because of its uniqueness, noteworthy is the wind-hydro power station of Gorona del Viento which in 2016 enabled 41% of the annual generation of the island of El Hierro to be covered with renewable energy, and which supplied the island's electricity system with 100% renewable energy for over 500 hours.

By autonomous community, Andalusia is clearly the region with the highest installed power capacity of this group of renewable energies, which accounts for more than 30% of the total installed capacity of these technologies nationwide. It is followed, in this order, by Catalonia, Galicia and Castilla-La Mancha.

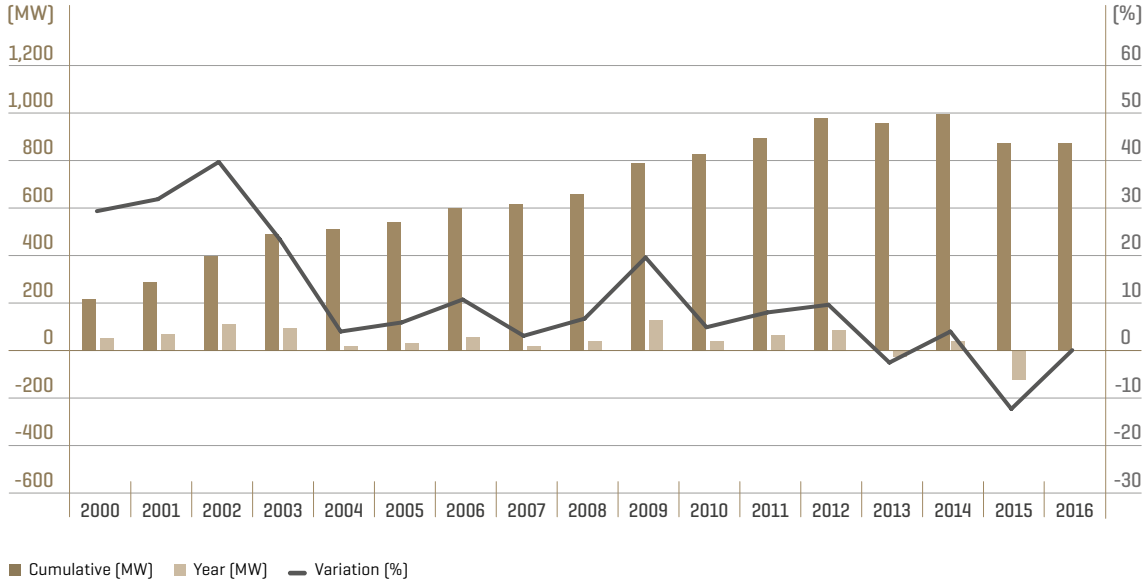
Regarding this type of energy, when compared with other European countries, Spain is far behind the leaders, such as Iceland, Finland and Denmark, where these technologies represent more than 10% of their respective installed power capacity and more than 15% of their generation. However, in most countries the installed power capacity of this type of energy stands at approximately 1%. In the case of the contribution of these technologies to the total production, a similar situation occurs, with Finland leading the series with 16%, followed by Denmark and Latvia with 15.3% and 12.2%, respectively.

[1] The evolution of these technologies over the years has undergone reorganisations due to regulatory changes such as that which happened in 2015 with Royal Decree 413/2014 regarding Renewables, Cogeneration and Waste. This is the reason why the installed power capacity of these technologies has shown a decrease as of that year.

[MW] [%]

REMAINING RENEWABLES [1]. INSTALLED POWER CAPACITY

NATIONAL ELECTRICITY SYSTEM

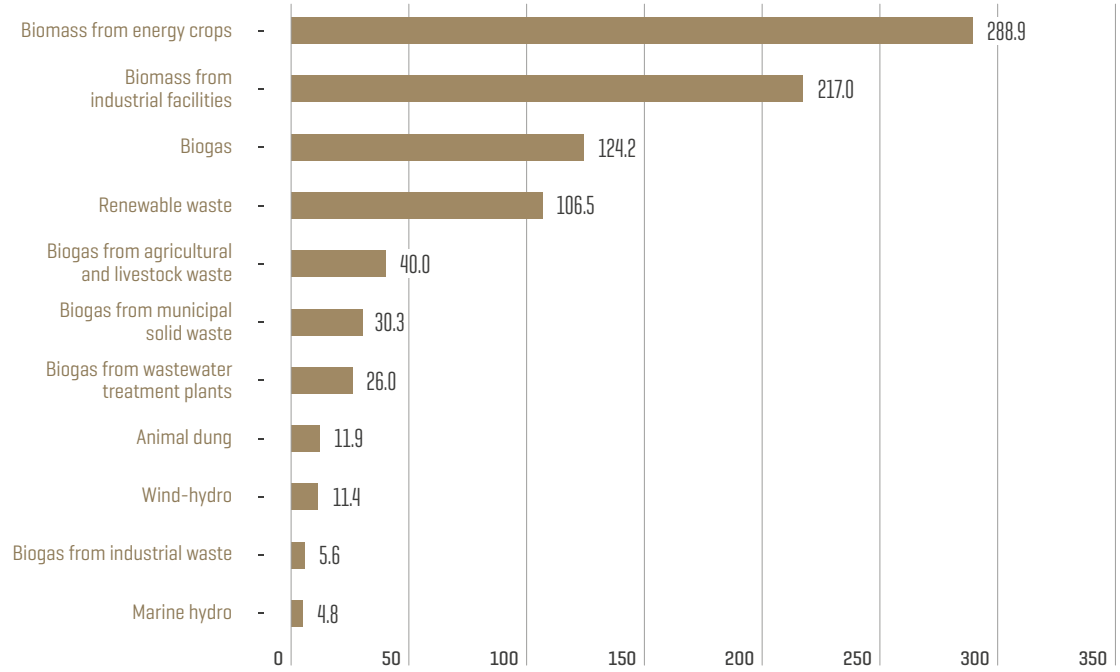


[1] Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. // Source: Data from the National Commission for Markets and Competition (CNMC). Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Melilla since 2007. // Note: Although 2015 shows a decrease in installed power capacity, this drop is due to a reorganisation of the different technologies as a result of Royal Decree 413/2014 regarding Renewables, Cogeneration and Waste.

[MW]

REMAINING RENEWABLES. INSTALLED POWER CAPACITY PER FUEL TYPE

NATIONAL ELECTRICITY SYSTEM AS AT 31.12.2016

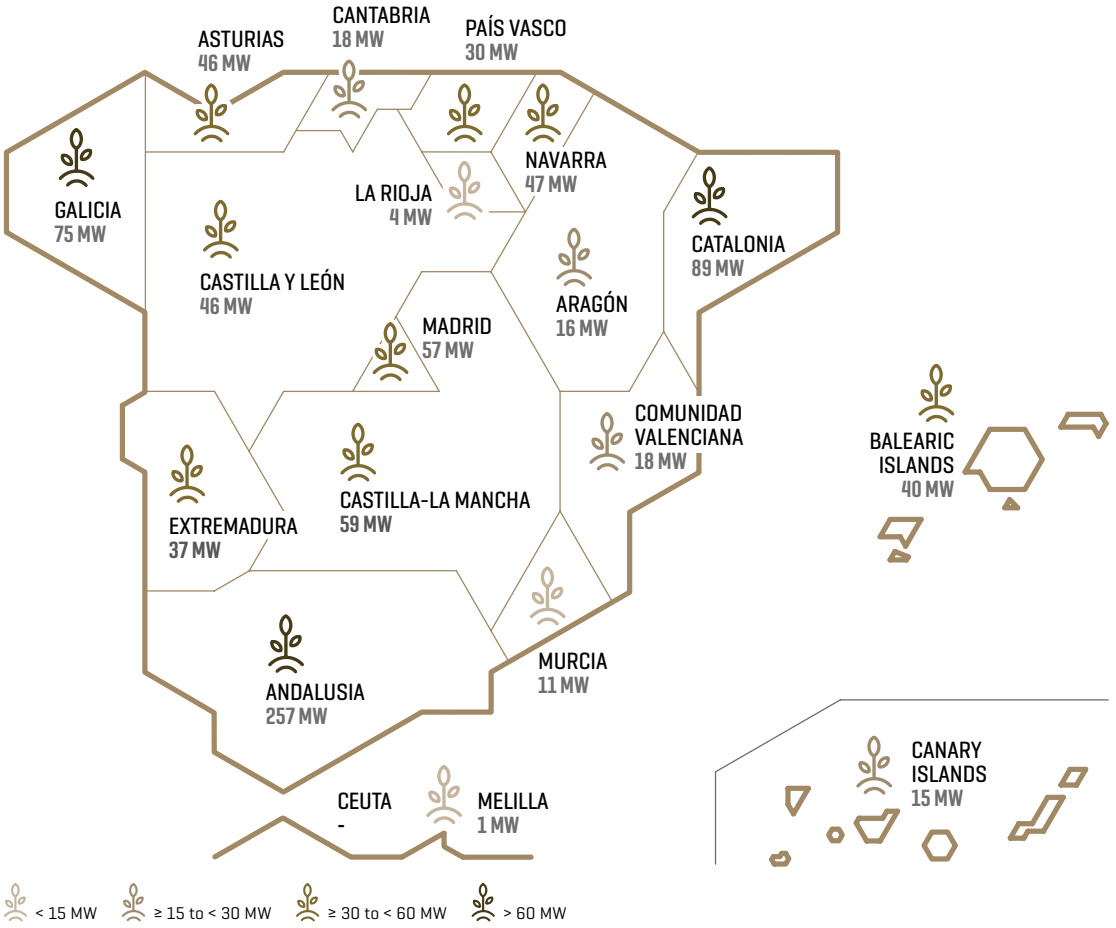


Source: Data from the National Commission for Markets and Competition (CNMC) and REE.

[MW]

REMAINING RENEWABLES [1]. INSTALLED POWER CAPACITY

PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM AS AT 31-12-2016

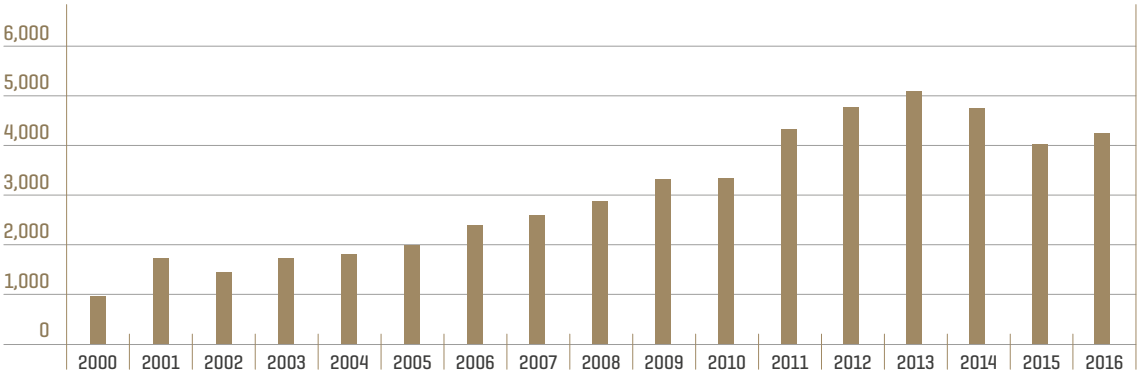


[1] Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. Source: Data from the National Commission for Markets and Competition (CNMC).

[GWh]

GENERATION FROM REMAINING RENEWABLES [1]

NATIONAL ELECTRICITY SYSTEM

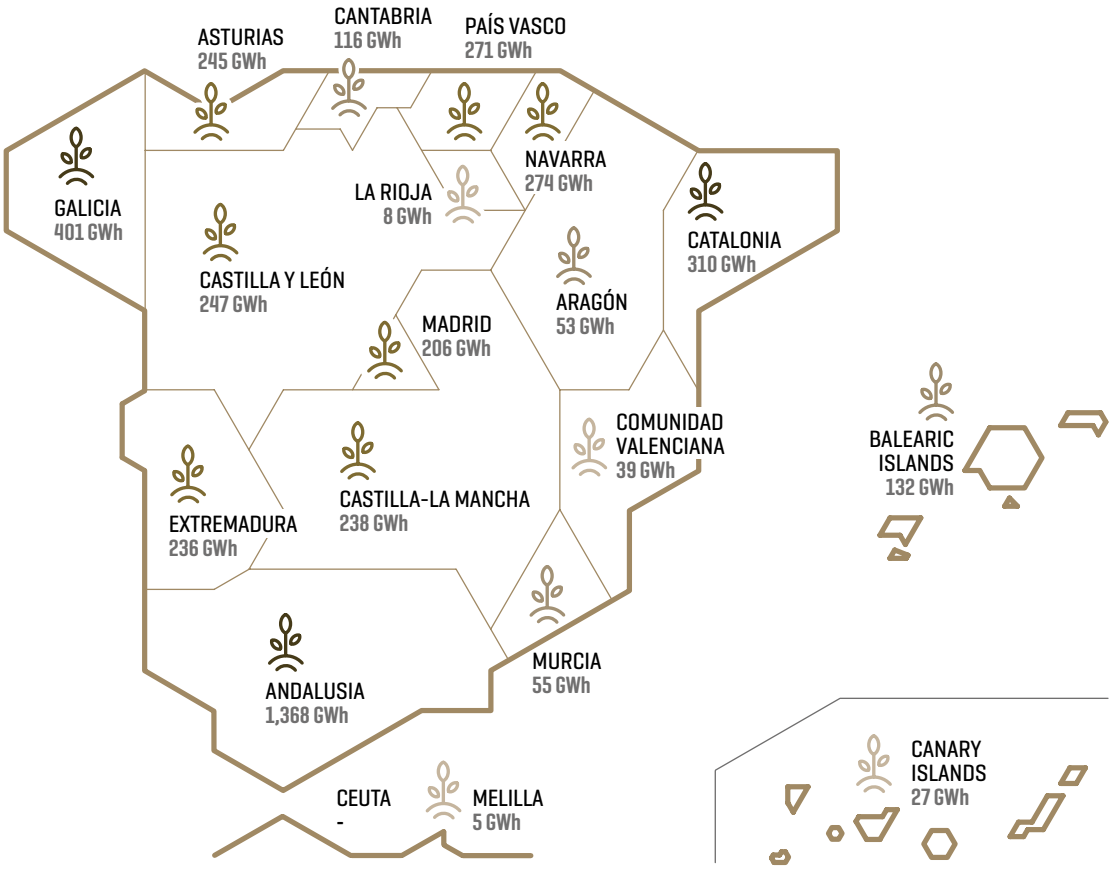


[1] Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. // Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Ceuta and Melilla since 2007.

[GWh]

GENERATION FROM REMAINING RENEWABLES IN 2016 [1]

PER AUTONOMOUS COMMUNITY. NATIONAL ELECTRICITY SYSTEM

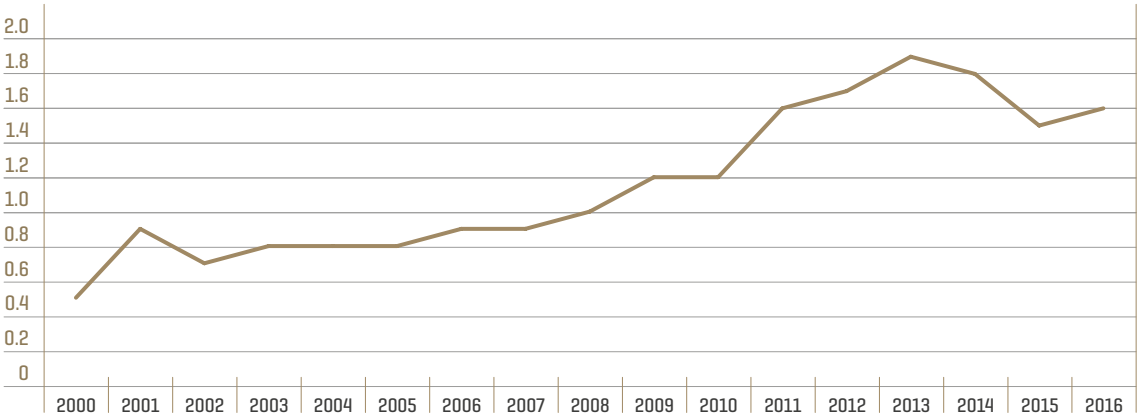


[1] Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. // Source: REE.

[%]

SHARE OF GENERATION FROM REMAINING RENEWABLES [1]

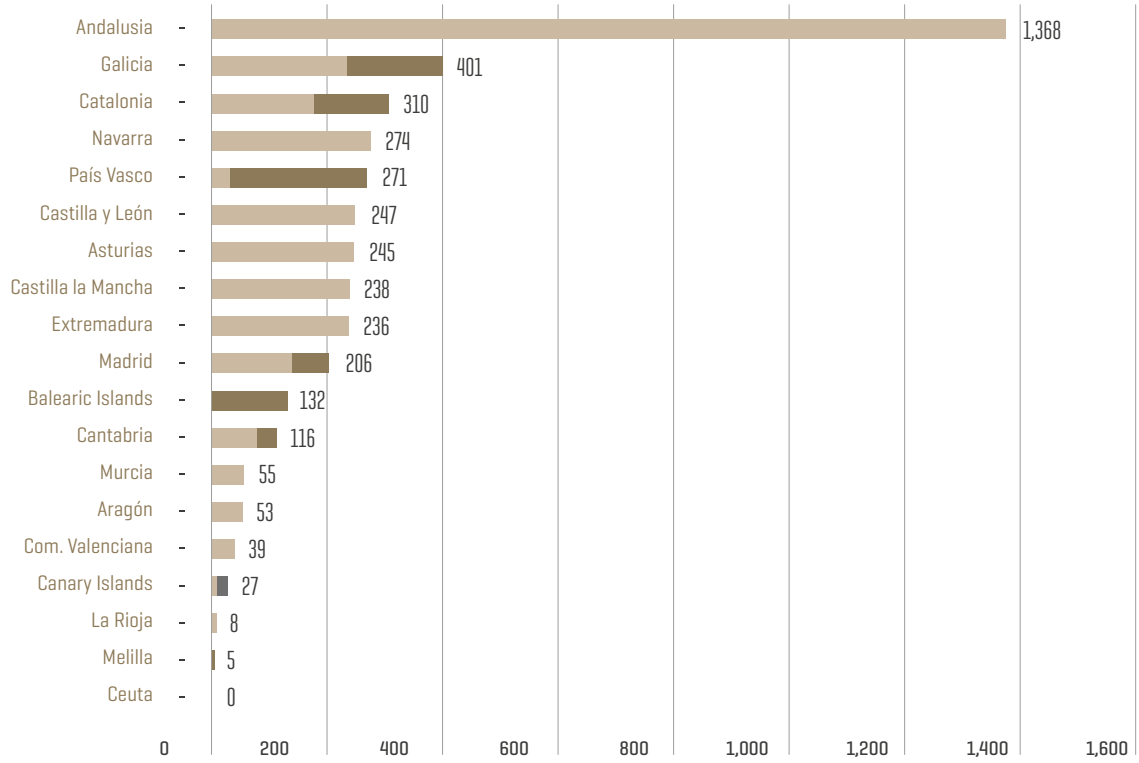
IN THE TOTAL GENERATION MIX. NATIONAL ELECTRICITY SYSTEM



[1] Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. // Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Ceuta and Melilla since 2007.

[GWh]

GENERATION FROM REMAINING RENEWABLES PER REGION AND TYPE OF TECHNOLOGY IN 2016

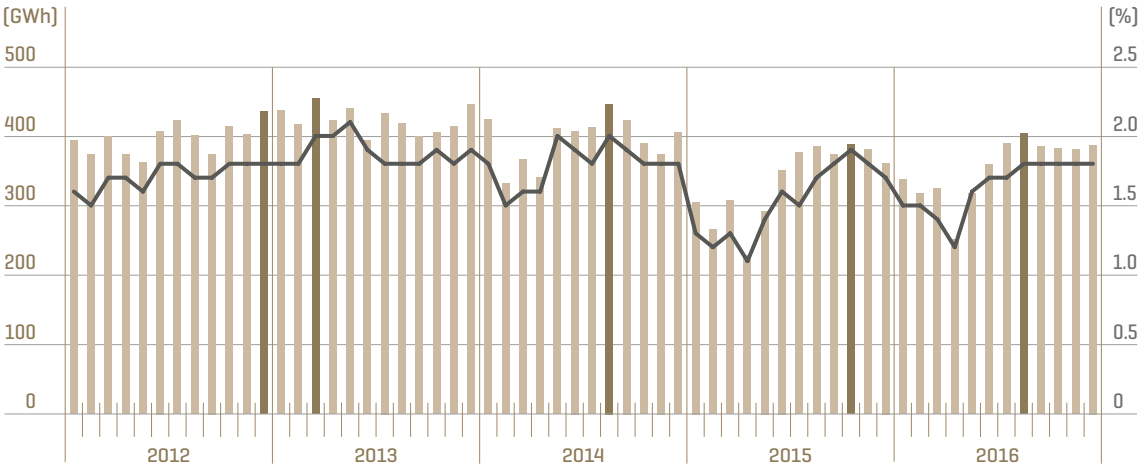


(1) Includes biomass, biogas and marine hydro // Source: REE.

[GWh] [%]

NATIONAL GENERATION FROM REMAINING RENEWABLES (1), MONTHLY MAXIMUM VALUES AND SHARE IN THE TOTAL GENERATION MIX

NATIONAL ELECTRICITY SYSTEM

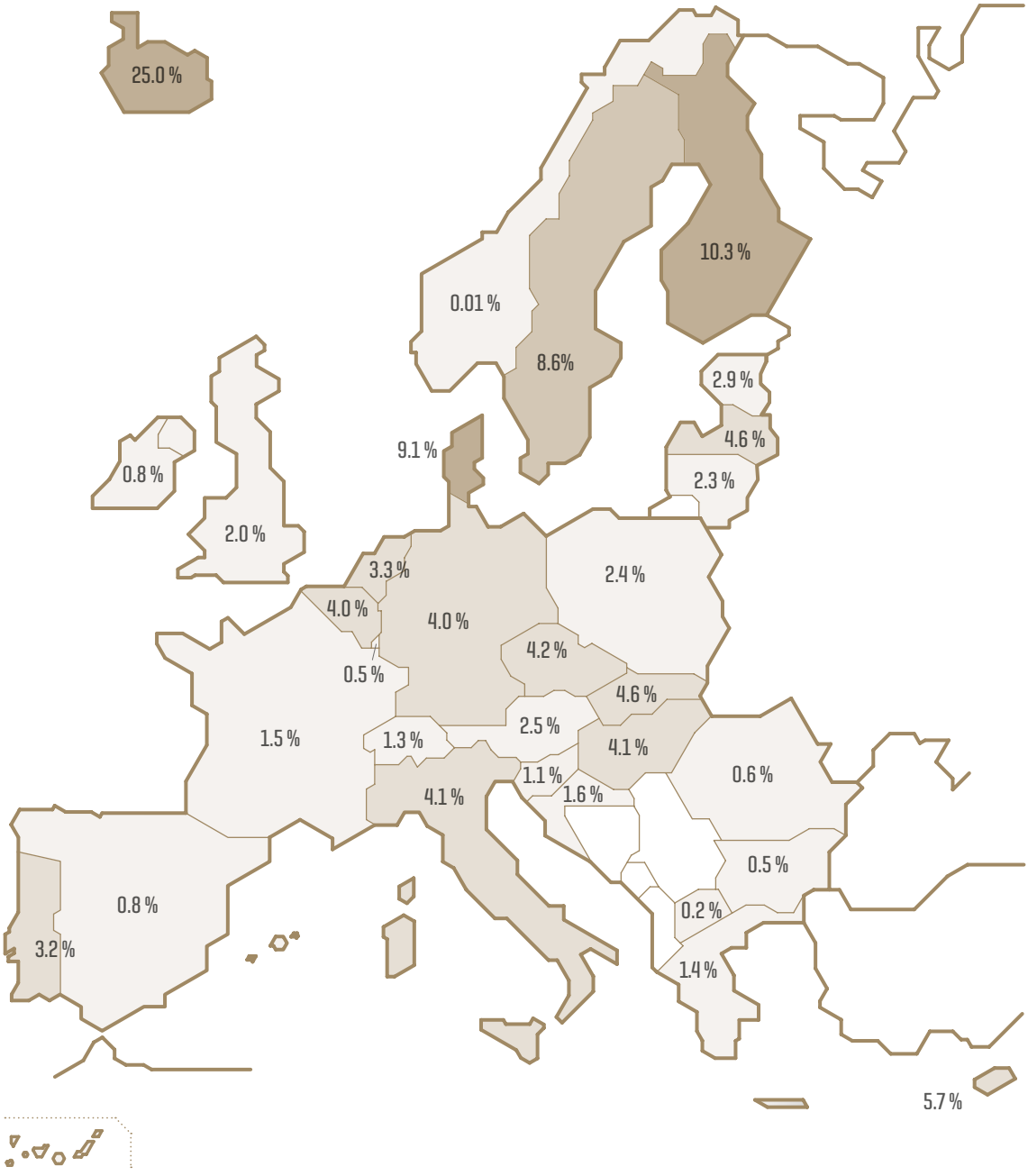


(1) Includes biogas, biomass, geothermal, marine hydro, wind-hydro and renewable waste. // Source: REE. Data regarding the Balearic Islands and the Canary Islands available as of 2006 and Melilla since 2007.

[%]

POWER CAPACITY OF REMAINING RENEWABLES IN RELATION TO TOTAL CAPACITY

IN ENTSO-E MEMBER COUNTRIES IN 2016 [1]



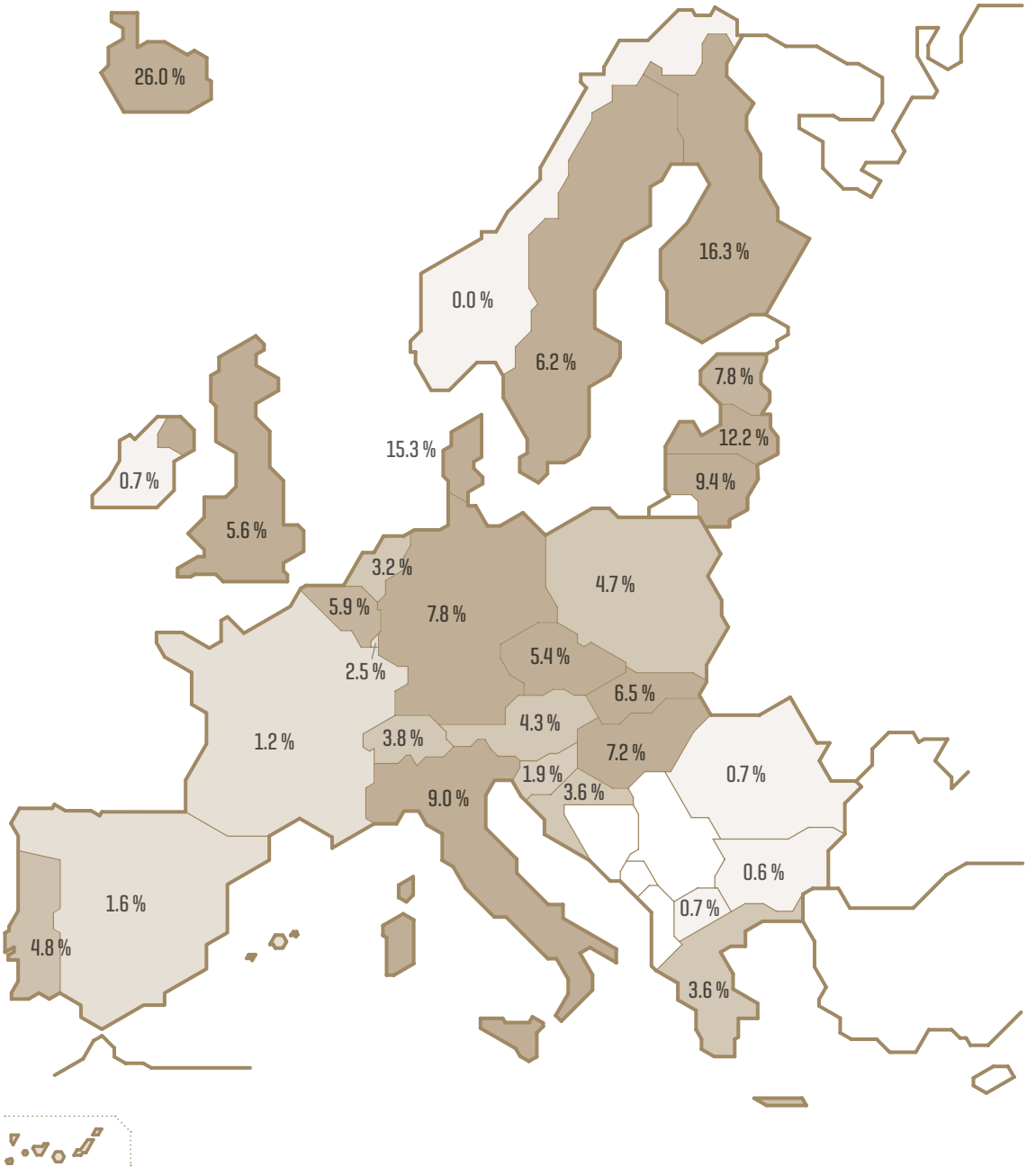
< 3 % ≥ 3% to < 6 % ≥ 6% to < 9 % ≥ 9%

[1] ENTSO-E countries include biomass, biogas, geothermal, marine hydro and renewable waste technologies. // Source: ENTSO-E. Data portal 24 May 2017. Great Britain includes data for Northern Ireland. Spain REE. // Note: data for Slovakia, Slovenia, France, FYROM (Macedonia), Great Britain, Greece, Holland, Hungary, Ireland, Sweden and Switzerland correspond to 2015, the 2016 data was not available at the close of this report.

[%]

GENERATION FROM REMAINING RENEWABLES IN RELATION TO THE TOTAL GENERATION MIX

IN ENTSO-E MEMBER COUNTRIES IN 2016 [1]



< 1 % ≥ 1% to < 3% ≥ 3% to < 5 % ≥ 5%

[1] ENTSO-E countries includes biomass, biogas, geothermal, marine hydro and renewable waste technologies. // Source: ENTSO-E. Data portal 24 May 2017. Great Britain includes data for Northern Ireland. Spain REE.

Glossary **of terms**

Biogas
Combustible gaseous fuel that is generated naturally or in specific devices, as a consequence of the reactions of biodegradation of organic matter, through the action of microorganisms and other factors, in the absence of oxygen (i.e. in an anaerobic environment). This gaseous fuel constitutes a source of renewable energy and can be used to produce electricity.

Biomass
Non-fossil organic material of biological origin that constitutes a source of renewable energy.

Cogeneration
Process through which electricity and useful thermal and/or mechanical energy are obtained simultaneously.

Geothermal
Geothermal energy is a source of renewable energy that takes advantage of the Earth's natural heat and that appears in the form of hot gases or liquids rising along the faults from underlying bodies of hot rock or through the circulation and convection of water reservoirs resulting in a hydrothermal process that takes place between fluids and rocks.

Hydroelectric Reserves
The hydroelectric reserve of a reservoir, at any given time, is the quantity of electricity that could be produced in the reservoir's own power station and in all the power stations situated downstream, with the total drainage of its current useable water reserves at that time and providing that drainage occurs without natural contributions. The annual regime reservoirs are those in which the fill and drainage cycle occurs over a one year period. Hyper-annual regime reservoirs are those which allow the variations in rainfall to be offset in cycles of more than one year.

Hydro Management Unit (HMU)
Each set of hydropower stations belonging to the same hydroelectric basin and the same individual agent.

Installed power capacity
Electrical energy capacity that a power station can generate and deliver under ideal conditions.

Marine hydro
Generation of electrical energy by taking advantage of some aspect of the physical or chemical properties of the oceans, i.e., tidal energy, wave energy, ocean currents, etc.

Mixed pumped storage
Production of electricity generated by power stations capable of generating electrical energy with or without prior pumping from its lower reservoir or catchment area. When there is a water surplus, the power station will function as a conventional power station, also having the possibility of storing energy by pumping water from the lower to the upper reservoir.

Non-renewable energies
These include nuclear, coal, fuel/gas, combined cycle, cogeneration and waste.

Producible hydroelectric energy
Maximum quantity of electricity that theoretically could be produced considering the water supplies registered during a certain period of time, and once the supplies for irrigation or uses other than the generation of electricity have been subtracted.

Producible hydroelectric index
This is the quotient between the producible energy and the average producible energy, both related to the same period and to the same hydroelectric equipment. A producible hydroelectric index of less than 1 indicates that the period is dry, while if greater than 1 it is a wet period.

Pure pumped storage
Production of electricity by hydroelectric power stations whose associated reservoir does not receive any natural water inputs, but this comes from it being pumped up from a lower reservoir or catchment area.

Renewable energy
Includes hydro (conventional hydro, mixed pumped storage and hydro that does not belong to a Hydro Management Unit (HMU)), wind-hydro, wind, solar photovoltaic, solar thermal, biogas, biomass, marine hydro, geothermal and 50% of urban solid waste.

Renewable waste
Non-fossil organic material of biological origin resulting from urban solid waste and some commercial and non-hazardous industrial waste. 50% of urban solid waste, also known as Municipal Solid Waste (MSW) is considered renewable.

Solar photovoltaic (PV)
Solar light converted into electricity through the use of solar cells, usually of a semiconductor material that, when exposed to light, generates electricity.

Solar thermal
Heat produced by solar radiation that can be used for the production of mechanical energy and, from this, electrical energy.

Waste
Combustible materials resulting from a product or by-product of waste which, when processed, produces energy for purposes such as heating and electricity generation.

Wind-hydro
Production of electricity through the integration of a wind farm, a pumping unit and a hydroelectric power station. The operation allows the wind farm to supply electricity directly to the grid and, simultaneously, to feed a pump that moves water from a catchment area to a reservoir upstream, as an energy storage system. The hydroelectric power station harnesses the stored potential energy, guaranteeing the electricity supply and the stability of the grid.

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