Spain 2021

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Foreword

The International Energy Agency (IEA) has conducted in-depth peer reviews of its member countries' energy policies since 1976. This process supports energy policy development and encourages the exchange of and learning from international best practices. By seeing what has worked – or not – in the "real world", these reviews help to identify policies that deliver concrete results. Since 2017, the IEA has modernised the reviews by focusing on the key challenges in today's rapidly changing energy markets.

Spain has shown important leadership on clean energy transitions, including through support for key IEA initiatives. I am especially grateful to Teresa Ribera – Fourth Vice President of the Spanish Government and Minister for the Ecological Transition and the Demographic Challenge – for her longstanding dedication to action on climate change and ensuring fair and equitable energy transitions. She has played an invaluable role in the Global Commission for Urgent Action on Energy Efficiency and the Global Commission on People-Centred Clean Energy Transitions, two high-level groups of leading international figures that I convened in recent years to bring greater attention and policy action in these critical areas.

Since the last IEA review in 2015, Spain has solved a long-standing problem of electricity and gas tariffs not covering costs, and has closed all of its coal mines, allowing it to prioritise the energy transition in its policy agenda. Spain has emphasised the concept of a just transition by ensuring that communities in traditional energy sectors, notably coal mining, are not left behind.

The Spanish framework for energy and climate is based on a 2050 objective of national climate neutrality and 97% renewable energy in the total energy mix. As such, it is centred on the massive development of renewable energy, energy efficiency, electrification and renewable hydrogen. Notwithstanding its considerable progress to date on decarbonising and increasing the share of renewables in the electricity sector, Spain's total energy mix is still heavily dominated by fossil fuels. The transport, industry and buildings sectors all have considerable work ahead of them to meet the country's targets for increasing the share of renewables and reducing emissions.

When all of Spain's plans and strategies are implemented, a completely different energy sector will emerge, where fossil fuels are no longer dominant and end-user sectors are mostly electrified. Such a transformation will bring new challenges in the form of energy security, as fluctuating renewable generation will require new forms of back-up and flexibility. The changes will also bring opportunities, particularly in areas such as energy system integration. Importantly, Spain's plans to recover from the COVID-19-induced economic crisis present a major opportunity to frontload its planned investments in its clean energy transition over the upcoming three years.

I sincerely hope that the recommendations proposed in this report will help Spain navigate its energy system transformation as it seeks to build momentum towards achieving climate neutrality and a renewables-based energy system by 2050.

Dr. Fatih Birol

Executive Director

International Energy Agency

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1. Executive summary

Overview

Since the last International Energy Agency (IEA) in-depth review in 2015, Spain has solved a long-standing issue of tariff deficits in its electricity and gas sectors and closed all of its coal mines, which has allowed it to prioritise the issue of climate change on its national agenda and align its goals with European Union (EU) objectives and ambitions. In doing so, Spain has placed the energy transition at the forefront of its energy and climate change policies.

The current Spanish framework for energy and climate is based on the 2050 objectives of national climate neutrality, 100% renewable energy in the electricity mix and 97% renewable energy in the total energy mix. As such, it is centred on the massive development of renewable energy, particularly solar and wind; energy efficiency; electrification; and renewable hydrogen. This is seen as an opportunity to stimulate the economy; create jobs; modernise industry; enhance competitiveness; support vulnerable groups; improve energy security; and support research, development and innovation.

Notwithstanding its considerable progress to date on decarbonising and increasing the share of renewables in the electricity sector, Spain's total energy mix is still heavily dominated by fossil fuels. Notably, the transport, industry and buildings sectors all have considerably more work ahead of them to meet the country's targets for renewables penetration and decarbonisation.

Moreover, under Spain's decentralised system of government, regional administrations have considerable authority over energy policy development and implementation, making effective co-ordination between the centre and the regions even more critical to successful enactment of energy strategies in Spain.

When all of Spain's plans and strategies are implemented, a completely different energy sector will emerge, where fossil fuels are no longer dominant and end-user sectors are mostly electrified. Such a transformed energy landscape will come with new challenges and will provide new opportunities.

The challenges include energy security. The current system is backed up by massive stocks of oil, gas and coal that can be dispatched in a flexible way; the new system, with a large share of variable renewable generation, will require other forms of longer term backup, on top of short-term flexibility. New vulnerabilities will also arise, as electrification goes hand-in-hand with smartening of the system and digitalisation.

The opportunities are with energy system integration. The new energy system can be much more efficient than the current one, as end-use sectors can be coupled with higher electrification, the use of residual heat, waste to energy, but also using electricity to

produce renewable gases like hydrogen, among others. It will be important for Spain to adapt the policy and regulatory framework, where needed, to gradually shape such a new integrated energy system.

The current post-COVID-19 recovery context presents Spain with an important opportunity to frontload its planned energy transition investments to the upcoming three years. Spain is currently working on its green recovery plan, as it will be one of the key beneficiaries of EU recovery funds. The main areas defined in the initial draft of Spain's Recovery and Resilience Plan for the energy transition are efficiency, sustainable mobility, renewable energies, electricity infrastructure, storage and flexibility, and green hydrogen. Spain should capitalise on this opportunity to jumpstart actions outlined in its National Energy and Climate Plan (NECP).

Climate change policies

As a member of the European Union (EU), Spain is bound by EU targets for energy and climate change as part of the Energy Union.

Toward this end, the central strategy document guiding Spain's energy and climate policies over the coming decade is its NECP for the period 2021-30. It outlines a number of policy actions in various sectors that will support the country's climate targets, including in the areas of energy efficiency, renewables and transport. Its 2030 objectives include: a 23% reduction in greenhouse gas emissions from 1990 levles; a 42% share of renewables in energy end use; a 39.5% improvement in energy efficiency; and a 74% share of renewables in electricity generation. Policies include increasing renewable power installations and boosting the use of renewable gases in the power sector, modal shifts and electrification in the transport sector, refurbishments and increasing the use of renewable heating in the residential and commercial sectors, promoting energy efficiency and fuel switching in the industry sector, and energy efficiency improvements in the agricultural sector. The government anticipates that investments of EUR 241 billion will be needed to enact the measures outlined in the NECP, out of which 80% is estimated to come from the private sector.

Domestically, the Climate Change and Energy Transition Bill places the fight against climate change and the need for an energy transition at the centre of the economy and society. Its main targets are similar to those in the NECP, also placing renewable energy and energy efficiency at the centre of the energy transition.

Notably, Spain has emphasised the concept of a just transition to ensure that communities in traditional energy sectors, notably coal mining, are not left behind. To this end, Spain's Just Transition Strategy includes measures to promote employment opportunities in the energy transition, supported by a framework of vocational training, active labour policies, support measures to the most vulnerable and economic stimulus plans for those regions most affected by the energy transition. These are executed through "just transition agreements" between the government, unions and businesses, which can serve as an example to other countries facing similar issues.

Energy efficiency

Spain's overall energy strategy employs an "efficiency first" principle. In all sectors, Spain's energy transition objectives hinge heavily on reducing consumption. Already, Spain has begun to decouple economic growth from energy consumption; energy intensity, the ratio of total consumption to gross domestic product, fell by 18% between 2008 and 2019. Still, more reductions will be needed across all sectors.

The Bill on Climate Change and the Energy Transition as well as the NECP outline a number of measures to improve efficiency and reduce consumption in all economic sectors, including transport, buildings and industry. The policy plans are extensive and can achieve strong results, but will need to be accompanied by a predictable, long-term regulatory framework; sufficient incentives to mobilise private investments; and adequate public financing to underpin all the programmes over the coming decade.

In addition, under Spain's decentralised system of government, the implementation of a number of efficiency measures for transport, buildings and industry will fall on regional and local governments, making co-ordination between the central government and regional/local administrations as well as skills capacity at all levels of government essential to success.

Electricity transition

Spain is progressing toward its 2030 targets, notably in the electricity sector. After a slump in investments between 2013 and 2018 due to a lack of financial means to promote renewables, investments took off again in 2019. The share of renewables (including non-renewable waste) in the national electricity mix grew from 24% in 2009 to 38% in 2019. As such, Spain is well on track to meet its 2020 target to source 42% of its electricity from renewables.

Though Spain's progress on ramping up renewables in its electricity mix is commendable, the future trajectory of its power mix warrants careful consideration to ensure a smooth transition. To start, Spain plans to phase out both coal and nuclear power generation. The coal phase-out appears well on track, with coal only providing around 5% of electricity generation in 2019 and even less in 2020. Nuclear power, which accounted for 22% of power generation in 2019 (and an important source of low-carbon generation), will begin shutting down from 2027. Four of Spain's seven nuclear reactors are scheduled to close by the end of 2030, representing around 4 gigawatts of capacity. Natural gas combined-cycle plants provide around one-third of power generation, and will be crucial to balancing out a power system that is heavily dependent on variable renewables once coal and nuclear have left the market. As such, the government will need to pay special attention to prevent natural gas generation capacity from simultaneously exiting the system. In this regard, the government should thoroughly assess the cost implications for consumers of the expedited phase-out of both coal and nuclear generation.

Spain's targets also foresee a sizeable buildout of new renewables capacity to reach 74% of electricity generation by 2030, notably wind and solar. As such, a stable, long-term remuneration framework for supporting the growth of renewables, including for storage, will be essential. Spain's updated auction mechanisms are a step in the right direction, and investor sentiment and availability of financing appears on track. Additional help could

come in the form of expedited permitting and timely issuance of auction schedules and terms to improve investment clarity.

Moreover, the trajectory will require a concerted focus on system integration of variable renewables in the coming years. The government's strategy is centred on interconnections, storage, demand-side management and digitalisation. Public consultations and regulatory proceedings are underway in all of these areas, though timely issuance of a regulatory framework will be crucial to mobilising investments, including in next-generation technologies such as biogas and hydrogen. Co-operation with neighbouring governments on interconnection capacity will also be a key element of utilising Spain's full production capacity on renewables, notably with France to expand connection of the Iberian peninsula with the rest of continental Europe.

Energy system transformation

Beyond the electricity sector, the government plans to expand self-consumption of renewables and distributed generation, as well as promote the use of renewables in the industry and heating sectors. It also has plans to support the production of advanced biofuels and renewable gases, as well as hydrogen.

Overall, Spain plans to move toward a full energy system transformation, the foundations of which will be laid in the coming decade. The Long-Term Strategy projects that the electrification of the economy will be over 50% by 2050.

In order to integrate more renewables into other sectors of the economy, the government has a four-pronged strategy: 1) energy efficiency first; 2) renewables-based electrification; 3) storage; and 4) indirect electrification through renewable gases, mainly hydrogen. The promotion of renewable gases is a critical measure outlined in Spain's NECP, with uses planned in mobility, industry, seasonal storage and synthetic fuels.

To this end, the government has several initiatives in place or underway to jumpstart plans and investments in the 2030 time frame, including a Hydrogen Roadmap, a Biogas Roadmap, an Offshore Wind Roadmap, a self-consumption strategy public consultation and a smart meter evolution public consultation.

As Spain looks to a future of increased electrification of end-use sectors and sector coupling – an essential element to achieve an energy transition – the competitiveness of electricity against fossil fuels will be a critical element to achieving the desired results. As such, Spain should consider changes to its taxation system, notably to incorporate the cost of carbon into end-use prices, to reduce barriers to increased uptake of clean electricity in more end uses.

Energy security

From an energy security perspective, although Spain continues to be heavily dependent (73% dependency) on foreign sources for its energy, its sources for oil and gas are relatively well diversified and the government has robust emergency response frameworks in place in the case of a disruption.

Though the new policies and increased electrification will reduce Spain's import dependency, the rapid closure of coal and nuclear facilities over the coming decade bears watching, as it could increase the country's call on natural gas, especially if new renewables capacity cannot be built as quickly as planned.

Interconnectivity with other European countries is also a critical element for Spain to improve security of supply. While electricity projects with Portugal are progressing, existing interconnection with France is often congested and new projects have been delayed, causing Spain to fall short of its EU interconnectivity targets of 10% by 2020 and putting at risk its 15% target by 2030.

Key recommendations

The government of Spain should:

- Ensure that the National Recovery and Resilience Plan supports achieving the NECP's targets.
- Improve co-ordination with regional authorities and municipalities to implement the NECP's measures, especially on energy efficiency, more effectively.
- Reinforce efforts to create more flexibility in the electricity market and to ensure proper price signals for investments in generation, through increased interconnectivity, continued integration of regional markets, and the development of demand-side response and storage.
- Review taxation to avoid excess charges and distortionary impacts on electricity relative to oil and gas consumption to promote electrification. Consider additional carbon-based taxation as well as other mechanisms to progressively redistribute electricity charges among all actors in the energy system.

2. General energy policy

Key data

(2019)

Total energy supply (TES): 121.4 Mtoe (oil 42.4%, gas 25.4%, nuclear 12.5%, bioenergy and waste 6.6%, coal 4.0%, wind 3.9%, solar 2.8%, hydro 1.7%, electricity imports 0.5%), -4.5% since 2009

TES per capita: 2.6 toe/cap (IEA average* 3.7 toe/cap, IEA median 3.5 toe/cap)

TES per unit of GDP:* 68 toe/USD million (IEA average* 85 toe/USD million, IEA median 79 toe/USD million PPP)

Total final consumption (TFC): 85.5 Mtoe (oil 50.8%, electricity 23.8%, natural gas 17.1%, bioenergy and waste 6.9%, solar 0.4%, coal 1.0%), -12.1% since 2008

TFC per capita: 1.8 toe/cap (IEA average* 2.8 toe/cap, IEA median 2.4 toe/cap)

TFC per unit of GDP:** 48 toe/USD million (IEA average* 62 toe/USD million PPP, IEA median 62 toe/USD million PPP)

Energy production: 34.0 Mtoe (nuclear 44.8%, biofuels and waste 24.5%, wind 14.1%, solar 9.9%, hydro 6.2%, natural gas 0.3%, oil 0.1%), +11.9% since 2009

* Weighted average of IEA member countries in 2018.

** GDP data are expressed in 2015 prices and purchasing power parity (PPP).

Country overview

Spain has a population of around 47 million and an area of 505 000 km^2. It covers most of the Iberian peninsula and also includes the Canary Islands, Balearic Islands and the autonomous cities of Ceuta and Melilla in North Africa. Due to its size and geography, the country's climate can vary substantially by region.

Spain's population has been stable since 2008, after increasing in previous years due to immigration. The Spanish economy grew by 4.5% between 2008 and 2018, as the financial crisis in 2008 strongly affected the industry, services and transport sectors. After decreasing by 9% between 2008 and 2013, the economy rebounded by 14% between 2013 and 2018. This successful recovery has been guided by structural reforms, robust employment growth and gains in competitiveness, allowing Spain's economic growth to be consistently higher than that of the euro area between 2014 and 2018 (OECD, 2018). However, unemployment rates remain higher than the OECD average, with youth unemployment close to 40%.

In 2020, Spain was hit hard by the COVID-19 pandemic. OECD projections forecast Spain's economy to contract by 14.4% in 2020, or by 11.1%. The rebound for 2021 is predicted to be between 5% and 7% (OECD, 2020).

The services sector accounted for almost three-quarters of gross domestic product (GDP) in 2018, industry for almost one-quarter and the agricultural sector for the remaining 3%. All shares are close to the OECD average. Tourism is particularly important, and Spain's tourism industry was the second-largest in the world in terms of financial receipts and the fourth-largest in terms of arrivals. The impact of COVID-19 on the tourism sector was very strong, as Spain closed its borders for nearly four months due to the pandemic between February and June 2020.

Since 1978, Spain has been a parliamentary monarchy, and the king has a limited role in day-to-day politics. The government is led by Prime Minister Pedro Sánchez of the Spanish Socialist Workers' Party (PSOE), who took over on 1 June 2018 after seven years under a government led by Mariano Rajoy of the People's Party. Sánchez called an early general election in April 2018, but did not form a government, leading to another election in November 2019. The PSOE and Unidas Podemos formed the first Spanish coalition government since 1978, and Sánchez was renominated as Prime Minister on 13 January 2020.

A fairly decentralised country, Spain is divided into 17 autonomous communities, each with its own parliament, plus 2 autonomous cities (Ceuta and Melilla). In the energy sector, the autonomous regions are responsible for areas such as authorising certain power plants and energy networks. Spain joined the European Union (EU) in 1986 and adopted the euro as its currency in 2002.

Figure 2.1 Map of Spain

Supply and demand

Most of Spain's energy supply and demand is met with fossil fuels, which accounted for 72% of total energy supply (TES)[1] and 68% of total final consumption (TFC)[2] in 2019 (Figure 2.2). Only one-quarter of TES was produced domestically in 2019; the remainder was imported.

Domestic production consists mostly of nuclear energy (45% of total production) as well as bioenergy and waste and other renewables, notably wind and solar. Production of

[1] TES is made up of production + imports – exports – international marine and aviation bunkers ± stock changes. This equals the total supply of energy that is consumed domestically, either in transformation (e.g. power generation and refining) or in final use. Nuclear energy supply in TES includes losses. The primary energy equivalent of nuclear electricity is calculated from the gross electricity generation by assuming a 33% conversion efficiency.

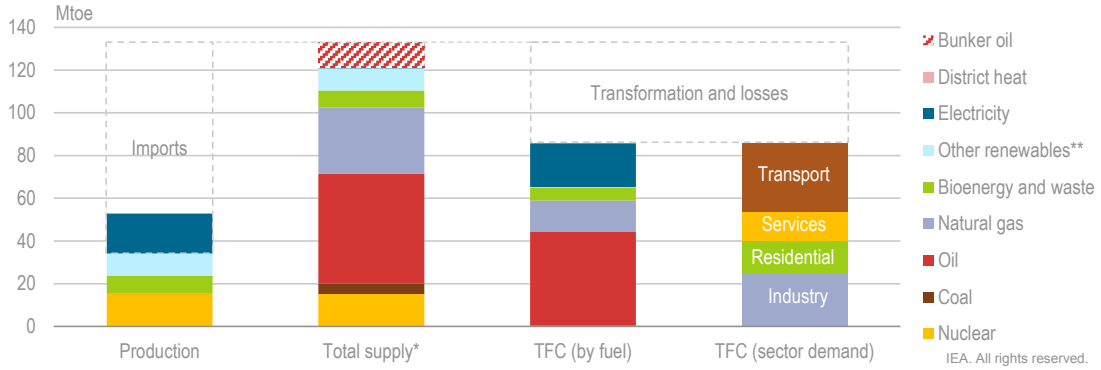
[2] TFC is the final energy consumption (electricity, heat and fuel, such as natural gas and oil products) by end users, not including the transformation sector (e.g. power generation and refining).

renewable energy increased by 47% between 2009 and 2019 to cover more than half of total domestic production in 2019 (55%).

TES is dominated by oil and gas, which accounted for 42% and 25% of TES, respectively, in 2019. TES was 121 million tonnes of oil equivalent (Mtoe) in 2019, with an additional 12 Mtoe of oil products used in international marine bunkers and aviation. However, the share of renewables significantly increased between 2009 and 2019, reaching 15% of TES in 2019 compared with 11% in 2009.

Transport and industry are the highest energy-consuming sectors, accounting for 38% and 29% of TFC, respectively, followed by the residential (17%) and services (16%) sectors. TFC was 86 Mtoe in 2019, with high shares of oil (51%) and gas (17%). Electricity, on the other hand, was largely used in the services (53%) and residential (43%) sectors. Bioenergy and waste were also a significant source of energy for residential consumption in 2019, accounting for 18% of TFC in the sector.

Figure 2.2 Overview of Spain's energy system by fuel and sector, 2019



While producing renewables and nuclear energy, Spain relies on imports of fossil fuels, which accounted for almost three-quarters of total supply and TFC in 2019.

* Total energy supply + international bunker fuels.

***Other renewables* includes wind, hydro, solar and a small amount of geothermal.

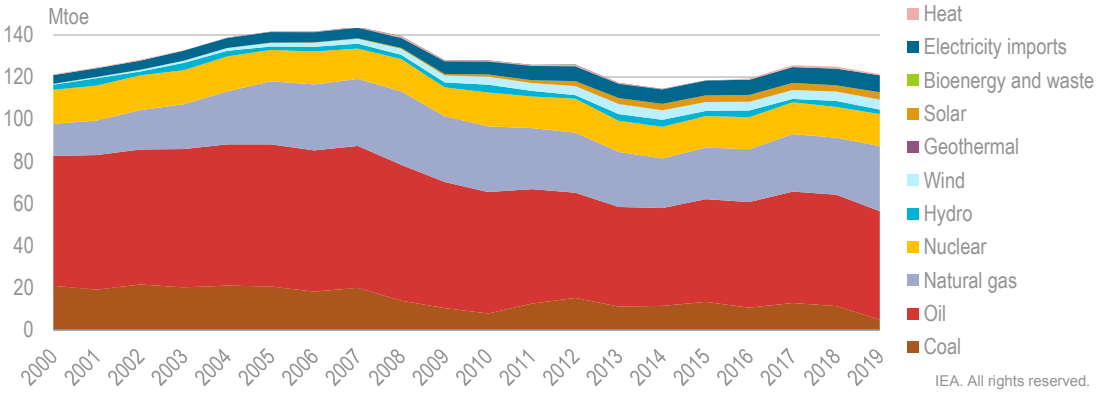
Notes: Mtoe = million tonnes of oil equivalent. TFC = total final consumption.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Total energy supply

TES in Spain peaked in 2007, before dropping in the following years as a consequence of the financial crisis, which led to a decrease in supply to match cuts in the energy-consuming sectors (Figure 2.3). Between 2014 and 2017, however, TES started to increase again, rebounding by 10% in three years, to compensate for half of the 20% drop experienced between 2007 and 2014. In 2019, TES again fell to 121 Mtoe from 126 Mtoe in 2017. Natural gas, oil, and bioenergy and waste were the main sources supporting this increase, while energy from solar and wind remained flat between 2014 and 2018, due to a decline in investor confidence after a major overhaul of the renewables support mechanism. Compared with other International Energy Agency (IEA) member countries, Spain ranks 20th for its share of fossil fuels in TES, which in 2018 accounted for 74% of total supply.

Figure 2.3 Spain's total energy supply by source, 2000-19



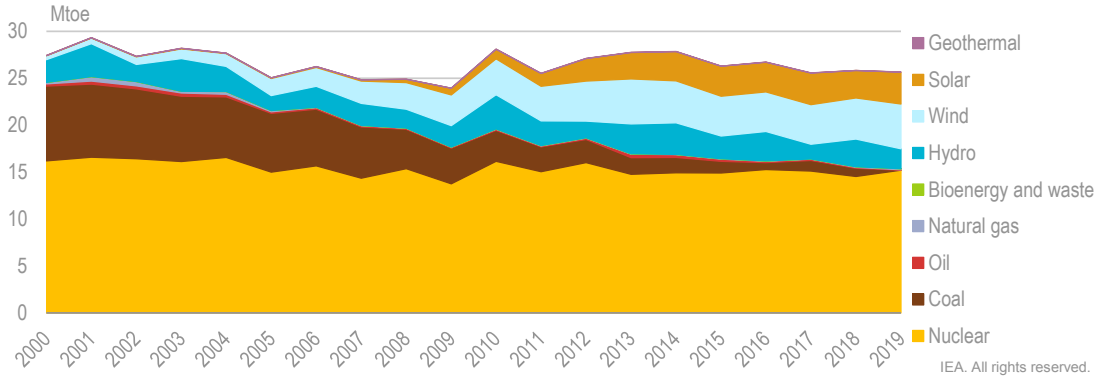
TES in Spain peaked in 2007 and fell afterwards as an effect of the financial crisis. Between 2014 and 2018, total supply started to increase again, though fell again in 2019.

Notes: Mtoe = million tonnes of oil equivalent. The share of geothermal is not visible at this scale.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy production and import dependency

As opposed to TES, domestic energy production increased by 12% in Spain between 2009 and 2019 (Figure 2.4). Nuclear energy consistently provided around 15 Mtoe per year, while energy from coal decreased by almost 80% between 2008 and 2018; production ceased entirely in 2019. In contrast, energy production from bioenergy and waste, wind, and solar experienced a steady upward trend in the same decade (46% growth), leading to an increase in energy production from renewables and waste of 54% of total production in 2019.

Figure 2.4 Spain's energy production by source, 2000-19



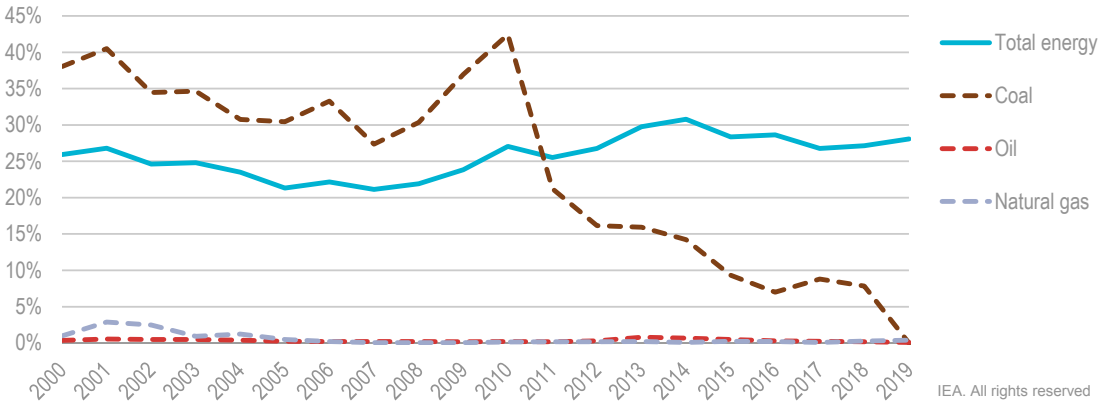
Total domestic energy production did not change significantly between 2010 and 2019, but the share of coal has significantly decreased, balanced by increased renewables.

Note: Mtoe = million tonnes of oil equivalent.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Spain's domestic production covers about one-quarter of TES (Figure 2.5), though the country completely relies on imports for oil and gas. Internal production

of coal covered up to 40% of total energy supply in 2010, but since fell to less than 10% self-sufficiency in 2018 and 0% in 2019.

Figure 2.5 Spain's production/total energy supply by energy source, 2000-19



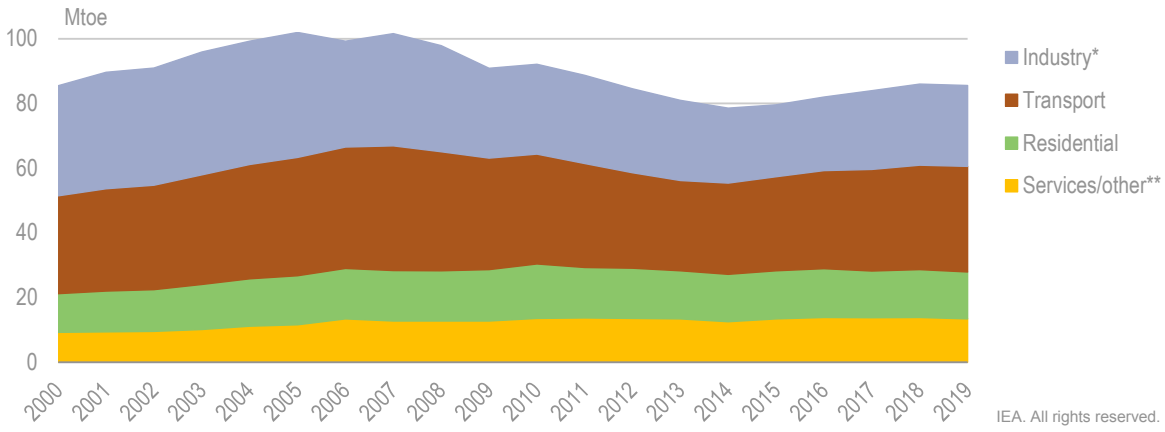
Three-quarters of total supply are imported, with high dependency on imported fossil fuels.

Note: Domestic energy production as a share of total energy supply + international bunker fuels (oil).
Source: IEA (2021), *IEA World Energy Statistics Balances* (database), www.iea.org/statistics.

Energy consumption

After peaking in 2007, TFC decreased in Spain as a consequence of the economic crisis, until 2014, when it started to increase again to reach 86 Mtoe in 2019 (Figure 2.6). Most of these changes were guided by the transport and industry sectors, which saw outsized impacts on consumption from the crisis in 2008.

Figure 2.6 Spain's total final consumption by sector, 2000-19



Total final consumption peaked in 2010, after which it fell until 2014, then increased again until 2019. Most of the energy is used in the transport and industry sectors.

* *Industry* includes non-energy consumption.

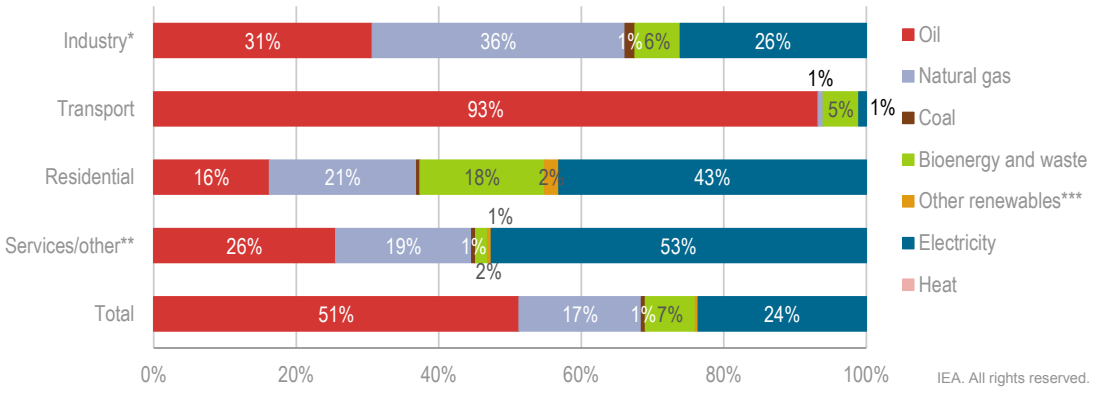
** *Services/other* includes commercial and public services, and agriculture and forestry.

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The transport sector was the largest energy-consuming sector in 2019, with final consumption of 33 Mtoe. More than 90% of transport consumption constituted oil (Figure 2.7), with a small share of biofuels. Industry was the second-largest sector in TFC, consuming 25 Mtoe in 2019. Final consumption in the industry sector is almost equally provided by gas, oil and electricity. The residential and services sectors used 15 Mtoe and 13 Mtoe in 2019, respectively. Electricity is the first energy carrier used in these sectors, followed by oil and gas. Bioenergy has an important role in residential consumption, covering 18% of the sector's demand.

Figure 2.7 Spain's total final consumption by source and sector, 2019



Oil covered half of total final consumption in 2019. The transport and industry sectors are dominated by fossil fuels, but electricity is significant in the residential and services sectors.

* *Industry* includes non-energy consumption.

** *Services/others* includes commercial and public services, and agriculture and forestry.

*** *Other renewables* includes geothermal and solar thermal.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

COVID-19 impacts on energy demand

Spain declared a state of emergency between 14 March 2020 and 20 June 2020 due to the COVID-19 pandemic. During this time, total electricity demand fell by 12.7% relative to the same period in 2019, hitting an 18% decline during the period of total confinement between 30 March and 12 April, led by the industry and services sector. Natural gas demand during the emergency period fell by 15.5% while petroleum products demand fell more significantly, by 60% for gasoline, 43% for diesel and 88% for aviation fuels.

Institutions

In the energy sector, the Ministry for the Ecological Transition and the Demographic Challenge – currently led by Teresa Ribera Rodríguez – holds the basic competencies on energy, which are focused at the national level, and leads on energy policy formulation. The main responsibilities of the ministry include:

- regulations concerning energy and mining matters, which are shared with other ministries for evaluation

- legislation overseeing the tariff structure, prices of energy products, and levies and tolls (though the regulator sets the rates)
- legislation to save energy, promote renewable energy, and support new energy and mining technologies
- legislation of measures to ensure energy supply
- legislation and actions related to the demographic challenge.

The Secretary of State for Energy falls under this ministry, while the Directorate General for Energy Policy and Mining falls under the Secretary of State for Energy. Also under the Secretary of State for Energy are several institutions that hold competencies in various areas of energy policy, including:

- The Just Transition Institute, which oversees the economic transition of regions where coal mines and coal power plants are closing.
- The Institute for Energy Diversification and Savings (IDAE), which oversees research programmes on electrification, mobility, energy efficiency and renewable energy, among others. Its activities include increasing public knowledge and awareness, technical advice, and project financing of technology innovations.
- The Corporation of Strategic Reserves of Oil Products (CORES), which is the stockholding agency in charge of maintaining stocks of oil products and monitoring industry obligations to hold stocks of oil products, liquefied petroleum gas and natural gas. CORES also verifies operators' obligations to diversify their natural gas supplies.
- The City of Energy Foundation, which is focused on the execution of research and innovation programmes related to energy and the environment and contributing to economic development.
- The National Radioactive Waste Company (Enresa), which is focused on the management of radioactive waste.

The Secretary of State for Environment also falls under the Ministry for the Ecological Transition and the Demographic Challenge. Within the Secretary of State for Environment are the Spanish Office for Climate Change, which provides advice to different bodies of government on climate change, as well as the National Climate Council, which co-ordinates the development and monitoring of climate change policies and measures of the central government. The National Climate Council promotes information gathering, analysis, preparation and implementation actions.

The National Commission of Markets and Competition (CNMC) is an independent regulatory body that reports directly to the Spanish parliament. Its authorities on energy include supervising and controlling the proper operation of energy markets and calculating network access tariffs according to transmission and distribution costs. The CNMC also supervises access to cross-border interconnections. At the EU level, the CNMC co-operates with other regulators through the Council of European Energy Regulators and the Agency for the Co-operation of Energy Regulators on developing network codes and implementing the internal electricity market.

The Nuclear Safety Council (CSN) has authority over matters of nuclear safety and radiation protection. It is directly accountable to the Spanish parliament and formally independent from the administration.

The National Statistics Institute publishes statistical information on various fields such as the economy, society and the environment, among others, in order to facilitate decision making.

Other relevant ministries and bodies in the energy sector that co-ordinate policies with the Ministry for the Ecological Transition and the Demographic Challenge are:

- The Ministry of Agriculture, Fishing and Food is responsible for several energy-related policies, such as air pollution and climate change.
- The Ministry of Economic Affairs and Digital Transformation is in charge of the proposal and execution of the government's policies on economic issues and reforms to improve competitiveness, industrial development, telecommunications and the information society, development of the Digital Agenda, and other competencies and powers conferred by the legal system.
- The Ministry of Science and Innovation is responsible for the execution of the government's policy regarding scientific and technical research, technological development and innovation in all sectors, including the management of international relations in this area and Spanish representation in programmes, forums and international organisations, including the European Union.
- The Ministry of Industry, Trade and Tourism develops and implements government policy in the areas of industry, trade and tourism.
- The Ministry of Transport, Mobility and Urban Agenda oversees land, aviation and maritime infrastructure; the control, management and administrative regulation of transport services; as well as access to housing, building, urban planning, land and architecture.

The autonomous communities have legal competencies related to energy, primarily in authorising power plants of less than 50 megawatts (MW), and distribution networks of electricity and natural gas. They are also heavily involved in designing and implementing climate change, energy efficiency and renewable energy policies at the regional level.

General energy policy overview

Spain has built a stable, long-term strategy to transform the Spanish economy to a more sustainable one, providing investment signals to guide its industrial composition toward one where future competitive advantages are focused on greater innovation, better efficiency and zero environmental footprint.

One of the major changes in Spain's energy system since the last in-depth review has been addressing the so-called tariff deficit, or a major imbalance between regulated costs and revenues of the electricity and gas systems. In recent years, Spain has made considerable headway in managing the tariff deficit in its electricity system, in part caused by significant subsidies for renewables, which peaked at EUR 6.3 billion in 2008. Since reforms enacted in 2013, system costs have been balanced with revenues, and a small surplus was even recorded in 2014-18. A small deficit is expected for 2019, though surpluses from previous years will cover it. The gas sector tariff deficit has similarly been erased.

The current Spanish framework for energy and climate is based on the 2050 objectives of national climate neutrality, 100% renewable energy in the electricity mix and 97% renewable energy in the total energy mix. As such, it is centred on the massive

development of renewable energy, particularly solar and wind; energy efficiency; electrification; and renewable hydrogen. This is seen as an opportunity to stimulate the economy; create jobs; modernise industry; enhance competitiveness; support vulnerable groups; improve energy security; and support research, development and innovation.

As a member of the EU, Spain is bound by European targets for energy and climate change as part of the Energy Union, which for 2020 include: a 20% reduction in greenhouse gas (GHG) emissions, 20% of energy from renewable sources, a 20% improvement in energy efficiency and a 10% electricity interconnection target. For 2030, the level of ambition will grow to: a minimum 40% reduction in GHG emissions, a minimum 32% share of renewable energy, a minimum 32.5% improvement in energy efficiency and a 15% interconnection target. The EU is currently finalising plans to further strengthen the 2030 targets; notably the GHG emissions reduction target is planned to increase from 40% to 55%.

To achieve these targets, the central strategy document guiding Spain's energy and climate policies over the coming decade is its National Energy and Climate Plan (NECP) for the period 2021-30, which Spain submitted to the European Commission in early 2020. The document outlines a number of policy actions in various sectors that will support the country's climate targets, including in the areas of energy efficiency, renewables and transport. Its 2030 objectives include: a 23% reduction in GHG emissions from 1990 levels; a 42% share of renewables in energy end use; a 39.5% improvement in energy efficiency; and a 74% share of renewables in electricity generation. Policies include increasing renewable power installations and boosting the use of renewable gases in the power sector, modal shifts and electrification in the transport sector, refurbishments and increasing the use of renewable heating in the residential and commercial sectors, promoting energy efficiency and fuel switching in the industry sector, and energy efficiency improvements in the agricultural sector.

The government anticipates that investments of EUR 241 billion will be needed to enact the measures outlined in the NECP, out of which 80% is estimated to come from the private sector. It expects that as a result of the NECP's measures, Spain will create up to 350 000 jobs annually, increase its GDP as much as EUR 25.7 billion, and avoid 2 400 premature deaths.

Domestically, the Spanish government issued the Climate Emergency Declaration in January 2020, which outlined 30 action areas to reach the climate neutrality goal by 2050, with its three pillars being: 1) the Climate Change and Energy Transition Law; 2) the Just Transition Strategy; and 3) the Long-Term Strategy. A supplemental National Energy Poverty Strategy was also issued.

The Climate Change and Energy Transition Bill, approved by the government in May 2020 to be discussed in parliament, places the fight against climate change and the need for an energy transition at the centre of the economy and society. Enshrining the principle of carbon neutrality by 2050, it is the framework that will facilitate the co-ordination of policies among different fields with coherence (see the section on climate change for more details). Its main targets are similar to those of the NECP and include achieving at least 70% of renewables in electricity by 2030 and 100% by 2050, at least 35% renewables in final energy consumption by 2030, and to reduce primary energy consumption by at least 35%. In this regard, it places renewable energy and energy efficiency at the centre of the energy transition.

The Just Transition Strategy includes measures to promote employment opportunities in the energy transition, supported by a framework of vocational training, active labour policies, support measures to the most vulnerable and economic stimulus plans for those regions the most affected by the energy transition.

In line with Paris Agreement commitments and the European Green Deal, Spain's Long-Term Strategy (LTS) anticipates and plans the transition towards climate neutrality in the 2050 horizon, with a reduction of at least 90% in total GHG emissions by 2050 compared to 1990. The document includes interim milestones for 2030 and 2040, seizing the benefits derived from the energy transition and bolstering the transformation and competitiveness of the economy. The LTS defines the path that will enable an almost completely renewables-based energy system (including in the transport, buildings and economic sectors). Following an initial public consultation in April 2019 and a draft presentation in July 2020, the LTS went through a second public consultation from July to September 2020, and was adopted by the Council of Ministers in November 2020. It will be reviewed every five years.

The National Energy Poverty Strategy 2019-2024 was approved in 2019 as the instrument to approach and analyse the energy poverty concept from a comprehensive perspective for the medium and long term. This strategy includes a definition of energy poverty and uses four indicators to measure the degree of energy poverty and its evolution: 1) percentage of households in which energy expenditure (as a share of household income) is more than double the national average; 2) percentage of households in which absolute energy expenditure is less than half the national average; 3) inability to maintain dwellings at adequate temperatures; and 4) delays in energy bill payments.

Post-COVID-19 recovery

Given that Spain was hit hard by the COVID-19 pandemic and associated lockdowns, the government has already approved energy-related measures to help stimulate the economy. In particular, Royal Decree-Law 23/2020 from June 2020 includes measures to advance energy storage, promote aggregation services in the electricity market, encourage the formation of renewable energy communities, facilitate regulatory sandboxes, stimulate demand management and sector coupling, as well as expand electric vehicle charging infrastructure.

In the current post-COVID-19 context, the NECPs are expected to serve as the guiding tool to direct the EU recovery plan's actions, by frontloading the investments outlined in the plan in the upcoming three years. In July 2020, EU leaders agreed to EUR 750 billion in funding for recovery efforts. In order to receive support from the Recovery and Resilience Facility, member states must prepare national recovery and resilience plans, setting out their reform and investment agendas over the period 2021-26; funds must be invested in the green and digital transformation.

Spain is currently working on its green recovery plan, as it will be one of the key beneficiaries of EU recovery funds. Spain's prime minister presented his government's plans for spending the EU recovery funds in early October. The Spanish government expects to receive up to EUR 140 billion worth of grants and loans from the recovery funds, out of which it plans to spend EUR 72 billion in the first three years (2021-23); of this amount, over 37% is targeted for green investments. This will be supplemented by EUR 27 billion from Spain's national 2021 budget.

The main areas defined in the initial draft of Spain's Recovery and Resilience Plan for the energy transition are efficiency, sustainable mobility, renewable energies, electricity infrastructure, storage and flexibility, green hydrogen, and the just transition.

Energy efficiency

Spain's overall energy strategy employs an "efficiency first" principle. Its energy efficiency objectives are aligned with EU Energy Efficiency Directives, which establish a common framework of measures to promote energy efficiency within the European Union, with EU-wide targets of a 20% improvement in 2020 and 32.5% in 2030 (relative to 2005 levels). Spain assumes these objectives and establishes, in the NECP, a national guideline for energy efficiency of 24.2% (excluding non-energy uses) by 2020, and by 2030, a national indicative energy efficiency target of 39.5%. The reduction in primary energy consumption proposed in the NECP is equivalent to 1.9% every year since 2017, which when linked to an expected increase in GDP in the same period of around 1.7% will result in an improvement in the primary energy intensity of the economy of 3.5% per year until 2030, which would be well above the IEA average over the last decade.

The National Energy Efficiency Fund was created in 2014 and is the main instrument to implement measures for financial and economic support, technical assistance, training and information, and other measures to increase energy efficiency across all sectors. It is mainly financed by contributions from wholesale petroleum operators as well as natural gas and electricity trading companies.

The NECP proposes 17 measures to meet the targets, 10 of which were designed along a sectoral approach. Allocation of targets and funding for energy efficiency is granted proportionally to the energy consumption of each sector, with transport receiving the largest share. As such, the transport sector stands out in the NECP, with four measures, followed by the industrial and residential sectors. The tertiary and agriculture and fishing sectors represent the lowest contributions.

Given that the transport sector is the largest energy-consuming sector in Spain, accounting for 38% of final consumption in 2019, the government has placed a particular focus on reducing fuel consumption in the sector through a range of policies, including: promoting modal shifts from road to rail and to bicycles, walking, public transit and shared vehicles; increasing the use of advanced biofuels; renewing the vehicle fleet; and putting 5 million electric vehicles on the road by 2030 (supported by a buildout of electric charging infrastructure). The NECP establishes a target to source 28% of transport fuels from renewables, which will mainly consist of biofuels and renewable electricity, well above the 14% required by the EU for 2030.

Electricity transition

Renewables

Spain's renewable energy policy is aligned with EU 2020 targets, which set a binding national target for renewable energy equal to 20% of gross final consumption of energy (including 10% in transport). Spain's targets on renewable energy for 2020 and the policies and measures to meet them were initially laid out in the National Renewable Energy Action Plan 2011-2020, which set a national 2020 target of 20.8% of renewable energy in gross final energy consumption. Spain expects to reach a 20% share of renewables in gross final energy consumption in 2020, up from 18.4% in 2019.

Spain is now focused on its 2030 targets. Overall, Spain's NECP expects to achieve a 42% share of renewables in total end use of energy by 2030. This level will be led by the power sector, where the plan projects the installation of nearly 60 gigawatts (GW) of new renewable generation through 2030, led by wind and solar, amounting to 74% of total electricity generation that year. This will put Spain on a pathway toward achieving its 2050 objective to source 100% of its power from renewable sources, in line with its 2050 carbon-neutrality goal.

To achieve its ambitious targets for renewables in electricity, Spain envisions a three-pronged strategy: 1) the promotion of large generation projects; 2) the deployment of own consumption and distributed consumption; and 3) measures to integrate renewables into the electricity system and market. The NECP 2021-2030 considers auctions to be the main tool for the development of these technologies, in accordance with EU Directive 2018/2001 on the promotion of the use of energy from renewable sources.

In addition, the NECP includes planned measures to adapt electrical networks for the integration of renewables by revising transmission and distribution network planning through the creation of new transmission nodes and the strengthening of existing ones, as well as the development of new international interconnections and underwater lines.

Grid codes are also expected to be updated to keep up with changing technological developments and digitalisation, as is the definition of network connection capacity. The government is also in the process of developing a national strategy for storage and in 2020 already issued new regulations to support the integration of storage technologies into electricity systems. Similarly, regulations are also pending to increase the role that demand-side management will play, including through the promotion of aggregation services.

Coal phase-out

As part of its climate change and energy transition agenda, Spain has a plan to phase out the use of coal in its energy sector. However, unlike in some countries that have imposed specific mandates for the industry to shut down coal-fired generation capacity, Spain expects that market conditions will drive coal closures.

The NECP expects that up to 9 of Spain's existing 15 coal-fired power plants (as of 2019) will no longer be operational by 2021. Already, based on market conditions, on 30 June 2020, eight plants with around 4.6 GW of capacity shut down and four more are expected to follow by 2022. By 2030, Spain expects that coal-fired power plants will no longer be competitive and coal will be fully phased out of the power sector. Accordingly, the government plans to offer support measures to affected regions to help them adjust to the transition.

Nuclear phase-out

Spain's NECP also foresees an orderly and staggered closure of the country's nuclear power plants within the 2027-35 time frame. Nuclear plants are already facing financial difficulties, in part due to high levels of taxation. The planned retirements of Spain's existing fleet of seven reactors (7.4 GW of installed capacity) will begin in 2027, and by 2030, around 4 GW of installed nuclear capacity is planned for orderly shutdown. Following the coal and nuclear closures, natural gas-fired generation will become the predominant source of dispatchable power in Spain's electricity system to balance out the growth in variable renewables generation.

Energy system transformation

Beyond the electricity sector, the government plans to expand self-consumption of renewables and distributed generation, as well as promote the use of renewables in the industry and heating sectors. It also has plans to support the production of advanced biofuels and renewable gases, as well as hydrogen.

Overall, Spain plans to move toward a full energy system transformation, the foundations of which will be laid in the coming decade. The LTS projects that the electrification of the economy will be over 50% by 2050, with 250 GW of new renewable energy capacity.

The power sector is planned to evolve from one characterised by centralised generation based on base load and peak demand needs with mostly passive demand to a new model marked by variable, decentralised, intelligent and interconnected generation. The new system is expected to be supported by large-scale storage and demand-side management to ensure system flexibility, while new technology, such as electric vehicle charging infrastructure, will be smartly integrated to enable improved demand and network management.

In order to integrate more renewables into other sectors of the economy, the government has a four-pronged strategy: 1) energy efficiency first; 2) renewables-based electrification; 3) storage; and 4) indirect electrification through renewable gases, mainly hydrogen. The promotion of renewable gases is a critical measure outlined in Spain's NECP, with uses planned in mobility, industry, seasonal storage and synthetic fuels. In order to plan its strategy for renewable gas, the government is in the process of estimating the domestic production potential and demand, and believes that its generous renewable resource endowment will offer a competitive edge in this space.

To this end, the government has several initiatives underway to jumpstart plans and investments in the 2030 time frame, including a Hydrogen Roadmap, a Biogas Roadmap, an Offshore Wind Roadmap, a self-consumption strategy public consultation and a smart meter evolution public consultation.

To align with its strategy to promote electrification, in December 2020 the government issued the draft Law on establishing the National Fund for the Sustainability of the Electric System. The policy would reallocate the levies associated with subsidies for renewables, co-generation and waste – currently borne entirely by electricity consumers – to energy companies across the energy system (oil, gas and electricity companies based on annual sales volumes).

Energy security

Spain is almost entirely reliant on imports for oil and gas, though its sources and routes for imports are diversified. For crude oil, Spain's imports reflected a variety of countries and regions in 2019, including Nigeria, Mexico, Saudi Arabia, Libya, the Islmaic Republic of Iran and Iraq, while oil products came from Morocco, Italy, Gibraltar, France and Algeria, among others. Moreover, Spain enjoys a unique oil infrastructure system with wide geographic and interconnecting coverage, including an extensive network of pipelines and storage capacity connected to refineries.

Similarly, Spain's imports of natural gas in 2019 were sourced from a range of countries, including Algeria, Qatar, Nigeria, the United States and the Russian Federation, both in the form of pipeline gas and liquefied natural gas (LNG). In fact, diversification of natural gas supply sources is a requirement for gas suppliers under Spanish law to avoid overdependence on a given country.

As the Spanish policy agenda shifts its focus toward a future energy system that is based around renewable energy, new benefits and challenges will emerge with respect to energy security. Mainly driven by energy efficiency measures and a reduction in oil consumption, the government expects that its import dependency will fall from 73% in 2017 to 61% in 2030. The change is projected to result in savings on fossil fuel imports of EUR 13.3 billion in the year 2030.

At the same time, the overhaul of the power sector – away from coal and nuclear generation towards variable renewable sources – will increase the role that dispatchable gas-fired generation will play in the electricity system. As gas plant operators face possible financial challenges due to low load factors, ensuring sufficient gas backup capacity in the system is becoming a more pressing matter, and one the Spanish government is currently studying, including through the possibility of introducing a capacity mechanism. Moreover, the energy security role that coal plants previously provided – notably through a requirement to store fuel on site – will need to be provided through other means, including by introducing more flexible resources into the system.

In addition, interconnections with neighbouring countries are also being expanded to help integrate the sizeable expected capacity of variable renewables generation. New interconnection capacity is under construction or planned with both France and Portugal, though Spain will still fall short of its EU interconnection target of 10% by 2020 and 15% by 2030. In particular, existing interconnection with France is often congested and new projects have been stalled or delayed.

Lastly, an economic shift toward electrification across sectors and an associated rollout of digital infrastructure will require an increased focus on cyberthreats. Already, the Spanish government completed a rollout of smart meters to end users by the end of 2018; Spain's main energy strategy documents point toward sizeable new investments in digitalisation across the energy space, with particular prominence in the electricity sector.

Pricing and taxation

Spain's energy taxation system is centred on a value-added tax, with a rate of 21% for the consumption of energy products, as well as additional special taxes that include: a tax on hydrocarbons, a special tax on coal and a special tax on electricity. The special tax on electricity is transferred to the regions and can be applied to fund renewable energy support programmes. The government also offers lower registration taxes for the purchase of electric vehicles, tax benefits for the use of electricity in the shipping sector, property and construction tax rebates for buildings with solar facilities, an exemption to the hydrocarbon tax for fuel used in power plants or co-generation facilities, and an exemption to the special tax on electricity for renewable energy producers with 50 MW or less of installed capacity.

Autonomous communities, within the scope of their regulatory powers, also apply taxes that impact energy policy, such as a tax deduction in the Murcia region for the installation of renewable energy resources in homes or a tax deduction in the La Rioja region for the purchase of a new electric vehicle. Overall, electricity taxes in Spain remain relatively high, notably compared to taxation levels for oil and natural gas.

Spain has no carbon-based taxation, only the Emissions Trading System (ETS)-related costs for industry and power plants. There is no carbon tax applied in non-ETS sectors. However, in February 2019, the Spanish government published the “Change Agenda” to align its strategies with the United Nation’s 2030 Agenda for Sustainable Development. The document notes the need for a “new green taxation” that is aligned with environmental impacts. Moreover, the NECP includes an action line to analyse and develop the best taxation system for a low-carbon and resilient economy.

Spain recognises its relatively low levels of environmental taxation within the EU. Different assessments and studies to introduce environmental taxation in different sectors have been carried out in recent years, with an eye to citizen acceptance. Such taxation would effectively support the implementation of the NECP’s measures by internalising environmental costs and accelerating the transformation to a low-carbon economy.

Nonetheless, advancing environmental taxation is also challenging due to the need to reach a consensus among the different autonomous communities with competencies for certain taxes. Furthermore, it implies challenges in the implementation and management of the mechanisms for tax collection.

Assessment

Since the last in-depth review in 2015, Spain has solved the tariff deficits for electricity and was able to close its coal mines, which allowed it to prioritise the issue of climate change on its national agenda and align its goals with EU objectives and ambitions. In doing so, Spain has placed the energy transition at the forefront of its energy and climate change policies.

Spain brought its energy policy in line with the EU’s strategy for a carbon-neutral economy by 2050. To achieve 2050 carbon neutrality, the Spanish framework for energy and climate change is centred on the massive development of renewable energy (particularly solar and wind), energy efficiency, electrification and renewable hydrogen. According to the government, this provides an opportunity to stimulate the economy, create jobs, modernise industry, enhance competitiveness, support vulnerable groups, improve energy security, and support research and innovation.

The NECP is the backbone of Spain’s climate and energy policy. It outlines a number of policy actions that will support the country’s 2030 climate targets, including in the areas of energy efficiency, renewables and transport. Its targets include: a 23% reduction in GHG emissions from 1990 levles; a 42% share of renewables in energy end use; a 39.5% improvement in energy efficiency (compared to 2005 levels); and a 74% share of renewables in electricity generation. Spain’s ambitious targets and detailed policy plans are highly commendable and will place it well on track toward an energy transition in the coming decades. Notably, the NECP outlines a number of measures at the sectoral level for the power, transport, residential and commercial, industry, and agricultural sectors that

will serve as the building blocks of the pathway to its 2030 targets. At the same time, the government should be mindful of the high costs associated with the plan and ensure thorough assessments of action items, to take advantage of the most cost-effective solutions.

On the domestic front, along with the NECP, the Spanish government issued the Climate Emergency Declaration in January 2020, which outlined 30 action areas to reach the climate neutrality goal by 2050. Its three pillars are: the Climate Change and Energy Transition Law, the Just Transition Strategy, and the Long-Term Strategy. A supplemental National Energy Poverty Strategy was also issued.

The draft Law on Climate Change and Energy Transition, approved by the government in May 2020 and currently under debate in parliament, places the fight against climate change and the need for an energy transition at the centre of the economy and society, and provides a framework for policies to achieve carbon neutrality by 2050. Its targets are closely aligned with those in the NECP. The draft law calls for: at least a 20% reduction in GHG emissions by 2030 (from 1990 levels); 70% of electricity sourced from renewables; a 35% reduction in primary energy consumption (compared to 2005 levels); and a 35% share of renewables in energy end use. Though the targets serve as a minimum baseline and are not incompatible with the headline targets in the NECP, harmonisation of the targets could further improve clarity around objectives and guide investment plans.

The Just Transition Strategy includes measures to promote employment opportunities in the energy transition, supported by a framework of vocational training, active labour policies, support measures to the most vulnerable, and economic stimulus plans for those territories most affected by the energy transition. As Spain is already on track to phase out coal from its electricity mix, the strategy will be particularly important for assisting coal communities to cope with the energy transition.

Finally, the LTS anticipates and plans the transition towards climate neutrality in the 2050 horizon, with a reduction of at least 90% in total GHG emissions by 2050 compared to 1990 levels. The LTS defines the path that will enable an almost completely renewables-based energy system (including in the transport, buildings and industry sectors). Following a public consultation that was completed in September 2020, the Council of Ministers adopted the LTS on 3 November 2020.

Once all of the plans and strategies mentioned above are implemented, a completely different energy sector will emerge, where fossil fuels no longer dominate and end-user sectors are mostly electrified. Such a new energy landscape will come with new challenges and will provide new opportunities. The challenges concern energy security. The current system is backed up by massive stocks of oil, gas and coal that can be dispatched in a flexible way; the new system, with a large share of variable renewable generation, will require other forms of longer term backup, on top of short-term flexibility stemming from batteries, pumped hydro and demand response, among others. New vulnerabilities will also arise, as electrification goes hand-in-hand with smartening of the system and digitalisation. Special attention should be given to analysing the potential new hazards and incidents that can affect security of supply.

The opportunities are with energy system integration. The new energy system can be much more efficient than the current one, as end-use sectors can be coupled with higher electrification, the use of residual heat, waste to energy, but also use electricity to produce renewable gases like hydrogen, among others. Spain, like other countries, has only begun

to explore these opportunities, which can be stimulated by targeted RD&D policies. It is also important to adapt the regulatory framework, where needed, to gradually shape such a new integrated energy system.

Spain is progressing towards its 2030 targets, notably in the electricity sector. After a slump in investments between 2013 and 2018 due to a lack of financial means to promote renewables, investments took off again in 2019. The share of renewables (including non-renewable waste) in the national electricity mix increased from 24% in 2009 to 38% in 2019. As such, Spain is on track to meet its 2020 target to source 42% of its electricity from renewables.

Though Spain's progress on ramping up renewables in its electricity mix is commendable, the future trajectory of its power mix warrants careful consideration to ensure a smooth transition. To start, Spain plans to phase out both coal and nuclear power generation. The coal phase-out appears well on track, with coal only providing around 5% of electricity generation in 2019 and even less in 2020. Nuclear power, which accounted for 22% of power generation in 2019 (and is an important source of low-carbon generation), will begin shutting down in 2027. Four of Spain's seven nuclear reactors are scheduled to close by the end of 2030, representing around 4 GW of capacity. Natural gas plants provided 31% of power generation in 2019, and will be crucial to balancing out a power system that is heavily dependent of variable renewables once coal and nuclear have left the market. As such, the government will need to pay special attention to prevent natural gas generation capacity from simultaneously exiting the system. In this regard, the government should thoroughly assess the cost implications for consumers of the expedited phase-out of both coal and nuclear generation.

Spain's targets also preview a sizeable buildout of new renewables capacity to reach 74% of electricity generation by 2030, notably wind and solar. As such, a stable, long-term remuneration framework for supporting the growth of renewables, including for storage, will be essential. Spain's updated auction mechanisms are a step in the right direction, and investor sentiment and availability of financing appears on track. Additional help could come in the form of expedited permitting and timely issuance of auction schedules and terms to improve investment clarity.

Moreover, the trajectory will require a concerted focus on system integration of variable renewables in the coming years, a topic for which the Spanish government has already developed a strategy. The government's strategy is centred on interconnections, storage, demand-side management and digitalisation. Public consultations and regulatory proceedings are underway in all of these areas, though a timely issuance of a regulatory framework will be crucial for mobilising investments, including in next-generation technologies such as biogas and hydrogen. Co-operation with neighbouring governments on interconnection capacity will also be a key element of utilising Spain's full production capacity on renewables, notably with France to expand connection of the Iberian peninsula with the rest of continental Europe.

The issue of digital security is becoming an increasingly pressing problem for modern energy systems, and cyberthreats are even more likely in a period of increased use of remote connections. Energy automation systems and controlling software may become the target of cyberattacks, especially in a period of accelerated energy transition when the share of individual energy sectors and their role in the system evolves over a short period of time. All possible risk-reducing measures like threat intelligence, vulnerability analyses,

adequate planning and awareness training along the supply chain will likely be cost-effective and fairly easy to implement.

Notwithstanding its considerable progress to date on decarbonising and increasing the share of renewables in the electricity sector, Spain's total energy mix is still heavily dominated by fossil fuels. Oil and gas provide 42% and 25% of total energy supply, respectively. Notably, the transport, industry and buildings sector all have considerably more work ahead to meet the country's targets for renewables penetration and decarbonisation.

The transport sector, in particular, is the single biggest emitter of CO_2 emissions, accounting for nearly 41% of total CO_2 emissions in 2019. This makes it a priority sector for the government, which aims to have 5 million electric vehicles on the roads by 2030 in addition to increasing the use of advanced biofuels. Given the relatively low penetration of electric vehicles on Spanish roads (less than 100 000 currently) and the task of building sufficient charging infrastructure, the target is ambitious, as is the overall target to source 28% of transport fuels from renewables (including renewable electricity) by 2030, from 5.4% in 2019. Plans for decarbonising the transport sector also include modal shifts, which will also require sizeable outlays on new infrastructure and a shift in public behavioural preferences.

In all sectors, Spain's energy transition objectives hinge heavily on reducing consumption. Already, Spain has begun to decouple economic growth from energy consumption; the ratio of total consumption to GDP decreased by 15% between 2009 and 2019. Still, more reductions will be needed across all sectors.

The draft Law on Climate Change and the Energy Transition as well as the NECP outline a number of measures to improve efficiency and reduce consumption in all economic sectors, including transport, buildings and industry. The policy plans are extensive and can achieve good results, but will need to be accompanied by a predictable, long-term regulatory framework; sufficient incentives to mobilise private investments; and adequate public financing to underpin all of the programmes over the coming decade. Moreover, Spain should pay due consideration to alternative measures in the event that some assumptions, such as the EU Emissions Trading System price-driving sufficient decarbonisation efforts by industry, do not pan out.

Under Spain's plans, allocation of targets and funding for energy efficiency is granted proportionally to the energy consumption of each sector, with the largest share going to transport. A prioritisation of measures within sectors based on cost-effectiveness would help Spain achieve its targets more effectively. In addition, implementation of a number of efficiency measures for transport, buildings and industry will fall on municipal governments, making co-ordination between the central government and municipal administrations as well as skills capacity at both levels of government essential to success. Additional effort and funding for capacity building at all levels of government toward this end would be helpful.

Spain was hit hard by the COVID-19 pandemic in 2020. It declared a state of emergency between 14 March and 20 June 2020, during which energy demand dropped considerably. Petroleum products demand fell most significantly, by 60% compared to the same period in 2019, while total electricity demand fell by 12.7% and natural gas demand fell by 15.5%.

Although demand has recovered since the easing of the lockdown measures, the country is now facing the economic aftermath of the pandemic. Spain is currently working on a recovery plan, as it will be one of the key beneficiaries of EU recovery funds through the Recovery and Resilience Facility, which are meant to be invested in the green and digital transformation. To this end, Spain's National Recovery and Resilience Plan represents an important opportunity to accelerate measures included in its NECP and draft Law on Climate Change and Energy Transition. In particular, it will enable a greater outlay of public investment to jumpstart the NECP and guide timely private investment in these areas. As such, the government should promptly finalise specific guidelines on priority areas for spending within its energy and climate plans.

Spain has a fairly decentralised governance system, which is divided into 17 autonomous communities, each with its own parliament. This gives great importance to how the central government interacts with these regions and their representatives, who have competence to implement key national energy and climate policies. In the energy sector, the autonomous communities are responsible for areas such as authorising power plants and energy networks. The decentralised governance system has benefits, as regions and municipalities can work more directly with end users to promote changes in energy consumption and transport. However, problems can also arise from the difference in approaches and standards between regions and can result in uneven implementation of measures across regions. Improved training for municipal and regional authorities and standardisation of tendering processes would help improve outcomes.

Prices and taxes are also critical elements to drive change in consumer behaviour. Electricity bills, including taxes, in Spain remain relatively high, notably compared to taxation levels for oil and natural gas. As Spain looks to a future of increased electrification of end-use sectors and sector coupling – an essential element to achieve an energy transition – the competitiveness of electricity against fossil fuels will be a critical element to achieving the desired results. As such, Spain should consider changes to its taxation system, notably to incorporate the cost of carbon into end-use prices, to reduce barriers to increased uptake of clean electricity in more end uses. The recently announced National Fund for the Sustainability of the Electric System is a significant step in the right direction to redistribute electricity costs across the energy system to promote increased electrification.

In October 2020, Spain issued its Hydrogen Roadmap for the development of renewable hydrogen, in line with the European Hydrogen Strategy. The government should also issue its planned road map in the area of biogas to ensure long-term clarity for investments that further support sector coupling.

From an energy security perspective, although Spain continues to be heavily dependent (73% dependency) on foreign sources for its energy, its sources for oil and gas are relatively well diversified and the government has robust emergency response frameworks in place in the case of a disruption. Notably, these frameworks are well integrated with those in the IEA and the EU. The LTS projects that new policies and increased electrification will reduce Spain's import dependency to 10%. However, the rapid shutdown of coal and nuclear facilities over the coming decade bears watching, as it could increase the country's call on natural gas, especially if new renewables capacity cannot be built as quickly as planned.

Interconnectivity with other European countries is also a critical element for Spain to improve security of supply. While electricity projects with Portugal are progressing, existing interconnection with France is often congested and new projects have been delayed, causing Spain to fall short of its EU interconnectivity targets of 10% by 2020 and putting at risk its 15% target by 2030. Spain should consider expanding the scope of its cross-border network planning today with an eye on the 2030 target. Importantly, increased interconnections would also enable Spain to export surplus renewable electricity and gas from its underutilised LNG import capacity.

Recommendations

The government of Spain should:

- Review taxation to avoid excess charges and distortionary impacts on electricity relative to oil and gas consumption to promote electrification. Consider additional carbon-based taxation as well as other mechanisms to progressively redistribute electricity charges among all actors in the energy system.
- Use cost-effectiveness analysis for energy efficiency measures to better prioritise financing for measures and achieve targets more effectively.
- Improve co-ordination with regional authorities and municipalities to implement the NECP's measures more effectively.
- Improve electricity interconnection capacity to boost security of supply and facilitate further integration into the European energy market.
- Regularly review and strengthen when needed the energy system's cyber resilience by testing and simulating scenarios that involve cyberattacks along the value chains of electricity, nuclear, gas and oil in collaboration with all stakeholders.
- Ensure that the National Recovery and Resilience Plan supports achieving the NECP's targets.

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OECD (2020), *OECD Economic Outlook,* Vol. 2020/1, https://doi.org/10.1787/0d1d1e2e-en.

OECD (2018), *OECD Economic Surveys: Spain 2018*, https://doi.org/10.1787/eco_surveys-esp-2018-en.

3. Energy and climate change

Key data

(2019)

GHG emissions with LULUCF* (2018): 296.2 Mt CO_2-eq, -27.4% since 2007, -15.2% since 2000, +16.9% since 1990

GHG emissions without LULUCF* (2018): 334.3 Mt CO_2-eq, -25.3% since 2007, -14.0% since 2000, +15.5% since 1990

Energy-related CO_2 emissions:

CO_2 emissions from fuel combustion: 230.9 Mt CO_2, -31.7% since 2007, -17.1% since 2000, +13.9% since 1990

CO_2 emissions by fuel: oil 60.8%, natural gas 30.7%, coal 7.3%, other 0.6%

CO_2 emissions by sector: transport 40.6%, electricity and heat generation 23.3%, industry 13.5%, other energy 9.2%, service 7.3%, residential 6.2%

CO_2 intensity per GDP:** 0.13 kg CO_2/USD (IEA:*** 0.21 kg CO_2/USD)

* Land use, land-use change and forestry (Source: UNFCCC).

** Gross domestic product in 2015 prices and purchasing power parity.

*** Weighted average of IEA member countries in 2018.

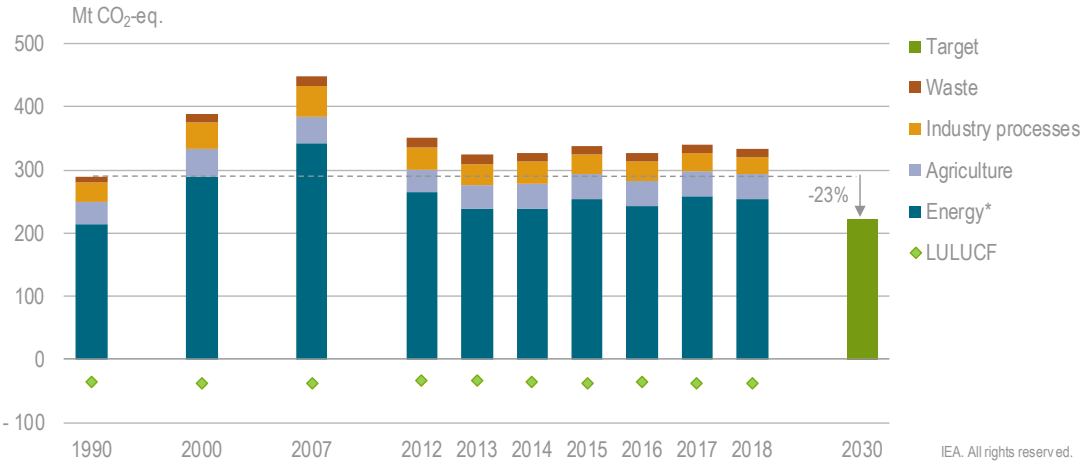
Overview

Spain has set ambitious policies, in line with European Union (EU) requirements, to reduce greenhouse gas (GHG) emissions. In January 2020, Spain submitted a ten-year National Energy and Climate Plan (NECP) to the European Commission. The NECP sets a target of reducing GHG emissions by 23% by 2030 compared to 1990 levels and achieving climate neutrality by 2050.

In 2018, GHG emissions in Spain were 334.3 million tonnes of carbon dioxide equivalent (Mt CO_2-eq) (not including effects from land use) (Figure 3.1). This corresponds to a 25% drop since 2007, mainly driven by the energy sector, compared to the highest level reached in 2007 at 447.3 Mt CO_2-eq. Since then, emissions in Spain began to fall significantly as a result of the 2008-09 economic crisis. Emissions stopped declining in 2013 and have remained relatively stable since at around 330 Mt CO_2-eq. Over the decades, land use, land-use change and forestry (LULUCF) has continuously contributed as a carbon sink at around -37 Mt CO_2-eq per year.

Similar to most countries, the energy sector is the largest emitter of GHG emissions, accounting for 76% of the total in 2018, followed by agriculture at 12%, industrial processes at 8% and waste at 4%.

Figure 3.1 Greenhouse gas emissions in Spain by sector, 1990-2018



In 2018, total GHG emissions in Spain were 325 Mt CO_2-eq, representing a 25% drop compared to a peak in 2007. Spain set a GHG reduction target of 23% below 1990 levels by 2030.

* *Energy* includes power and heat generation, services, households, industrial energy consumption, and transport, and excludes indirect CO_2.

Note: Mt CO_2-eq = million tonnes of carbon dioxide equivalent.

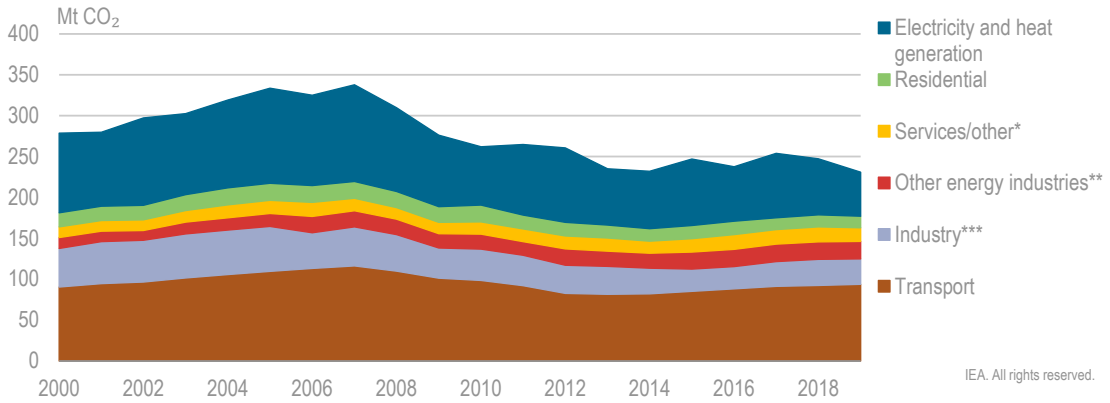
Source: UNFCCC (2020), *Spain 2020 National Inventory Report*, https://unfccc.int/documents/228014.

Energy-related CO_2 emissions

In 2019, energy-related CO_2 emissions in Spain amounted to 230.9 Mt CO_2, a 31.7% reduction from the peak in 2007 (Figure 3.2). Energy-related emissions fell significantly following the 2008-09 global financial crisis, notably in electricity generation. Since 2013, emissions have stopped declining in other sectors (industry, transport, residential).

The transport sector was the largest CO_2 emitter in 2019, accounting for 41% of total emissions from fuel combustion, followed by electricity and heat generation (23%), industry (14%), other energy (e.g. refineries, oil and gas extraction) (9%), services (7%), and residential (6%). CO_2 emissions in the transport sector have continued to grow since 2013, as Spain is largely dependent on road transport, based on a well-developed road transport infrastructure. The second-largest CO_2 emitter, electricity and heat generation, had increasing energy-related CO_2 emissions until 2007. Since then, emissions from electricity and heat generation have been on a downward trend with fluctuations (dependent on weather conditions) correlating with the increasing use of wind and solar energy to generate electricity.

Figure 3.2 Energy-related CO_2 emissions in Spain by sector, 2000-19

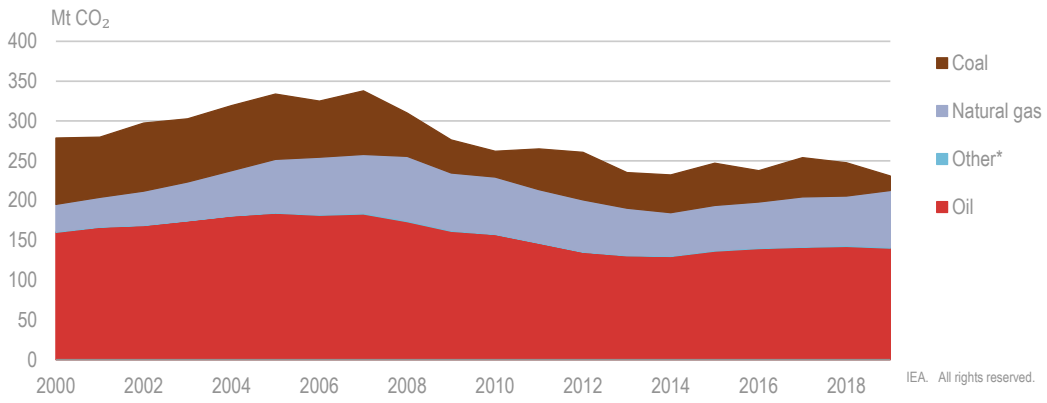


Since peaking in 2007, energy-related CO_2 emissions have declined noticeably across all sectors, but started to increase again in 2013.

* *Services/other* includes commercial and public services, agriculture/forestry, and fishing.
** *Other energy industries* include emissions from oil refineries, coke evens, coal mines, oil and gas extraction.
*** *Industry* includes CO_2 emissions from non-metallic minerals, chemical and petrochemical, iron, and steel.
Note: Mt CO_2 = million tonnes of carbon dioxide.
Source: IEA (2021), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Oil accounted for 61% of total energy-related CO_2 emissions in 2019, followed by natural gas (31%) and coal (8%) (Figure 3.3). Emissions from oil consumption decreased from 2007, and rebounded again from 2014 to 2018 due to increasing oil consumption in the transport sector. They fell slightly again in 2019. Emissions from natural gas combustion also showed a similar trend as oil during the economic crisis. Due to the increased share of gas in electricity generation, emissions from natural gas combustion in 2019 more than doubled compared to 2000. Coal emissions have fluctuated, depending on demand in electricity generation, but have overall experienced a clear downward trend in recent years.

Figure 3.3 Energy-related CO_2 emissions in Spain by energy source, 2000-19



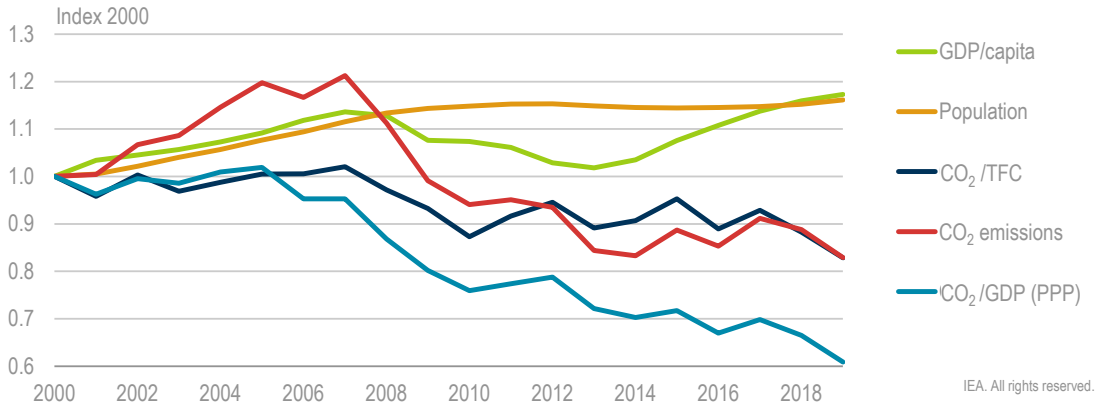
Oil and natural gas emissions declined between 2007 and 2014, but picked up again, while emissions from coal have fluctuated depending on demand in electricity generation.

* *Other* includes emissions from non-renewable waste, which is not visible at this scale.
Note: Mt CO_2 = million tonnes of carbon dioxide.
Source: IEA (2021), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Carbon intensity

Energy-related CO_2 emissions in Spain significantly decreased from 2007 to 2013, driven by reduced economic activity (GDP per capita dropped by 10% over the same period) (Figure 3.4). While GDP per capita rebounded again from 2013 onwards, the carbon intensity of the economy (CO_2/GDP PPP) has consistently declined, showing signs of a decoupling effect. However, the carbon intensity of the energy mix (CO_2/TFC) has remained stable since 2010.

Figure 3.4 Energy-related CO_2 emissions and key drivers in Spain, 2000-19



Despite population and economic growth, energy-related CO_2 emissions have been trending downward over the last two decades, thanks to a drop in the carbon intensity of the economy.

* *GDP* refers to real gross domestic product in USD 2015 prices and purchasing power parity (PPP).

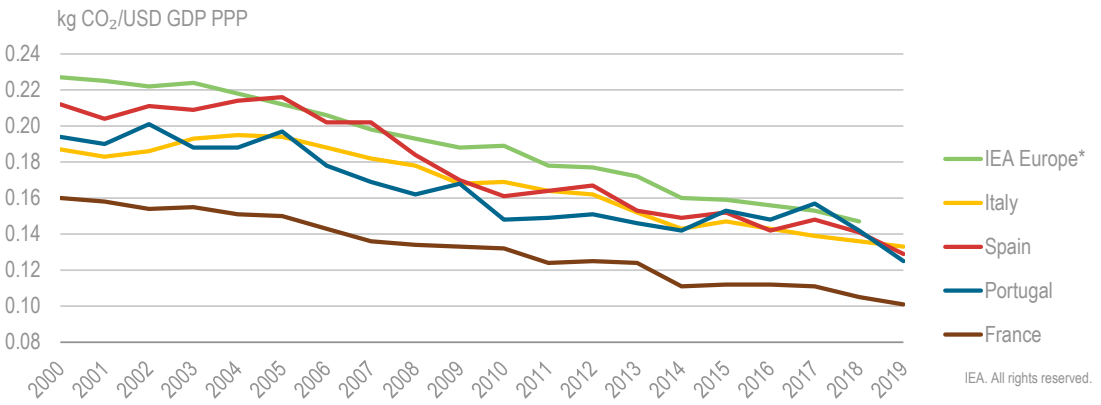
Notes: TFC = total final consumption. CO_2 emissions refers to energy-related CO_2 emissions from combustion processes.

Source: IEA (2021), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

From 2000 to 2007, Spain's carbon intensity of the economy, measured as energy-related CO_2 emissions per unit of GDP, remained relatively high, at around 0.21 kg CO_2/USD PPP (Figure 3.5). However, it showed a rapid decline of 25% between 2007 and 2010, driven by a reduction in electricity and heat production (EEA, 2020). In 2019, Spain's carbon intensity per GDP was 0.13 kg CO_2. Compared to other IEA member countries, Spain is in the lower half, 30% below the IEA weighted average (0.21 kg CO_2/USD PPP in 2018) and just below the weighted average among European IEA countries (0.15 kg CO_2/USD PPP in 2018).

In 2019, Spain emitted 198 grammes of CO_2 per kilowatt hour (g CO_2/kWh) for electricity and heat generation, which was just below the weighted average of European IEA countries (267 g CO_2/kWh in 2018) (Figure 3.6). Since 2000, the CO_2 intensity of electricity and heat generation has continuously declined due to the increasing share of renewables in electricity and heat generation.

Figure 3.5 CO_2 intensity in Spain and selected IEA member countries, 2000-19



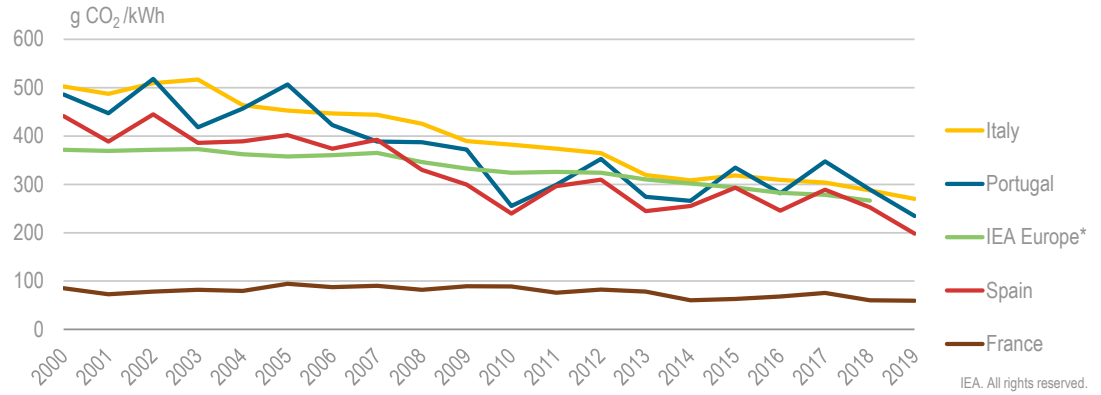
In 2019, Spain's CO_2 intensity of the economy had fallen by 40% from the highest level in 2005, which is just below the weighted average of European IEA countries.

* *IEA Europe* refers to a weighted average of European IEA member countries. 2019 data are not available yet for all countries.

Notes: kg CO_2 = kilogrammes of carbon dioxide. GDP refers to real gross domestic product in USD 2015 prices and purchasing power parity (PPP).

Source: IEA (2021), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Figure 3.6 CO_2 intensity of electricity and heat generation in Spain and selected IEA member countries, 2000-19



Since 2000, Spain's CO_2 intensity in electricity and heat generation has significantly fallen by 55%, with large fluctuations, mainly driven by variations in coal and natural gas.

* *IEA Europe* refers to a weighted average of European IEA member countries.

Note: g CO_2/kWh= grammes of carbon dioxide per kilowatt hour.

Source: IEA (2021), *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), www.iea.org/statistics.

Institutional responsibilities

Spain has improved its institutional co-ordination on climate change in recent years. Since 2018, the Departments of Energy, Climate Change and Environment have been integrated into a single ministry, the Ministry for the Ecological Transition and the Demographic Challenge. The new ministry is tasked with co-ordinating and implementing

the country's climate plan and long-term decarbonisation strategy, mainly through a working group of experts from different ministries. Additional governance improvements are also addressed in the Bill on Climate Change and Energy Transition.

For administration of the implementation of the EU Emissions Trading System (ETS), the central government (led by the Ministry for the Ecological Transition and the Demographic Challenge) oversees the free allocation of allowances, auctions and the registry of companies, while the autonomous communities (regional governments) oversee permitting, monitoring and reporting and, in most cases, the infringement regime.

A Climate Change Policy Coordination Commission and the Climate Change Council co-ordinate actions between the federal and regional governments as well as other stakeholders.

Emission targets and strategy

Since the last in-depth review in 2015, Spain has prioritised the issue of climate change on its national agenda, bringing it in line with EU objectives and ambitions. Since 2018, the government has focused on the concept of a "just transition", quickly moved to abolish what was popularly known as the "sun tax" on rooftop solar installations, and reached an agreement with the coal industry and unions to close all non-competitive coal mines in the country. It also introduced a new climate package in early 2019 that included a number of new measures and updated targets to meet its climate objectives.

The EU and its member states, including Spain, share a joint nationally determined contribution under the United Nations Framework Convention on Climate Change process, which includes a binding target of a net reduction of at least 55% in GHG emissions by 2030 compared to 1990 levels. Furthermore, the EU has also committed to achieving climate neutrality by 2050.

As a member of the EU, Spain's climate policy is guided by the framework of EU climate policies: the 2020 climate package and the 2030 climate framework. Large combustion facilities in the power and industry sectors are part of the EU ETS, whereas non-ETS emissions are subject to the Effort Sharing Decision (ESD) until 2020 and the Effort Sharing Regulation (ESR) until 2030 (see below).

Several policy documents guide Spain's climate change strategy, namely: the Long-Term Strategy to 2050, the National Energy and Climate Plan to 2030, the Bill on Climate Change and Energy Transition for 2030 and 2050, and the Second National Adaptation Plan.

Long-Term Strategy

The Long-Term Strategy (LTS) maps out a plan for Spain to achieve carbon neutrality by 2050. The document includes interim milestones for 2030 and 2040, seizing the benefits derived from the energy transition with an eye to the transformation and competitiveness of the economy. The LTS defines the path that will enable an almost completely renewables-based energy system. Specifically, it expects Spain's carbon-neutral economy to source 100% of electricity from renewable sources and 97% of final energy consumption from renewables in 2050.

Its components include mitigation actions related to energy efficiency and renewables, as well as strategies for adaptation and the decarbonisation of different sectors, including electricity, mobility, industry and buildings. Measures outlined in the LTS include: mobilisation of investment in green innovative technologies, transition to sustainable mobility by means of electrification and use of renewable fuels, increased sustainability in the building sector, efficiency improvements in the agricultural sector, and increased use of natural carbon sinks, among others.

Reducing absolute levels of energy consumption is one of the central tenets of the LTS. It projects primary energy consumption to fall by around 30% from 2020 to 2050. By 2050, 60% less energy would be necessary to create one unit of GDP compared to 2015. This means that today's primary energy consumption of about 120 million tonnes of oil equivalent (Mtoe) would fall to 100 Mtoe in 2030 and to approximately 90 Mtoe in 2040 and less than 80 Mtoe in 2050.

In order to meet emissions reduction targets, renewable energy is expected to account for 28% of final energy use in the transport sector in 2030 and 79% in 2050 (including the aviation sector). In the heating/cooling sectors, renewable energy is expected to account for 97% by 2050 due to the use of heat pumps, biomass, renewable hydrogen and solar energy.

According to the LTS, the sectors of the economy that would reduce their emissions most in absolute terms by 2050, achieving climate neutrality, are the following:

- electricity generation, 57 Mt CO_2-eq reduction (100% from 2020)
- mobility and transport, 85 Mt CO_2-eq reduction (98% from 2020)
- residential, commercial and institutional sectors, 28 Mt CO_2-eq reduction (100% from 2020)
- industry, 65 Mt CO_2-eq reduction (90% from 2020).

Moreover, around 10% of the remaining GHG emissions in 2050 (37 Mt CO_2-eq) are expected to be absorbed by natural carbon sinks.

The LTS was approved by the Council of Ministers in November 2020. It will be reviewed every five years. Several regional governments, including Catalonia, Galicia and Basque Country, have already committed to net-zero targets by 2050 as well.

National Energy and Climate Plan

The measures provided for in Spain's NECP 2021-2030, submitted to the EU in February 2020, target a 23% reduction in GHG emissions in 2030 compared to 1990 levels. The latest inventory shows that as of 2018, Spain's GHG emissions were 15.5% above 1990 levels (not including LULUCF), indicating that sizeable cuts are needed in the coming years to meet the country's and the EU targets (Spain was permitted a 15% increase in emissions under the EU's Kyoto Protocol plan for 2020) (EEA, 2019). Spain expects that non-ETS sectors will contribute to achieving this target with a 39% reduction by 2030 compared to 2005 levels, while ETS sectors will contribute with a decrease of 61% compared to 2005 levels.

The NECP adopts a strategy for reducing GHG emissions that places "energy efficiency first", with a planned 39.5% improvement in energy efficiency (or 3.5% annual reduction in primary energy intensity) by 2030. The strategy includes measures to improve energy efficiency in buildings through renovations and to reduce fossil fuel consumption in the

transport sector (see Chapter 4). It also calls for expanding Spain's use of renewables to reach 42% in energy end use, especially solar and wind (EC, 2020).

As a critical part of the penetration of renewables, Spain aims to achieve a 74% share of renewables in electricity generation by 2030. The decarbonisation of the electricity sector will be facilitated by an expected phasing out of coal-fired generation and a high penetration of renewables, which will also allow for the decommissioning of 4 gigawatts (GW) of nuclear capacity by 2030. The NECP expects that up to 9 of Spain's existing 15 coal-fired power plants (as of 2019) will no longer be operational by 2021. Already, based on market conditions, on 30 June 2020, seven plants with around 4.6 GW of capacity shut down and four more are expected to follow by 2022. By 2030, Spain expects that coal-fired power plants will no longer be competitive based on an EU ETS price of EUR 35/t CO_2, along with continued cost reductions for renewables technologies and relatively low prices for natural gas.

In the transport sector, the NECP plans to achieve emissions reductions through a modal shift away from conventional internal combustion vehicles toward public, shared and low-emissions modes of transport. Moreover, the government will designate low-emissions zones in cities with more than 50 000 inhabitants starting in 2023, where access for the most highly emitting vehicles will be restricted. As a result of the implementation of modal shift measures, it is estimated that 35% of passenger-kilometres that are currently travelled by conventional vehicles will shift to non-emitting forms of transport by 2030. Moreover, the government projects 5 million electric vehicles on the roads by 2030, including cars, vans, motorcycles and buses, as well as higher use of advanced biofuels in conventional combustion vehicles.

For the industry sector, planned emissions reductions are expected from changes in the fuels used in combustion processes, as well as the continuation of energy efficiency improvements. In the longer term, to 2050, the decarbonisation of industry will require new technological advances that will come from research, innovation and competitiveness policies (see Chapter 6).

From a financial perspective, the government anticipates that the implementation of the NECP will require EUR 241.4 billion, of which 80% is expected to come from the private sector. Renewables will lead with 38% of investment, followed by efficiency at 35%, and grid and electrification at 24%.

The NECP also takes stock of the interactions between air quality and emissions policy, from both a policy and methodological point of view. Emissions of several air pollutants have fallen over the last few decades, but air quality remains a concern, particularly concentrations of nitrogen dioxide (NO_2). Personal transport and traffic congestion exacerbate problems with air quality in major metropolitan areas (namely, Madrid and Barcelona), leading to health and economic costs. To this end, Spain's projections of GHG and air pollutant emissions have been developed in a consistent way and the NECP makes a link with plans included in the National Air Pollution Control Programme. Benefits to air pollution and public health of the proposed climate and energy measures create value added to the plan.

Bill on Climate Change and Energy Transition

The government declared a "climate emergency" in January and pledged to reintroduce a draft Bill on Climate Change to parliament within its first 100 days in office, though that was delayed by the COVID-19 pandemic.

The Bill on Climate Change and Energy Transition was accepted by the government in May 2020 and submitted to parliament. It will transpose much of the NECP into national law, though the NECP's main targets are also binding at the national level, in line with EU Regulation 2018/1999 on the Governance of the Energy Union and Climate Action.

The new bill is also meant to guide Spain's post-COVID-19 recovery efforts, as Spain expects to receive EUR 140.4 billion from EU recovery funds. It proposes a target of at least a 20% reduction in GHG emissions by 2030 (from 1990 levels) and to attain climate neutrality in 2050, when almost 100% of energy will be sourced from renewable sources.

The Bill on Climate Change and Energy Transition provides more ambitious goals than the EU 2030 targets on renewables and energy efficiency. While the EU aims for a 32% share of renewables in overall energy use by 2030, the Spanish bill provides for a 35% target, and a 70% sub-target for the use of renewables in electricity generation. Compared to the EU energy efficiency target of at least 32.5%, Spain's bill increases the target to 35%. These Spanish targets are, in principle, aligned with the new EU target of a 55% GHG emissions reduction by 2030.

Among its many measures, the bill provides for a portion of the general state budget to be allocated to the energy transition, and envisages a ban on research permits and exploration concessions for all hydrocarbons, including a complete ban on fracking activities.

To support the expanding role of renewables in electricity, the bill establishes a new remuneration framework for new renewable energy generation facilities based on a contract for difference, awarded through competitive tendering procedures. It also calls for new hydroelectric concessions to be granted priority for supporting the integration of renewable energy into the electricity system and for optimising already-awarded access and connection rights to the grid, making it possible to increase the power capacity of existing generation facilities.

In the transport sector, the bill requires all new vehicles sold to be zero emissions by 2040, and promotes electric vehicle charging points (see Chapter 4). It also introduces low-emissions zones in cities with more than 50 0000 inhabitants, as outlined in the NECP. Moreover, it establishes annual targets for biofuels and other alternative fuels for air transport, and requires state-owned ports to be carbon neutral by 2050.

From a financial disclosure perspective, the bill requires financial institutions to publish specific decarbonisation objectives for their loan and investment portfolios from 2023 in line with the Paris Agreement. It also establishes non-financial reporting obligations of listed companies (based on their level of exposure to climate risks and their strategies and objectives for mitigation).

On the adaptation and conservation side, the bill integrates climate risks into coastal planning and management, transport infrastructure, and land-use development under the

National Adaptation Plan (see below). Moreover, it sets out a biodiversity strategy to protect and restore Spain's wildlife and ecosystems.

To help communities adjust to the energy transition, the bill requires approval by the regions of a transition strategy for communities dependent on fossil fuel industries for their livelihood every five years. As part of this strategy, specific transition agreements to promote alternative economic activities will be developed in affected areas.

Lastly, to increase awareness and build public support for the energy transition, the bill introduces climate change to school curriculums and promotes professional training in new low-carbon skills and technologies. It also establishes a framework to ensure governance, including the establishment of an independent committee of experts, regional energy and climate plans, public participation, and internal administrative procedures for monitoring and reporting.

The Bill on Climate Change and Energy Transition will be implemented in conjunction with complementary strategies, such as the Just Transition Strategy (see Chapter 9), the Spanish Strategy on Circular Economy, the Future Sustainable Mobility Law and the Long-Term Building Rehabilitation Strategy.

Carbon pricing

Spain participates in the EU ETS, which is a cap-and-trade system covering around 1 000 stationary installations and 30 aircraft operators that represent around 40% of total GHG emissions in Spain. The emissions reductions target under the system, set at the EU level, is a 21% reduction from 2005 levels by 2020 and a 43% reduction by 2030, though there are no targets at the national level. In Spain, between 2005 and 2019, emissions covered by the EU ETS fell by 45%.

Allowances are provided for free to some installations based on carbon leakage (mainly industrial companies and airline operators), though many free allocations will wind down by 2030; the electricity sector already no longer receives free allowances. Auctioning is the main allocation method for the electricity sector and will be increasingly used for industrial companies transitioning away from free allocations. Spain uses 90% of its auction revenues to support renewable energy, while the remaining 10% is used to support other climate change priorities. Over the 2013-19 period, Spain raised EUR 4.6 billion in auction revenues from over 1 000 auctions.

This ETS regime is complementary to the EU Effort Sharing Regulation, which covers all emissions not affected by the EU ETS, as well as the EU LULUCF Regulation that covers emissions and removals from land use, land-use change and forestry activities.

All of these EU emissions regulations, together with other regulations on renewable energy, energy efficiency, waste, etc., are applied nationally in a consistent way to ensure that Spain achieves its national, EU and international GHG commitments.

In addition, Spain developed a national carbon pricing policy in 2012, the so-called "Climate Projects" (Proyectos Clima), as a system aimed at encouraging the reduction of GHG emissions from facilities and sectors not covered by the EU ETS (transport, residential, waste, agricultural, industrial, fluorinated gases), excluding removals by carbon sinks. The programme supports projects that deliver CO_2 equivalent emissions reductions that are then verified and purchased by a national carbon fund (Carbon Fund for a

Sustainable Economy, FES-CO_2) at a fixed price during the first four years of a project. Energy projects have included solar PV projects and solar irrigation projects in isolated areas of the grid, electric and hybrid vehicles, modal shifts, as well as waste to energy projects and slurry biodigestion projects with electric generation. This policy has proven to drive innovation too, facilitating the transfer of clean technology and encouraging mitigation efforts across sectors.

Spain does not currently apply any carbon pricing in non-ETS sectors, although it has undertaken a number of assessments and studies to introduce environmental or carbon taxation into various sectors, with an eye to citizen acceptance and co-ordination with the autonomous communities that have competencies in certain areas of taxation.

However, there is a notable exception with Law 16/2013, which establishes some environmental taxation measures, including a national tax on fluorinated gases, which has been a very efficient measure for mitigating GHG emissions. According to the Spanish National Inventory of Emissions, since the implementation of the tax in 2014, emissions of fluorinated gases in Spain have fallen by approximately 65%.

Given the recent ratification of the Doha Amendment, the second commitment period of the Kyoto Protocol entered into force in October 2020, which means that Spain's goal under the Kyoto Protocol is binding. Spain is one of the most active players in the Kyoto Protocol mechanisms market, and currently holds around 17 million certified emissions reductions (17 Mt CO_2 reduced) from the Clean Development Mechanism that could be used to reach the Kyoto Protocol goal (which should be met easily, leaving a surplus of certified emissions reductions). Spain has indicated that it will not use any Kyoto Protocol units toward its goal under the second commitment period of the Kyoto Protocol.

Adaptation to climate change

The Spanish energy sector could be affected by a number of potential impacts of climate change, including: increased frequency and severity of droughts and floods that could affect hydroelectric generation; changes in sun and wind patterns that could affect local solar and wind production; and an increase in extreme weather events that could disrupt energy infrastructure. Changes in weather patterns, but especially the increased frequency and intensity of extreme events, can cause damage to infrastructure that is critical to the proper functioning of electricity, gas or oil systems. Recent storms reveal that damage can affect overhead power lines, although liquefied natural gas (LNG) and conventional gas terminals and refineries located in coastal areas will also face increased risks due to storms, flooding and rising sea levels.

For Spain, climate scenarios point to an increase in the number of days per year with high temperatures, which will lead to an increase in peak electricity demand associated with cooling needs at certain times of the day and seasons. If no appropriate measures are taken to target the most vulnerable segments of the population, there could also be an increase in seasonal energy poverty ratios in certain regions associated with cooling needs. Moreover, high temperatures can also hamper thermal power generators that need water from rivers for cooling.

The Spanish government has already put in place measures to respond to climate change. Since 2013, environmental impact assessments made for new energy infrastructure have

been required to account for the impacts related to climate change. In 2014, the Spanish Office for Climate Change completed the first report on adaptation to climate change in the Spanish energy sector with action plans and timelines.

More recently, a new Spanish National Adaptation Plan 2021-2030, which was adopted by the Council of Ministers in September 2020, includes a number of measures on adaptation for the energy sector. Notably, the plan attempts to cover the entire energy value chain, a leading example among countries with adaptation plans. Its components include: primary energy supply; electricity generation; transport, storage and distribution; and electricity demand.

Specifically, it calls for the integration of changes in primary energy supply resulting from climate change into energy planning and management by: developing projections, for various climate change scenarios, on the availability of water resources and their generation potential by hydrographic basins; developing projections, for various climate change scenarios, of the biomass potential by type of crops and regions; and using projections on possible changes in available resources for energy planning and management.

Given that changes in annual or seasonal rainfall patterns, average air and water temperatures, and average wind speeds can affect the performance and optimal operation of power plants, the National Adaptation Plan also calls for remedial actions, including: making estimates on the potential impacts associated with climate change by type of technology and region; identifying and analysing technological improvements that promote the implementation of more resilient, efficient and adapted electricity generation facilities; integrating the results in the planning of the energy transition into successive NECPs; and identifying the needs of water resources for the generation of electricity.

Lastly, the National Adaptation Plan also includes a measure to prevent the impacts of climate change on energy transport, storage and distribution. Action items will include: carrying out analyses on the impact of climate change on the functionality and resilience of electricity transmission and distribution networks and defining consequent adaptation measures; identifying energy infrastructures that are highly vulnerable to extreme events and promoting specific adaptation programmes; and integrating the results into energy transition planning in successive NECPs.

Assessment

Spain has made substantial progress on policies mitigating climate change since the last in-depth review by establishing an NECP, proposing a Bill of Climate Change and Energy Transition, a Long-Term Decarbonisation Strategy 2050 and a Second National Adaptation Plan. These key documents, in addition to supporting initiatives such as road maps and strategies, provide greater clarity on Spain's climate change ambitions.

Spain has committed to become a carbon-neutral economy by 2050. Spanish climate and energy legislation as well as the NECP are comprehensive on targets and sectoral contributions and entail policies and measures for decarbonisation, including renewable energy and energy efficiency. The closure of coal mines and decommissioning of remaining coal power plants will further help to achieve decarbonisation goals. However,

a carbon-neutral economy needs to be underpinned by equally ambitious policies on security of supply, competitive markets, and research and innovation.

The domestic long-term framework for climate policy is set in the draft Bill for Climate Change and Energy Transition. Currently in the Spanish parliament, the bill, in addition to the 2050 climate neutrality goal, sets targets for 2030 (at least a 20% reduction of GHG emissions from 1990 levels). The Long-Term Strategy 2050 will include an intermediate target of GHG mitigation by 2040.

Under the NECP, Spain has set an ambitious target for GHG emissions reductions from the effort-sharing sectors: 39% by 2030 compared to 2005 levels, which is 13 percentage points more than the binding target of 26% set in the EU Effort Sharing Regulation. This reduction would be reached with the additional measures specified in the NECP. Potential barriers for these additional measures, in particular regulatory and administrative ones, need to be removed. The national GHG reduction target of -20% in the draft Bill on Climate Change and Energy Transition is a minimum, which does not exactly align with the NECP. Moreover, the EU has agreed to increase the bloc's GHG emissions reduction target for 2030 to 55%. Thanks to its existing ambitious targets and policies, Spain may already be aligned with the new EU 2030 target.

The transport sector was the largest energy-related CO_2 emitter in 2019, accounting for 41% of total emissions from fuel combustion, followed by electricity and heat generation (23%), industry (14%), other energy industries (9%), services (7%), and residential (6%). Transport is the sector where GHG emissions continue to grow most. While Spain has a robust transport infrastructure, it relies almost exclusively on road transport for freight.

As such, in transport (with around a 40% share of non-ETS emissions), Spain aims to reduce emissions by 27 Mt CO_2-eq by 2030 (a 33% reduction compared to 2020). This is planned to be achieved by a more efficient organisation of the mobility system (e.g. promoting a modal shift towards less emitting modes of transport, promoting the use of the most efficient transport modes, promoting the renewal of the car fleet), and by an increased uptake of renewable sources of energy, in particular electricity and advanced biofuels. It is worth highlighting that concrete measures to this end have been identified, e.g. low-emissions zones in every large city (extended to those with more than 50 000 inhabitants as of 2023), and that the quantitative impact of certain measures on energy savings has been calculated. Regarding electro-mobility, the NECP aims at having 5 million electric passenger cars and light-duty vehicles on the roads in 2030. New vehicles sold in these categories should have zero emissions by 2040. This will be supported by grants for the purchase of electric vehicles and infrastructure development. Therefore, it is clear that Spain's strategy and measures for lowering transport emissions are well-considered; the next stage will be to ensure timely implementation and sufficient funding for the measures to keep progress on track.

To further achieve its climate target, the government is focusing on increasing the supply of renewable energy and reducing energy demand through efficiency measures. Notably, the NECP sets a target of a 74% renewable share in electricity by 2030, combined with strong goals for electrification and a 39.5% improvement in energy efficiency.

The Hydrogen Roadmap considers renewable hydrogen as a key technology to increase the production of renewable electricity and renewable gases, targeting 4 GW of hydrogen electrolysis capacity in 2030.

Air quality also needs to be ensured. Emissions of several air pollutants have decreased over the last decades, while air quality remains a concern, particularly concentrations of nitrogen dioxide (NO_2). Personal transport and traffic congestion exacerbate problems with air quality in major metropolitan areas (namely Madrid and Barcelona), leading to health and economic costs. A comprehensive approach is needed, which is related to environmental but also climate, energy and mobility issues. Investments in mobility, in particular, should be in line with the National Air Pollution Control Programme.

Total investments to achieve the NECP's objectives, including decarbonisation, are estimated at EUR 241 412 million between 2021 and 2030, including EUR 196 000 million of additional investments. The main sectors are: energy efficiency: 35% (EUR 83 540 million); renewables: 38% (EUR 91 765 million); and networks and electrification: 24% (EUR 58 579 million). Eighty per cent of investments are expected to be private and 20% are planned public investments, placing a heavy reliance for meeting emissions targets on sizeable private sector outlays. In this regard, it is imperative that policies and measures outlined in the NECP are successful at mobilising private investments.

Spain is also among the most exposed EU countries to climate change. It is therefore crucial to anticipate the adverse effects (e.g. floods, coastal erosion, droughts, heat waves, forest fires) through adaptation measures. The 2020 National Adaptation Plan 2021-2030 sets 18 thematic fields including forestry desertification, water and coastal areas in order to facilitate integration of adaptation action in the different sectors of public and private management.

Adapting the energy sector to climate change should be a core priority for the Spanish government, given its close correlation with GHG emissions reduction and energy security goals (e.g. variability of hydropower, cooling for fossil fuel plants, forests as biomass sources and carbon sinks, increasing energy demand). Climate change has a strong influence on the proper functioning of the energy system (like resilience of the electricity grid and gas networks), and its detrimental effects would be amplified by growing cooling demand and increased flooding risk.

Recommendations

The government of Spain should:

- Implement policies and measures in line with the NECP in a timely manner to achieve national GHG emissions reduction targets and remove barriers to their effectiveness.
- In co-ordination with industry, citizens and regional authorities, closely track the implementation of measures contained in the NECP, evaluate progress, enforce deadlines and adjust strategies, where needed.
- Monitor private sector investments between 2021 and 2030 toward decarbonisation targets, and develop strategies to mobilise supplementary financing, as needed.

- ☐ Step up efforts to implement the National Adaptation Plan for the energy sector given Spain's outsized exposure to the impacts of climate change among EU countries.

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4. Energy efficiency

Key data

(2019)

Total final consumption (TFC): 85.5 Mtoe (oil 51.3%, electricity 23.6%, natural gas 17.2%, bioenergy and waste 7.0%, coal 0.6%, solar 0.4%, other renewables 0.4%) -5.9% since 2009

Consumption by sector: industry 29%, transport 38%, residential 17%, services/other 16%

Energy consumption (TFC) per capita: 1.8 toe/capita (IEA average:* 2.8 toe/capita), -7% since 2009

Energy intensity (TFC/GDP):** 48 toe/USD million PPP (IEA average:* 62 toe/USD million PPP), -15% since 2009

* Weighted average of IEA member countries in 2018.

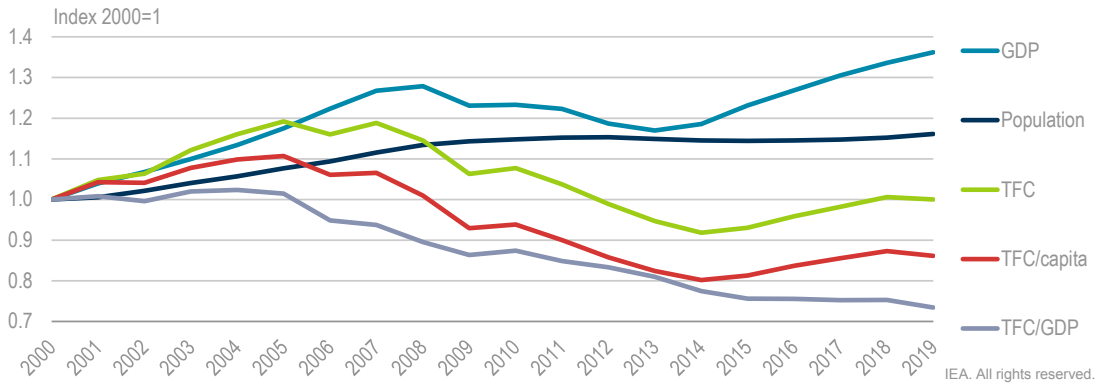
** GDP data are in billion USD 2015 prices and PPP (purchasing power parity).

Energy intensity

Spain's gross domestic product (GDP) fell by 7% between 2008 and 2014 as a consequence of the global financial crisis (Figure 4.1). Total final consumption (TFC) was strongly affected by the shrinking economy and decreased by 20% in the same time frame. While the economy rebounded by 15% in the next five years, TFC increased by 10% between 2014 and 2018, to then decrease by 1% in 2019. As a consequence, the TFC/GDP ratio decreased by 18% between 2008 and 2019, indicating that Spain has decoupled economic growth from energy consumption. With a population that has been relatively stable between 2008 and 2019 (+2%), TFC/capita also decreased in the same decade by 15%.

The coronavirus pandemic hit the country hard in 2020, and OECD projections forecast a contraction of the economy by at least 11% in 2020. This will likely have strong consequences for TFC.

Figure 4.1 Energy consumption and drivers in Spain, 2000-19



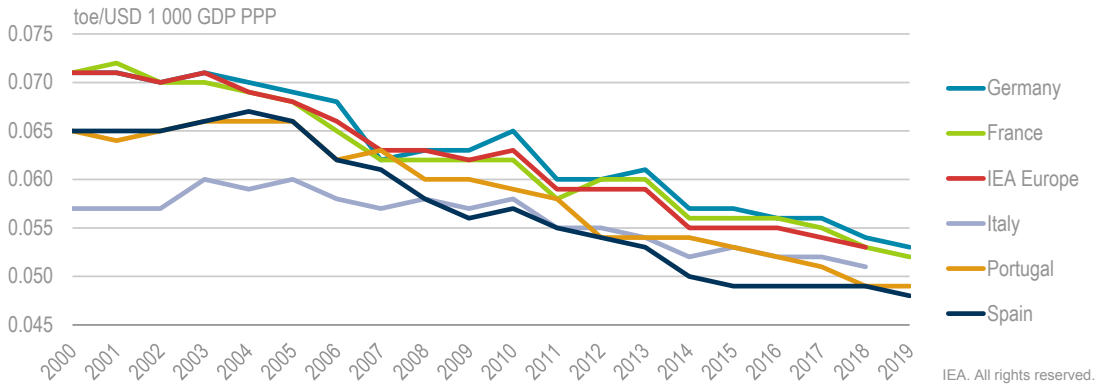
Spain has experienced a decoupling of TFC and economic growth in recent years; TFC in 2019 was at similar levels to 2000, while GDP was a third higher.

Notes: GDP = gross domestic product. TFC = total final consumption. GDP data are in billion USD 2015 prices and PPP (purchasing power parity).

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2019, the energy intensity of the Spanish economy, measured as the ratio of TFC per unit of GDP, was 48 tonnes of oil equivalent (toe) per USD million PPP, a decline of 26% since 2000 (Figure 4.2). Spain has a relatively low energy intensity compared to other IEA countries, both by GDP and per capita. In 2018, Spain was the seventh-lowest country based on TFC/GDP and the fifth-lowest based on TFC/capita.

Figure 4.2 Energy intensity in select IEA member countries, 2000-19



Spain's energy intensity per GDP has decreased in recent years, similar to other European countries.

Notes: toe = tonne of oil equivalent. GDP data are in billion USD 2015 prices and PPP (purchasing power parity). Data for Italy and IEA Europe are not available for 2019.

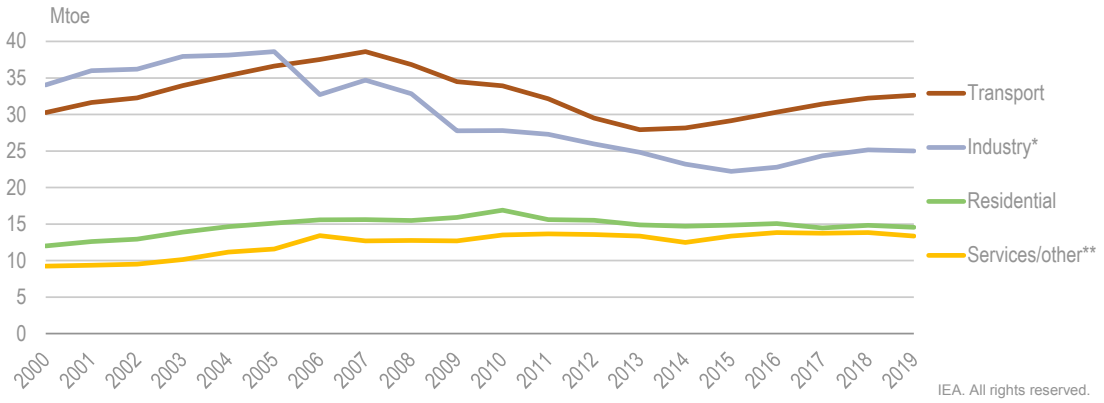
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy consumption by sector

Transport is the largest energy-consuming sector in Spain, accounting for 38% of TFC in 2019, followed by industry at 29% (Figure 4.3). Both of these sectors were affected by the global financial crisis in 2008, and rebounded several years later. However, the industry sector experienced a longer and deeper drop that started in 2005 and hit new lows in 2015, after which it started to increase again. The transport sector, in contrast, decreased between 2007 and 2013 and had a stronger rebound between 2013 and 2019.

The residential and services sectors accounted for 17% and 16% of TFC, respectively, in 2019, and were relatively stable between 2009 and 2019.

Figure 4.3 Energy consumption in Spain by sector, 2000-19



Energy consumption in the transport and industry sectors have followed the same trend as the economy in recent years, while TFC in other sectors has been relatively stable.

* *Industry* includes non-energy consumption.

** *Services/other* includes a small share of energy used in fishing.

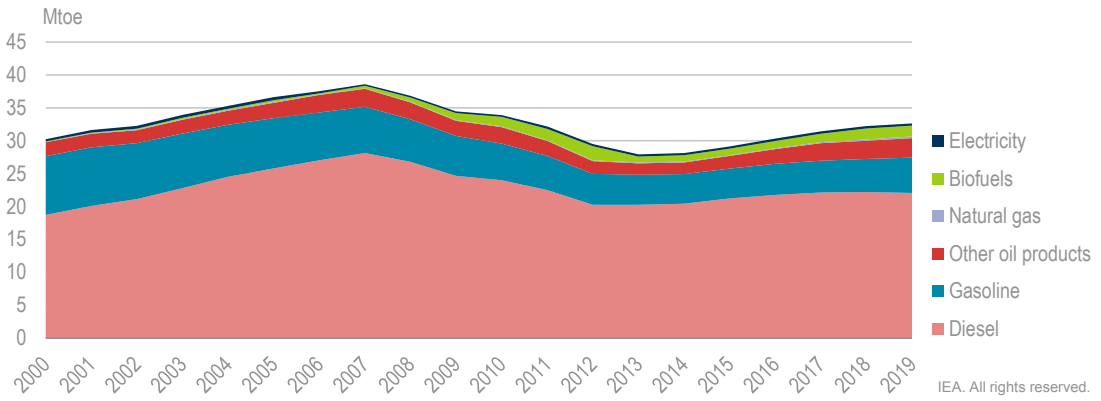
Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy consumption in transport

The transport sector in Spain consumed 32 Mtoe in 2019, equal to 38% of TFC. Transport consumption dropped by 28% between 2007 and 2013, then rebounded by 17% between 2013 and 2019 (Figure 4.4). As a result, between 2009 and 2019, consumption from the transport sector decreased by 5%. Oil represents the vast majority of transport energy demand at 93%: diesel accounted for 68% of transport demand in 2019, gasoline 16% and other oil products (mainly kerosene, fuel oil and liquefied petroleum gas [LPG]) 9%. In recent years, the shares of natural gas, biofuels and electricity have increased, but are still relatively minor. Road transport covered 88% of domestic transport energy use in 2019, followed by domestic aviation at 7%.

Figure 4.4 Energy consumption in transport in Spain by fuel, 2000-19



Almost all transport demand is met by oil, which covered 93% of fuels in 2018. The small shares of biofuels, electricity and natural gas have been slowly increasing in recent years.

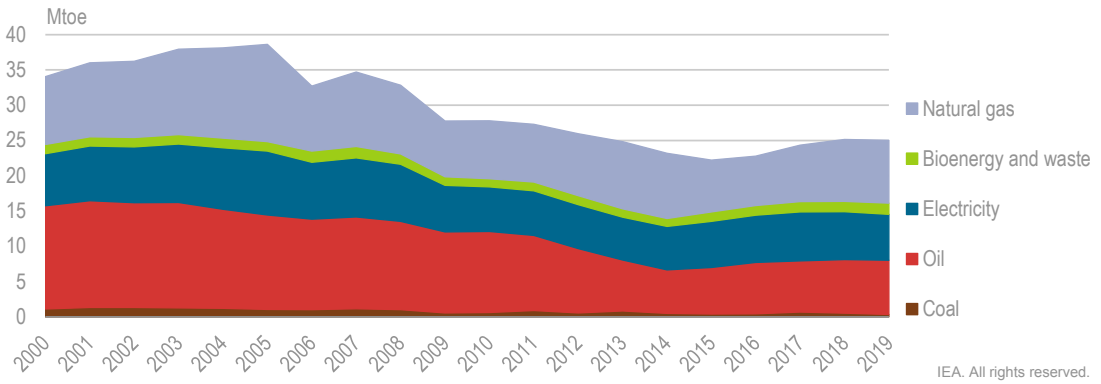
Notes: Mtoe = million tonnes of oil equivalent. The transport sector demand excludes international aviation and navigation.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Energy consumption in industry

The industry sector consumed 25 Mtoe in 2019 (Figure 4.5). Consumption decreased by 10% between 2009 and 2019, the result of a sizeable decline between 2004 and 2015, followed by a rebound from 2016 to 2018. Most of the total drop consisted of oil, which fell by 33% between 2009 and 2019. Coal, although it only represented a small share of TFC, also decreased by 37%. Natural gas, oil and electricity each accounted for about a third of total consumption by industry in 2019, with a slightly increasing share of bioenergy (+32% between 2009 and 2019).

Figure 4.5 Energy consumption in industry in Spain by fuel type, 2000-19



Total final consumption in the industry sector decreased between 2005 and 2015, after which it rebounded slightly in the following three years.

Notes: Mtoe = million tonnes of oil equivalent. Includes non-energy consumption.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

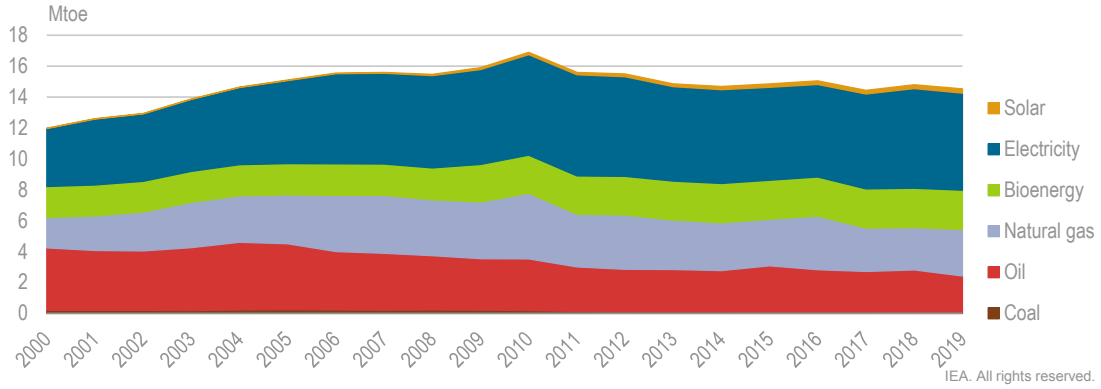
Industrial fuel consumption in Spain is spread out over several energy-intensive sectors. In 2019, the chemical and petrochemical sector accounted for almost one-third of industrial final consumption. Of this, about half is non-energy use (such as fuels that are used as raw materials or transformed into another fuel). The non-metallic minerals industry is the second-largest consuming sector, despite a 10% decrease between 2009 and 2019. All other sectors account for 10% or less of industrial TFC each. While almost all sectors reduced their consumption between 2009 and 2019, the construction sector expanded, registering a 107% increase.

Energy consumption in residential buildings

The residential sector consumed 14.5 Mtoe in 2019, accounting for 17% of TFC. After peaking in 2010, energy consumption by the residential sector fell and remained relatively constant between 2013 and 2019 (Figure 4.6). In recent decades, the contribution of electricity to residential energy consumption has increased, while fossil fuels have decreased. Between 2009 and 2019, electricity supply to residential buildings increased by 2%, while oil and natural gas decreased by 29% and 18%, respectively. Renewables also increased in the same time frame, with bioenergy increasing by 4% and geothermal and solar rising by 132% and 38%, respectively. They still represent minor shares of total consumption in residential buildings, however.

As a result, in 2019, electricity was the main energy source for the sector, accounting for 43% of total energy consumption, followed by natural gas (21%), bioenergy (18%) and oil (16%). Other renewables (mainly solar) accounted only for 2%, but have been increasing in recent years.

Figure 4.6 Energy consumption in the residential sector in Spain by fuel, 2000-19



The contribution of electricity to energy consumption in the residential sector has been increasing, while oil has declined.

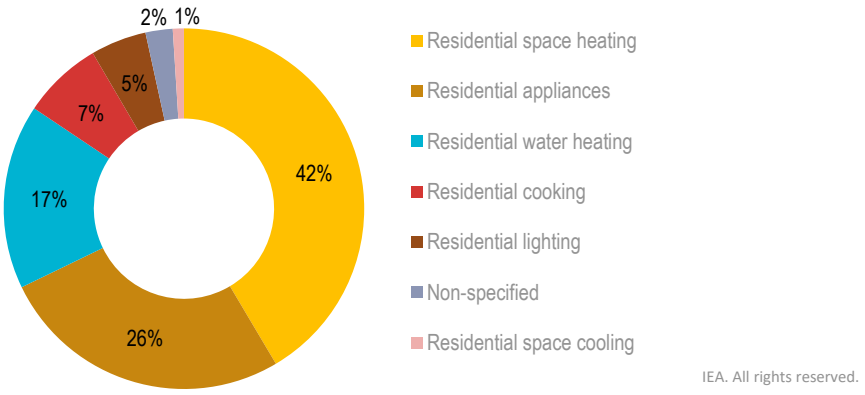
Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2018, 42% of the energy consumed by residential buildings was used for space heating, followed by residential appliances and water heating, which were responsible for around 26% and 17% of total residential energy consumption, respectively (Figure 4.7). Energy consumption for residential space and water heating has been decreasing over the last decade, while residential appliances increased their consumption by almost 60% between

2008 and 2018. In terms of both per capita and per dwelling, Spain's energy intensity of the residential sector is lower than the IEA average.

Figure 4.7 Breakdown of energy consumption in the residential sector in Spain by use, 2018



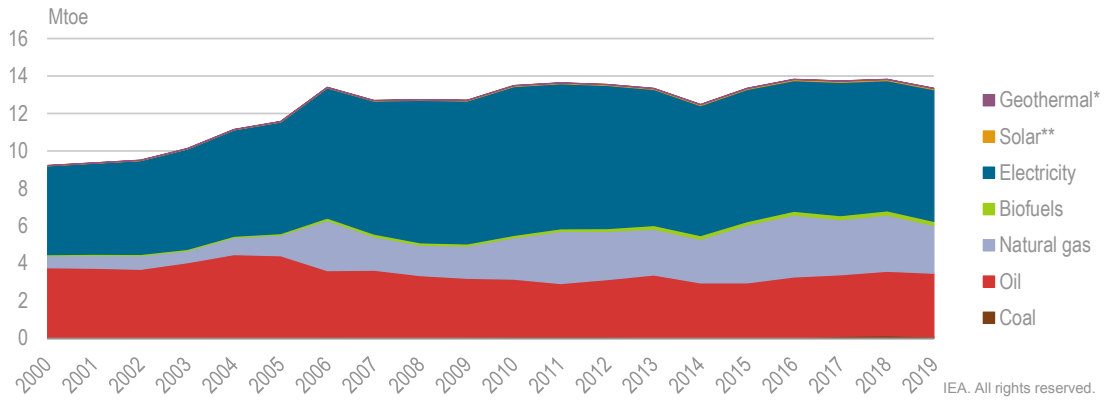
Residential space heating and residential appliances consumed more than half of total demand in the residential sector.

Sources: IEA (2020), *Energy Efficiency Indicators 2020* (database), www.iea.org/statistics.

Energy consumption in services and other sectors

In 2019, energy consumption in the commercial and public services sector was 13.3 Mtoe (16% of TFC). Electricity was the largest energy source, representing 53% of total energy demand, while the rest was comprised mainly of fossil fuels: oil (26%), natural gas (19%) and coal (1%), with a small share of bioenergy and waste (2%), and negligible contributions (<1%) by other renewables (solar and geothermal) (Figure 4.8). Energy consumption in commercial and public services grew by 5% from 2009 to 2019, mostly met by increased supply of natural gas (+48%). Solar's contribution doubled in the same time frame, but still needs to grow to make a significant contribution to total energy consumption in the sector.

Figure 4.8 Energy consumption in the services sector in Spain by fuel, 2000-19



Energy consumption in the Spanish services sector has increased since 2000, with growing electricity supply, which accounted for half of the sector's supply in 2019.

* *Geothermal* increased from 5 ktoe in 2000 to 8 ktoe in 2019.

** *Solar* increased from 6 kilotonnes of oil equivalent (ktoe) in 2000 to 62 ktoe in 2019.

Notes: Mtoe = million tonnes of oil equivalent. This graph also includes the agriculture and fishing sectors.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Institutional responsibilities

The Ministry for the Ecological Transition and the Demographic Challenge (MITERD) is responsible for preparing federal energy legislation, developing national energy policy and measures to ensure energy supply, co-ordination with other ministries, and monitoring of policies related to the fulfilment of energy policy objectives. Therefore, it is responsible for energy savings and efficiency policies, through the Secretary of State for Energy.

The General Sub-Directorate for Energy Efficiency and the Institute for Energy Diversification and Saving (IDAE), which is a public business entity, report to the Secretary of State for Energy.

The General Sub-Directorate for Energy Efficiency is in charge of developing the guidelines of the Secretary of State for Energy in the area of energy efficiency, while the IDAE manages energy efficiency programmes and projects to help Spain meet its energy efficiency objectives. The programmes are often financed by the National Energy Efficiency Fund (see below).

Energy efficiency policies and measures are frequently implemented at the regional and municipal level, so MITERD usually develops these policies and measures in co-ordination with the autonomous communities.

Energy efficiency targets and strategies

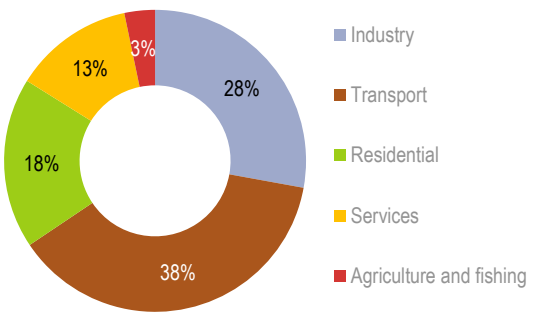
Since the last in-depth review, the National Action Plan for Energy Efficiency 2017-2020 was adopted as one of the main tools for energy efficiency policies and measures. Spain set a target of a 24.7% improvement in energy efficiency by 2020 in the plan (relative to 2005 levels), which will require not exceeding 122.6 Mtoe of primary energy consumption

in that year. In 2019, primary energy consumption in Spain was 120.7 Mtoe. Current measures to promote energy efficiency include a range of actions in the form of legislative changes and economic support.

Spain's energy efficiency objectives are aligned with EU Energy Efficiency Directives, which establish a common framework of measures to promote energy efficiency within the European Union, with EU-wide targets of 20% improvement by 2020 and 32.5% by 2030 (relative to 2007 levels). Spain accepts these objectives and establishes, in the National Energy and Climate Plan (NECP) 2021-2030, a national guideline for an energy efficiency improvement of 39.5% by 2030, which will translate into primary energy consumption of 98.5 Mtoe. For reference, according to Eurostat data, Spain's primary energy consumption in 2018 was 124.63 Mtoe. The reduction in primary energy consumption proposed in the NECP is equivalent to 1.9% every year since 2017, which when linked to an expected annual increase in GDP during the same period of around 1.7%, will require an improvement in the primary energy intensity of the economy of 3.5% per year until 2030. This would be well above the IEA average over the last decade (and 0.5% above the 3% annual improvement rate required to achieve the commitments of the United Nations Sustainable Development Goals or the Paris Agreement).

EU member states must also achieve a final *cumulative* energy savings target in the periods 2014-20 and 2021-30, in accordance with Article 7 of the EU Energy Efficiency Directive. For the first period, Spain's target is 15 979 ktoe (or 571 ktoe per year) of new and additional savings in final energy. The target for the second period is 36 809 ktoe (or 669 ktoe per year). These savings must be achieved through the implementation of a system of energy efficiency obligations on certain companies (electricity and gas trading companies and wholesale operators of petroleum products and LPG), or by applying alternative regulatory, fiscal, economic, or information and communication measures to be carried out by the government. Spain has opted for a combination of both systems. Spain's most recent Annual Monitoring Report sent to the European Commission indicated accumulated final energy savings from 2014 to 2018 of 14 047 ktoe, which represents 87.9% of the target.

Figure 4.9. Spain's cumulative final energy savings projected for 2021-30



Source: Ministry for the Ecological Transition and the Demographic Challenge.

The NECP proposes 17 measures to meet the 2030 target, 10 of which were designed along a sectoral approach, applying proportional savings to each sector based on its consumption. The transport sector stands out, with four measures, amounting to an

expected 14 Mtoe of savings in 2021-30. This is followed by the industrial and residential sectors, with 10.3 Mtoe and 6.7 Mtoe of savings, respectively. Lastly, the tertiary and agriculture and fishing sectors represent the lowest contribution with 4.7 Mtoe and 1.2 Mtoe, respectively.

The main financial instrument for energy efficiency actions in Spain is the National Energy Efficiency Fund (FNEE), which was created by Law 18/2014 approving measures for growth, competitiveness and efficiency. It is mainly financed by contributions of gas and electricity trading companies, operators of wholesale petroleum products, and wholesale LPG operators. It amounts to around EUR 200 million in annual funding over the 2014-20 period. Royal Decree-Law 23/2020 extended the validity of the FNEE to 31 December 2030. The fund's budget is dedicated to financing mechanisms for economic, financial, technical assistance, training, information or other measures to increase energy efficiency in various sectors in ways that help to achieve the national energy-saving objective. Around EUR 2 billion are expected from the fund over the 2021-30 period.

Additionally, the government is studying the complementary implementation of a system of energy-saving certificates, which will add to energy savings and associated investments. In addition to the FNEE, EUR 50 million from the general state budget has been allocated to sustainable and efficient mobility in recent years. The Spanish administration is also studying various financing mechanisms, with the aim of mobilising private capital, especially in building renovation, given its importance to meeting 2030 targets.

Spain also benefits from co-financing from the European Regional Development Fund (ERDF) in the period 2014-20, both in the Multiregional Operational Programme of Spain (POPE) and in regional programmes. The amounts allocated to these actions in the 2014-20 period are: EUR 1.98 billion for POPE Low Carbon Economy actions, of which around 70% corresponds to energy efficiency actions; EUR 1.3 billion for POPE Sustainable and Integrated Urban Development actions, of which 25% corresponds to energy efficiency actions; and EUR 1 billion in regional programmes, of which around 70% corresponds to energy efficiency actions.

Spain will also further benefit from the post-COVID-19 European recovery funds, whose disbursement channels will be Structural and Investment Funds and the European Social Fund. To this end, Spain's Recovery, Transformation and Resilience Plan includes a number of measures, such as financial support, to promote energy efficiency in buildings, the integration of renewables and the promotion of sustainable mobility. Specifically, the draft Recovery, Transformation and Resilience Plan promotes the acquisition of electric vehicles, deployment of recharging infrastructure, rehabilitation of buildings and urban redevelopment, integration of renewable energy in industry, etc. The national plans are expected to be approved by the European Commission in April 2021.

Energy efficiency policies in the transport sector

According to the Spanish government, the transport sector is the largest energy consumer in Spain, reaching nearly 43% of Spain's final energy consumption in 2019, with private vehicles responsible for 15% of total final energy consumption.

As such, transport is a priority area within the NECP and in the draft Law on Climate Change and Energy Transition. In particular, the government plans to cut consumption

and lower emissions in the transport sector by promoting a sizeable modal shift in mobility, accounting for 35% of the passenger-kilometres that are today carried out by internal combustion engine vehicles.

In this regard, like the NECP, the draft Law on Climate Change and Energy Transition includes the designation of low-emissions areas with limited access to the most polluting vehicles in all cities with over 50 000 inhabitants from 2023 onwards. These jurisdictions will develop sustainable urban mobility plans toward this end. In order to enforce such requirements, regional and local administrations will play a critical implementing role.

Another component for boosting efficiency and decarbonising the transport sector is fuel switching toward renewables, which is targeted to reach 28% in transport by 2030, mainly through electrification and the use of advanced biofuels. To this end, the draft Law on Climate Change and Energy Transition will require the installation of charging points in petrol stations with sales over 5 million litres.

In the longer term, Spain will adopt measures to improve vehicle efficiency in accordance with European regulations. Based on standards, new passenger cars and light commercial vehicles are expected to gradually reduce their emissions to reach 0 g CO_2/km no later than 2040.

The NECP outlines several measures in the transport sector over the 2021-30 period to lower energy consumption and reduce emissions. These include:

1. **Low-emissions zones and modal shift measures:** Focusing on urban transport, the government plans to work with local governments to discourage the use of private vehicles in favour of shared use systems and other modes of transport such as walking and cycling. Measures will include the establishment of low-emissions zones, restrictions on private transport (such as restricted access in concentrated urban zones for polluting vehicles), and increased spending on public transport and related infrastructure. The estimated energy savings for this measure is 5 622.9 ktoe of cumulative final energy savings in the 2021-30 period and its total cost is projected to be EUR 3.14 billion in public investment.

2. **More efficient use of the means of transport:** Reducing final energy consumption from public and private vehicle fleets in road and rail transport will be achieved through actions such as fleet audits and centralised technology systems to manage fleet energy consumption. The target for this measure is 2 221.4 ktoe of cumulative final energy savings and its estimated cost is EUR 73 million (out of which EUR 22 million is public).

3. **Renewal of the vehicle fleet:** The government plans to promote upgrades to more energy efficient vehicles, especially for urban delivery fleets and taxi services through car scrappage schemes, tax incentives, financing instruments and restrictions for older vehicles. This measure is expected to result in 2 519.6 ktoe of cumulative final energy savings and EUR 77 million of investment (public and private).

4. **Promotion of electric vehicles:** With a very low current penetration rate for electric vehicles (EVs), the government plans to deploy public charging infrastructure and targets to reach a fleet of 5 million EVs by 2030. The Ministry of Finance will also assess prospects for further altering the vehicle registration tax.

Accumulated final energy savings over the 2021-30 period are estimated at 3 524.2 ktoe/year, while the total investment associated with increased use of EVs is EUR 132.4 billion. The government projects public financial support of EUR 200 million per year over 2021-25, and estimates that after 2025, price parity for EVs will not require any more public support.

The NECP also includes measures to promote the transfer of goods and passengers from road to rail, electrification of railway networks and increasing electricity supply to ships in ports. Moreover, it aims to increase the role of biofuels in aviation and achieve greater energy efficiency in the sector.

The government also places due consideration on helping its automotive industry implement measures that facilitate the development and penetration of EVs. As such, in June 2020, it presented its aid package for the COVID-19 pandemic for the domestic auto industry, which represents 10% of the country's GDP and 19% of its exports, supporting up to 2 million direct and indirect jobs (second only to Germany in Europe) (Morgan, 2020). The stimulus package – called the Plan to Boost the Value Chain of the Automotive Industry, towards a Sustainable and Connected Mobility – includes 20 measures that cover the entire value chain of the industry.

The plan has a budget of EUR 3.75 billion and includes green measures to incentivise increased production and the purchase of cleaner vehicles. The transport efficiency component will consist of funds from the general state budget as well as the FNEE, which may be co-financed with money from the ERDF. Measures include:

- Plan RENOVE (EUR 250 million), aimed at upgrading the private vehicle fleet, which in Spain has an average age of 12 years.
- Plan MOVES II (EUR 100 million), to promote the acquisition of alternative fuel vehicles, EV charging infrastructure, electric bicycle systems and sustainable mobility programmes by companies and municipalities to adapt cities to the crisis caused by the COVID-19 pandemic.
- Plan MOVES Singulares II (EUR 30 million), to promote innovation in electro-mobility and green hydrogen for transport, storage and the use of information technology for the management of fleets, especially for road freight transport and last-mile solutions.
- DUS Program (ERDF), aimed at municipalities to promote modal change in cities through the implementation of urban mobility plans.

To further support the uptake of EVs, Spain is actively promoting the deployment of electric charging infrastructure from relatively low levels at present. The National Action Framework for Alternatve Energy in Transport was approved in December 2016 in response to EU Directive 94/2014 regarding the deployment of trans-European alternative fuel infrastructure. Currently, public EV recharging in Spain is a liberalised sector, with companies (and consumers) responsible for gradually deploying recharging services based on demand in the sector. More recently, the government announced it will add a new basic requirement HE6 to the Technical Building Code, which establishes the conditions for developing the minimum infrastructure necessary for smart charging of electric vehicles in parking lots. A public consultation on the plan is still underway, but the working draft of the plan includes requirements for new residential buildings from 2023: the pre-installation of charging infrastructure in 100% of new residential parking lots and 20% of the parking spaces in new commercial parking lots; one charging point per

40 parking spaces in new residential buildings, with one point as a minimum; and one charging point per 20 parking spaces in new public buildings.

In addition to the above-mentioned policies and measures, Spain also has additional strategies and efforts underway in the transport sector. These include a Sustainable and Connected Mobility Strategy that is currently under discussion; a draft Law on Sustainable Mobility and Financing of Public Transport, which is in process; a comprehensive review of environmental taxation by the Ministry of Finance that could lead to a new framework for taxation that better facilitates a low-carbon transition in the transport sector; and a public consultation on transport's role in the Long-Term Strategy.

Spain is also taking steps to bolster consumer awareness and public support for the energy transition in the transport sector. This includes European projects that collect data related to charging/refuelling points for alternative fuels and fuel price comparisons that will allow citizens to access information and take informed decisions on fuel consumption. The IDAE has also developed a web platform that includes a guide on commuting options, best practices, a directory of automobile companies and an automobile cost calculator. Royal Decree 28/2020 will further support options to encourage teleworking and reduce fuel consumption from commuting.

Energy efficiency policies in the industry sector

Spain's efforts in the industrial sector have focused on promoting programmes to improve technology and industrial process management systems. These programmes seek to not only substitute equipment and industrial installations that have poor energy performance with those that use more efficient technologies, but also to promote the realisation of a greater number of energy management systems in industry. These programmes operate in both small and medium-sized enterprises and large companies in the industrial sector, especially in facilities not included in the EU Emissions Trading System (ETS).

The main programmes executed to date are:

1. Program for the Promotion of Industrial Competitiveness, whose objective is to stimulate business investment that will contribute significantly to the generation of added value in industry. The programme has supported investment plans to improve operations at industrial facilities through changes and modifications that would have a major impact on their competitiveness. Active since 2013, the programme is organised annually.

2. Aid programmes for energy efficiency actions in small and medium-sized enterprises and large companies in the industrial sector supported by the FNEE, with the aim to incentivise actions in the industrial sector that reduce CO_2 emissions by improving energy efficiency and reducing final energy consumption.

The first call for projects, managed by the IDAE, was held from 5 May 2015 to 5 May 2016, while the second call, also managed by the IDAE, was held from 1 January 2017 to 31 December 2018. The third call has been managed by the autonomous cities and communities, and ran through 31 December 2020. The first call resulted in EUR 215 million in investments (with public support of EUR 69 million), while the second call resulted in EUR 681 million in investments (with public support of EUR 158 million).

Based on the positive results seen so far, the government plans to continue such programmes, along with voluntary agreements with the representative associations of more energy-intensive subsectors.

The NECP outlines one measure for the industry sector, "Improvements in the technology and management systems of industrial process." This measure aims to facilitate the use of final energy-saving technologies, replace equipment and implement energy management systems, especially in facilities not included in the EU ETS. This measure has been designed in a similar way to the programmes to promote energy efficiency in the industrial sector launched in Spain by the FNEE, from May 2015 to 2019, mentioned above. The measure aims to achieve 10 256 ktoe of cumulative final energy savings during the 2021-30 period, and will be funded by public support programmes and voluntary agreements. Total investment is estimated to be EUR 7.37 billion, with public support of EUR 1.647 billion.

Since February 2016, large companies have been obliged to carry out an energy audit every four years. This requirement covers around 85% of the total final energy consumption of all facilities located in Spain. Responsibility for the inspection of energy audits falls on the autonomous communities. A public Administrative Registry of Energy Audits was created by MITERD, which reflects the information from 34 423 audits to date, as well as voluntary submissions from other companies that have carried out audits. However, there is no comprehensive database of large companies in each region that fall under this obligation, so compliance is unknown, nor are there consistent penalties for non-compliance.

As an alternative, companies may apply an energy or environmental management system certified by an independent body in accordance with the corresponding European or international standards, such as the ISO 50001 energy management system, provided that the system includes an energy audit. However, the information collected in the official report that is sent to the Administrative Registry of Energy Audits does not specify whether a company has ISO 50001 certification. Moreover, there is no official registry of companies that have this certification, though the Association of Energy Efficiency Companies maintains a list.

Under the NECP, energy audits and management systems will also be promoted across the private sector. Public aid and support will help finance such audits, using the obligatory energy audits as the main assessment tool to define the eligible investment required to achieve savings. They will also promote energy audits in small and medium-sized enterprises that are not obligated to conduct audits.

The NECP also calls for increasing energy efficiency considerations for public procurement. Spanish legislation has a regulatory framework that promotes the use of energy savings and efficiency criteria in the procurement processes for goods, services and buildings by public administrations, including regional and local governments. Relatedly, the NECP also calls for increased professional and academic training in the area of energy efficiency.

Energy efficiency policies in the buildings sector

The Technical Building Code, approved by Royal Decree 314/2006, is the regulatory framework that establishes the basic quality requirements that buildings and facilities must meet. It was modified in December 2019 to comply with the latest EU Energy Performance

of Buildings Directive (EPB). In particular, the Basic Document of Energy Saving, which is mandatory for new and refurbished buildings, was amended to more clearly define nearly-zero energy consumption buildings. The new definition sets a more ambitious limit of a 40-60% reduction in energy consumption, improvements in thermal envelope requirements, tighter conditions for controlling energy demand, conditions for thermal installations, conditions for lighting installations, a minimum contribution of renewable energy to cover the demand for hot water and a minimum generation of electricity from renewable sources.

A new royal decree is expected to update the certification procedure for buildings. The broadened scope will include new buildings, sold or rented buildings, public administration buildings, deeply renovated buildings, and buildings greater than 500 square metres (m^2) for certain uses such as commercial activities. The amendments will transpose requirements from the EU EPB with respect to improvements to the quality of certification of buildings, including on-site technical evaluations, reduction of certification validity for poorly performing buildings, and more specific information during the certification about opportunities for improvements to building elements with the greatest efficiency impacts, notably the envelope, thermal installations, and automation and control systems.

At the same time, the government is preparing a new Royal Decree for the Regulation of Thermal Installations in Buildings, also in line with EU EPB requirements. The amendments are expected to be approved in 2021. The scope will remain focused on space heating, space cooling and water heating in new and renovated residential and commercial installations. The amendments will adapt to the new EU ecodesign requirements for equipment; tighten energy efficiency requirements, including imposing improvements to avoid oversized equipment and adjust working temperatures for heat pumps; district heating and cooling consideration in buildings and thermal installations (see below); and digitalisation of buildings.

The government also provides financial support for energy efficiency renovations through the Energy Rehabilitation of Existing Buildings (PAREER-CRECE) programme. Qualified projects must either include: energy efficiency improvements of the thermal envelope, space heating, space cooling and water heating installations, and lighting; or substitution of conventional energy for solar thermal, biomass or geothermal energy; or improvements to lighting installations. The programme is financed through direct grants of up to 30% and repayable loans of up to 70%. The first call under this programme was held for projects undertaken between October 2013 and May 2016 with a budget of EUR 200 million (of which EUR 181 million was executed), while the second call (PAREER II) took place from January to December 2018 with a budget of just over EUR 200 million. The average investment is EUR 291 000 per action, with an average aid of EUR 190 000 per action. To date, the majority of programme funds have supported upgrades to the thermal envelopes of buildings.

Moreover, Article 5 of the EU Energy Efficiency Directive requires that 3% of the surface area of public buildings be renovated annually in order to comply with the minimum energy performance requirements established under Article 4 of the EU EPB. Between 2014 and 2019, 1 626 214 m² were renovated, which represents 94% of the objective for 2020. The remaining area to be renovated (110 763 m²) can be compensated by exceeding the renovation objective in subsequent years. The renovation target for 2020 is 279 944 m². The NECP sets a renovation target for federal government buildings of 300 000 m^2 per year starting in 2021, which exceeds the 3% objective of the EU Directive.

For appliances, equipment and lighting, Spain follows the EU Energy Labelling and Ecodesign frameworks.

The NECP outlines the following efficiency measures in the buildings sector, several of which are already in place:

1. **Energy efficiency in existing buildings in the residential sector:** In line with an updated Long-Term Building Renovation Strategy, the government will promote energy upgrades of the existing building stock, prioritising the thermal envelope of buildings as well as thermal installations for heating, cooling and hot water. The activities will be pursued through grants and other financing instruments, building off the PAREER programme. The government expects the measures to achieve 4 756 ktoe of cumulative final energy savings over 2021-30, as well as upgraded thermal envelopes in 1.2 million dwellings at a total cost of EUR 5.5 billion, mainly funded by European Structural and Investment Funds.

2. **Renewal of residential equipment:** Focused on household appliances, with a priority to higher energy-consuming appliances such as fridges and washing machines, the government plans to increase consumer awareness and enter into voluntary agreements with manufacturers to improve communication to consumers. The market for household appliances is currently 76 million appliances. The government's target of around 2.4 million new high-efficiency appliances sold each year would create total cumulative final energy savings of 1 976 ktoe in the period 2021-30.

3. **Energy efficiency in services sector buildings:** The government will extend an obligation to renovate public buildings and offer financing options for the upgrade of other services buildings, including extending public support programmes such as PAREER and training for agents involved in energy upgrades. Support will include improvements to the thermal envelope, thermal installations and lighting systems. The measure is targeted to achieve 1 379 ktoe of cumulative final energy savings over 2021-30 from the energy renovation of 5 million m^2 per year of the public and private building stock. The total estimated public support for the measure is EUR 2.2 billion, a large portion of which is expected to come from European Structural and Investment Funds.

4. **Energy efficiency for cooling equipment and large air-conditioning systems in the services sector and public infrastructure:** The government plans to offer aid through grants and financing to upgrade large air-conditioning systems, cooling equipment, and refrigeration and freezing components, as well to improve the energy efficiency of publicly owned infrastructure, mainly street lighting and water treatment, purification and desalination facilities. The measure aims to achieve 3 350.4 ktoe of cumulative final energy savings during the 2021-30 period, and mobilise EUR 6.3 billion in investment, of which the public budget will cover EUR 3.9 billion.

The NECP also outlines cross-cutting measures that include the promotion of energy services. The role of energy service providers was incorporated into Spanish law by Royal Decree-Law 6/2010 from April 2010. Since then, Spain has approved plans and programmes with the main objective of increasing the utilisation of energy providers by the public sector. The recent publication of the Eurostat guide on accounting for energy performance contracts has helped remove one of the main barriers to investments in the

energy upgrade of public buildings. Under the NECP, energy agencies (the IDAE at the national level or others at the regional or local levels) will provide new contract templates adapted to Eurostat's recommendations and compliant with the new Public Sector Contracts Law, aimed to further support public sector energy performance contracts. For the private sector, the NECP plans for the removal of regulatory and administrative barriers to self-consumption, eventually leading to new business models based on renewables generation and demand reduction.

Spain's Long-Term Strategy also includes a plan for the energy rehabilitation of the building sector over 2020-50. The strategy includes an assessment of existing buildings, energy consumption in buildings, refurbishment of buildings, as well as past strategies and policies. It will map out objectives and scenarios as well as implementation measures and monitoring indicators.

In addition, the National Strategy against Energy Poverty 2019-2024, approved by the Council of Ministers, includes financial assistance for the energy rehabilitation of buildings.

District heating and cooling

In 2019, there were 414 district heating or cooling networks with a total installed power of 1 576 megawatts (MW). Of these, 1 189 MW were heating networks and 386 MW were cooling networks. Eighty per cent of the networks use renewable energy in their energy mix. The final energy consumption of district heating and cooling in 2017 was 41.5 ktoe, or 0.15% of the final energy consumption of the entire heating and cooling sector.

A full evaluation of the potential for the use of high-efficiency co-generation and efficient urban heating and cooling systems was carried out in 2015, in accordance with European directives. The aim was to analyse the technical and economic feasibility of high-efficiency co-generation systems and urban heating and cooling networks in Spain.

Three general groups own district heating and cooling networks in Spain:

1. Municipal district heating and cooling systems in Spain are owned by public-private associations. The ownership structure of these corporations, which are created exclusively to develop and manage large infrastructure, generally consists of one or more public organisations (municipal, regional or national) and a private operator that manages the network. This group represents more than a third of the country's total installed capacity and is expected to continue growing in the coming years. The networks are usually linked to urban renewal plans or new developments and tend to be technologically advanced, efficient and environmentally friendly.

2. Public district heating and cooling systems are generally owned by local public bodies (municipal councils or local energy coalitions) and service municipal facilities such as administration offices, sports facilities or social housing. This group represents approximately 32% of the total installed capacity and has grown steadily thanks to European financing programmes such as the European Social Fund and the ERDF.

3. Private district heating and cooling systems include systems owned by private companies to satisfy the energy demand required for their activities (hotels, farms,

business offices, educational institutions, hospitals, etc.) and residents' associations. This group represents approximately 35% of total installed capacity.

Regarding technology and fuels, in 2019 around three out of four of the networks used biomass exclusively or in combination with other fuels, typically due to their proximity to small- and medium-sized municipalities, farms and factories. On the other hand, 22% of networks use conventional fuels such as natural gas, LPG and diesel only. According to Spanish government data, the exclusive use of renewables in district heating and cooling networks has increased in recent years, from 16% in 2015 to 22% in 2019.

Although there is no specific regulation on the procedures for the authorisation, certification and licensing of heating and cooling networks, there are certain legal provisions that affect the development of heating and cooling networks in Spain. According to Royal Decree 56/2016, transposing EU Directive 2012/27 on energy efficiency, necessary measures must be taken to develop an urban heating and/or cooling infrastructure in those areas where high efficiency co-generation potential is identified. Moreover, under Royal Decree 1027/2007, which approves the Regulation of Thermal Installations in Buildings (RITE), heating systems for new buildings of more than 1 000 m^2 require a technical analysis that justifies systems choices based on energy efficiency. This analysis must include a comparison with alternative heating systems depending on the characteristics of the building and its environment, including the possibility of connecting the new building to a district heating network.

Specific programmes promoting district heating and cooling in Spain have included:

- The GIT Program: Provided financial support for large thermal energy production facilities in buildings using renewables. It was in operation between 2011 and 2020.
- CLIMA Projects: Provided funding to projects that reduce GHG emissions, operational from 2012 until 2019.
- Aid Programme for the Energy Rehabilitation of Existing Buildings (PAREER-CRECE programme): Provided aid and financing for the energy rehabilitation of buildings (see above).
- DUS: An aid programme for direct subsidies to specific projects of local entities that promoted a low-carbon economy in the framework of the operational programme of ERDF for sustainable growth in 2014-20.

The NECP includes a measure on a "Framework for renewable thermal energy development", which is focused on promoting renewable energy for thermal uses in the buildings sector, especially through the use of district heating and cooling. Actions included in this measure to promote district heating and cooling networks are:

- gather statistical annual information
- inform consumers about the renewable energy share of the district heating or cooling network they are connected to
- evaluate the potential of district heating or cooling in new urban developments through cost-benefit analysis
- development of renewable energy communities linked to district heating or cooling.

In particular, in the NECP, district cooling networks are considered one of the tools that will increase the share of renewable energy in the consumption of heating and cooling by 1.3% per year from 2020 levels.

Assessment

Spain's energy efficiency targets are driven by the EU Energy Efficiency Directive, which establishes a common framework of measures to promote energy efficiency within the European Union with the objective of improving energy efficiency by 20% and 32.5% by 2020 and 2030, respectively (relative to 2005 levels). It also establishes objectives on the renovation rate of public buildings and cumulative end-use energy savings.

Since 2015, the National Energy Efficiency Action Plan 2017-2020 has been one of the main policy documents for energy efficiency policies and measures in Spain. Spain set a target of a 24.7% improvement in energy efficiency by 2020 in the plan, which required not exceeding 122.6 Mtoe in primary energy consumption. Spain reviewed and updated the target in the NECP to 24.2% by 2020, which required not exceeding 123.4 Mtoe in 2020. According to Eurostat, in 2019, primary energy consumption was 120.7 Mtoe.

Looking ahead to the next decade, the preparation of the NECP was guided by the "energy efficiency first" principle. The NECP established an ambitious national indicative energy efficiency target of 39.5% by 2030, which is equivalent to improving primary energy intensity by 3.5% each year up to 2030, and will lead to a maximum primary energy consumption of 98.5 Mtoe in 2030.

The National Energy Efficiency Fund was created in 2014 and is the main instrument to implement measures for financial and economic support, technical assistance, training and information, and other measures to increase energy efficiency across all sectors. The fund is mainly financed by contributions of gas and electricity trading companies, operators of wholesale petroleum products, and wholesale LPG operators, amounting to around EUR 200 million a year. It will function over 2021-30, with an estimated budget of EUR 2 billion.

Under Article 7 of the Energy Efficiency Directive, Spain must achieve a cumulative final energy savings of 15 979 ktoe between 1 January 2014 and 31 December 2020, and 36 809 ktoe between 1 January 2021 and 31 December 2030. These savings will be achieved through the implementation of a system of energy efficiency obligations on certain companies (electricity and gas trading companies and wholesale operators of petroleum products and LPG), or by applying alternative regulatory, fiscal, economic, or information and communication measures to be carried out by the government. Spain has opted for a combination of both systems and has been using the National Energy Efficiency Fund to implement measures, supplemented by funds from the general state budget as needed. In 2018, the accumulated final energy savings were 14 047 ktoe, which represents 87.91% of the 2020 target.

To ensure clarity of financing, the government could more clearly define budgetary estimates necessary to achieve the objectives of each of its measures, especially as it relates to public financing. In this regard, early guidance on spending priorities for energy efficiency measures from post-COVID-19 EU recovery funds will be an important first step. To this end, Spain has demonstrated a high degree of ambition in its Recovery, Transformation and Resilience Plan with respect to promoting energy efficiency through fiscal measures across sectors, in buildings, industry and transport.

For 2021-30, 10 of the 17 energy efficiency measures presented in the NECP have been designed taking a sectoral approach, with the aim of contributing new energy savings

equivalent to 669 ktoe/year to the final energy savings target. The transport sector stands out with four measures, and will contribute with 14 Mtoe of savings, followed by the industrial and the residential sectors, with 10.3 Mtoe and 6.7 Mtoe, respectively. The tertiary and agriculture and fishing sectors represent the lowest contribution, with 4.7 Mtoe and 1.2 Mtoe, respectively.

The transport sector is the largest energy consumer in Spain, reaching nearly 43% of Spain's final energy consumption in 2019, with private vehicles responsible for 15% of total final energy consumption.

Spain set an ambitious objective for the transport sector in its NECP, including to promote modal shifts in urban areas to achieve a reduction in passenger traffic by 35% by 2030, and in interurban traffic by 1.5% per year. Other measures include: increasing the efficiency of the modes of transport used; renewal of the vehicle fleet toward the most efficient; electrification of the vehicle fleet starting with the deployment of public recharging infrastructure and a target of 5 million electric vehicles by 2030; and the shifting of goods and passenger transport from road to rail, along with the electrification of the railway network and electricity supply of ships in ports.

Furthermore, the draft Law on Climate Change and the Energy Transition foresees that from 2023 onwards, low-emissions areas will be identified in all cities with more than 50 000 inhabitants. Charging points for electric vehicles will be compulsory in petrol stations with sales of over 5 million litres.

To help the automotive sector manage a transition to produce more electric vehicles and to give an economic incentive during the COVID-19 pandemic, in June 2020 the government presented the "Plan to Boost the Automotive Industry Value Chain towards a Sustainable and Connected Mobility". This plan includes the MOVES II Program and the MOVES Singulares II Program. Both are incentive programmes for sustainable mobility and innovation, including electric vehicles and electric charging infrastructure. There is also a RENOVE Plan aimed at renovating the vehicle fleet, which in Spain has an average age of 12 years.

In addition, to improve energy efficiency in transport, the government also has plans to promote modal shifts in cities away from passenger cars to rail, public transit, walking, bicycles and shared rides. To support uptake, the government has launched public information campaigns. However, the government should also give due consideration to further supporting changes in consumer behaviour through fiscal measures, including the introduction of taxation on carbon-intensive fuels.

The industry sector is the second-highest energy consumer in Spain. Public support in this sector has focused on promoting programmes to improve technology and industrial processes and the implementation of energy management systems, through the Program for the Promotion of Industrial Competitiveness and the National Energy Efficiency Fund. Given the good results obtained so far, continuation of these types of programmes, together with the execution of voluntary agreements with representative associations of energy-intensive subsectors, are the main mechanisms of action that the NECP foresees to continue to improve energy efficiency in the industry sector.

Following Article 8 of the EED, Spain imposes an obligation on large companies to conduct energy audits every four years, or as an equivalent to this obligation, to implement a system of energy or environmental management. The company audit must cover at least

85% of the total final energy consumption of all its facilities located in the national territory. There is no obligation on industry to implement the results of audits. Spain has an online Administrative Registry of Energy Audits with information on the audits carried out, which currently includes 34 423 audits. The autonomous communities are responsible for checking the quality of the energy audits. An updated central registry of companies that are required to perform an audit, which would provide a clearer view of the universe of companies under the obligation, appears to be lacking.

The NECP foresees that the financial support programmes with a sectoral focus will use the mandatory energy audits as the main assessment tool to define eligible investments. The government will also promote energy audits in small and medium-sized enterprises that are not under the directive's obligation. To date, however, the success of energy audits in Spain is unclear. Rather than enforcing audits through a penalty system, the government could consider boosting incentives to businesses to increase compliance.

In the buildings sector, Spain has implemented the EU Energy Performance of Buildings Directive. The Technical Building Code was amended to introduce new energy efficiency requirements, including improvements in the nearly-zero energy buildings definition. The Regulation of Thermal Installations in Buildings and the Energy Performance Certification will also be amended, in accordance with the directive.

The programmes for the Energy Rehabilitation of Existing Buildings (PAREER-CRECE and PAREER II), with a budget of EUR 404 million, supported the energy renovation of existing buildings from 2013 to 2018, enabling the renovation of around 80 000 homes through measures to improve the energy efficiency of the thermal envelope (facades, roofs and walls); thermal installations for heating, air conditioning and hot water (including solar thermal); lighting installations; and substitution of conventional energy for biomass and geothermal energy. A similar programme was recently approved, with a budget of EUR 300 million until 2021, and may be extended until 2030, using the energy certificate as the basis for public support. Given that the existing building stock consumes around 30% of final energy, its renovation is a priority; the NECP set a target of 1.2 million home renovations by 2030. This objective has also been included in the Long-Term Strategy for Energy Retrofitting in the Building Sector in Spain.

Regarding public buildings, Article 5 of the EED requires that 3% of the total floor area of buildings owned by the central government be renovated each year to comply with at least the minimum energy performance requirements established in the Energy Performance of Buildings Directive. From 2014 to 2019, 1 626 214 m² were renovated, which represents 94% of the objective to 2020. The NECP foresees, from 2021, a renovation rate of 300 000 m^2/year and extends this obligation to all autonomous regional and local administrations. Given that the public sector represents a sizeable share of the market for energy efficiency in Spain, robust implementation frameworks in this sector are critical.

Energy efficiency requires strong co-ordination of national, regional and local authorities. At the national level, MITERD is responsible for energy policy and legislation, through the Secretary of State for Energy. The General Sub-Directorate for Energy Efficiency and the Institute for Energy Diversification and Saving are key players and report to the Secretary of State. In Spain, energy efficiency policies and measures are often implemented at the regional and municipal level, so MITERD develops these policies and measures in co-ordination with the autonomous communities. These organisations should continue to work hand-in-hand in a proactive development of appropriate policy options,

implementation and follow-up. There is also a need for multi-level stakeholder dialogue, including business, non-governmental organisations, and regional and local stakeholders, which are ultimately responsible for implementing many of the energy efficiency measures.

Furthermore, bolstering the technical capacity of central, regional and local governments to hold tenders, monitor audits and implement the identified measures will be a critical element to helping meet efficiency targets, especially in the industry and buildings sectors.

Recommendations

The government of Spain should:

- Step up implementation of measures that support the renovation of existing buildings in order to improve energy performance and thermal comfort. Prioritise deep renovation of public buildings and residences owned or rented by vulnerable consumers in order to reduce energy poverty and increase thermal comfort.
- Accelerate the deployment of public charging infrastructure for electric vehicles and support an infrastructure expansion to enable a modal shift of goods and passengers from road to rail.
- Consider an obligation on companies to implement measures that emerge from energy audits with short payback periods; also, use information from energy audits to prioritise financial support for specific energy efficiency measures.
- Enhance the technical capacity of central, regional and local governments to include energy efficiency criteria in tenders, and monitor the effectiveness of energy efficiency audits.

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5. Renewable energy

Key data

(2019)

Renewables in total final energy consumption (TFEC): 13.8 Mtoe/17.3% of TFEC (bioenergy* 6.4 Mtoe, wind 4.1 Mtoe, hydro 1.8 Mtoe, solar 1.5 Mtoe)

IEA median (2018): 15.5% of TFEC

Renewables in electricity generation: 101.1 TWh/37.3% of total electricity generation (wind 55.7 TWh, hydro 24.7 TWh, solar 15.1 TWh, bioenergy* 5.6 TWh)

IEA median: 38% of electricity generation

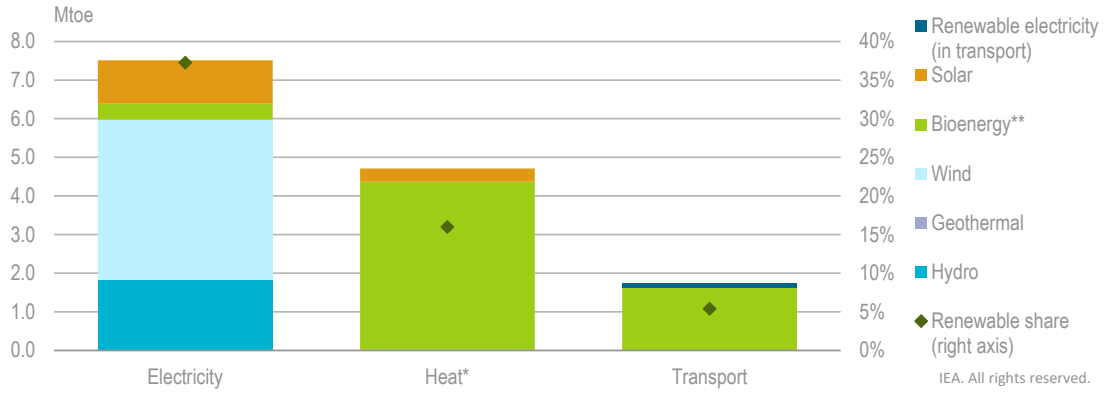
* *Bioenergy* includes solid primary biofuels, liquid biofuels and biogases, and excludes non-renewable industrial and municipal waste.

Renewable energy in total final energy consumption

Renewable energy in total final energy consumption (TFEC) in Spain consists mainly of renewable electricity, which covers more than half of renewables use, but also includes direct use of bioenergy for heat and transport (Figure 5.1). However, while more than one-third of electricity was produced using renewable energy in 2019, only 16% of energy used for heat came from renewable energy in 2018 and an even lower share (6%) was recorded in the transport sector, where the introduction of renewable energy is more challenging.

Renewable electricity was generated mainly using wind and hydro in 2019, covering together almost one-third of total electricity generation, with additional relevant shares of solar and bioenergy. Renewable heat and transport were instead dominated by the use of biofuels, with small shares of solar in heat and renewable electricity in transport.

Figure 5.1 Renewable energy in total final energy consumption in Spain, 2019



Significant shares of wind, hydro and solar brought the share of renewables in electricity up to 37% in 2019. Bioenergy was instead the main renewable source for heat and transport.

* Heat share of renewables refers to 2018.

** *Bioenergy* includes solid primary biofuels, liquid biofuels and biogases, and excludes non-renewable industrial and municipal waste.

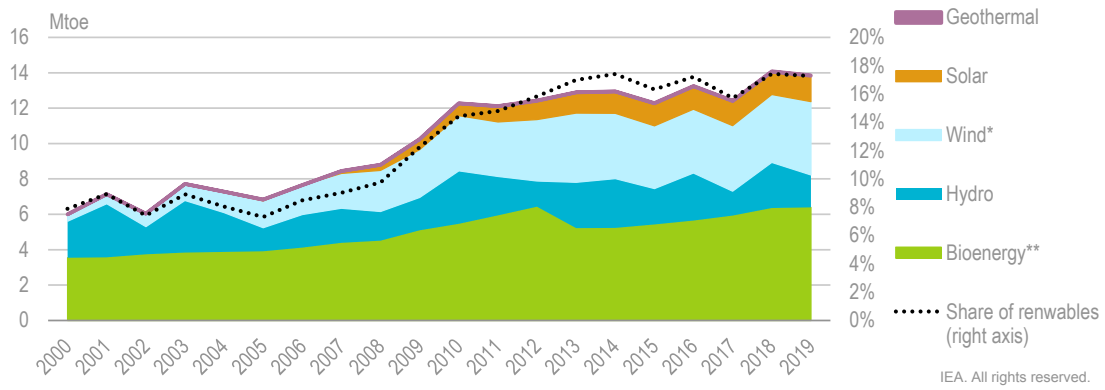
Notes: Mtoe = million tonnes of oil equivalent. Heat includes direct use of renewable energy and renewable district heating in industry, and residential and service buildings (including agriculture). Electricity refers to final electricity consumption in the same sectors, with the breakdown by fuel based on domestic electricity generation. Electricity used for heating is included under electricity due to limitations in statistical data collection.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The use of renewables in TFEC increased by 35% in the decade between 2009 and 2019 (Figure 5.2). A significant increase in electricity from wind drove this growth; in 2019, wind power generated more than 55 terawatt hours (TWh). Solar energy has also experienced a significant increase in recent years, with its contribution increasing twofold between 2009 and 2019. Bioenergy and hydro have contributed to Spain's renewable supply for longer, though energy supply from bioenergy also increased by 23% in the decade 2009-19, while electricity from hydro has experienced fluctuations caused by variability in water supply over time.

The increase in renewables share was particularly strong between 2005 and 2013, increasing by 133% in eight years. However, since 2013, renewable energy in TFEC has stabilised, with only a 1.6% increase in the five years between 2013 and 2018. This was caused by a marked slowdown in the installation of wind and photovoltaic (PV) plants, after a sizeable reduction in previous feed-in tariffs.

Figure 5.2 Renewable energy in total final energy consumption in Spain, 2000-19



Renewable energy consumption grew by 35% in the decade 2009-19, mostly driven by growth in renewable electricity from wind and solar.

* *Geothermal* contribution is minimal, but grew from 5.4 kilotonnes of oil equivalent (ktoe) in 2000 to 18.8 ktoe in 2019.

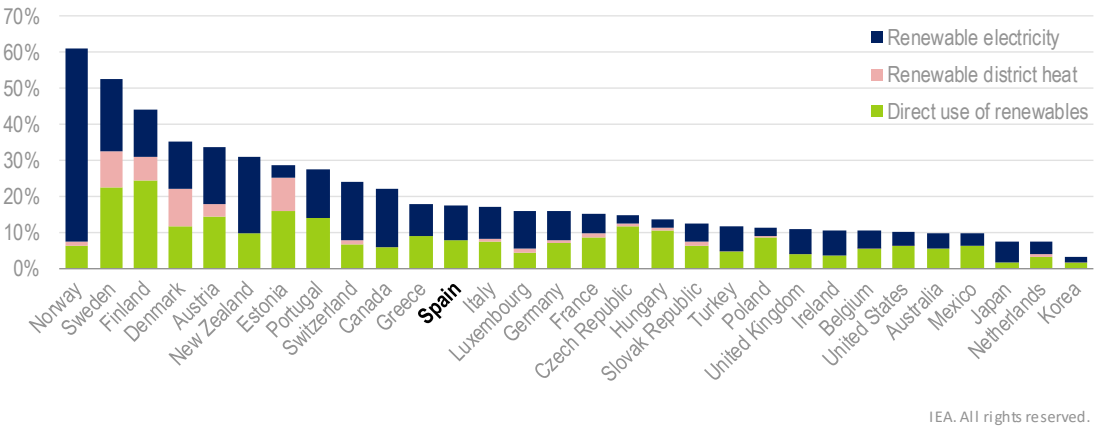
** Direct use of bioenergy, including mainly solid primary biofuels used for heating in the residential sector and minor shares of liquid biofuels used in transport and renewable district heat.

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Compared to other IEA member countries, in 2018, Spain had a share of renewables in TFEC (17%) that was slightly higher than the IEA median of 16%. Its renewable mix was equally divided between direct use of renewables and renewable electricity, with no reported contribution from renewable district heat (Figure 5.3).

Figure 5.3 Renewable energy as share of total final energy consumption in IEA countries, 2018



Spain ranked slightly higher than the IEA median for the share of renewables in TFEC in 2018.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

The low renewables share in transport is common in most IEA member countries; Spain ranks 11th with 6%, though in many countries the share of renewables in transport was below 5% in 2018.

Renewable energy in electricity

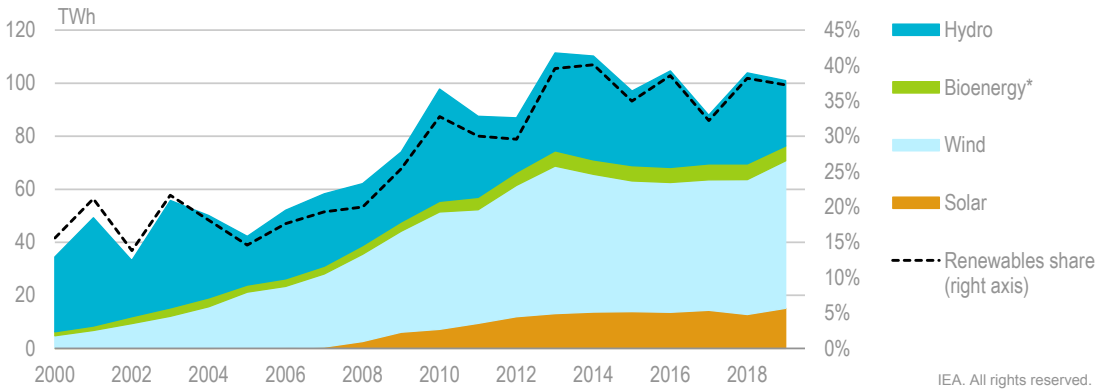
Growth of wind power in recent years drove a sizeable increase in Spain's renewable electricity in the first decade or so of the 2000s (Figure 5.4). Wind and solar contributed to 21% and 6% of total electricity generation, respectively, in 2019. This strong increase, combined with the installation of many PV plants since 2007, doubled the share of renewables in the national electricity mix, from 20% in 2008 to 40% in 2013. However, in the following years, the share of renewables in electricity plateaued, to reach 37% in 2019. Electricity from bioenergy also increased by 60% between 2009 and 2019, but its share in Spanish electricity generation was still only 2.1% in 2019. In the same decade, hydro made a fluctuating contribution to total electricity generation, ranging between 7% and 14%, due to the variability of water supply.

The EU methodology for calculating the renewable share in electricity generation uses normalisation formulas for generation from hydropower and wind. This normalisation has the effect of smoothing the contribution of hydro, as it averages the capacity factor of hydroelectric power plants over 15 years. As a result, Spain's share of renewables in electricity for the purpose of estimating progress towards EU renewable energy targets grew from around 28% in 2009 to 37% in 2019.

The increase in wind generation was particularly strong between 2000 and 2013, when installed capacity rose from 2.2 gigawatts (GW) to 22.9 GW. While installed wind capacity has stalled since then, and stood at 23.3 GW in 2018, it picked up again to 25.5 GW in 2019. Installed PV capacity had also plateaued since 2013, after growing from only 476 MW in 2007, but staged an impressive recovery in 2019 to 8.97 GW.

The share of electricity generation from renewables in Spain in 2019 (37%) was close to the IEA median (38%) (Figure 5.5). In terms of the share of wind, however, Spain ranked sixth-highest, after Denmark, Ireland, Luxembourg, Portugal and Germany. Meanwhile, it ranked seventh-highest for the share of solar.

Figure 5.4 Renewable energy in electricity generation in Spain, 2000-19



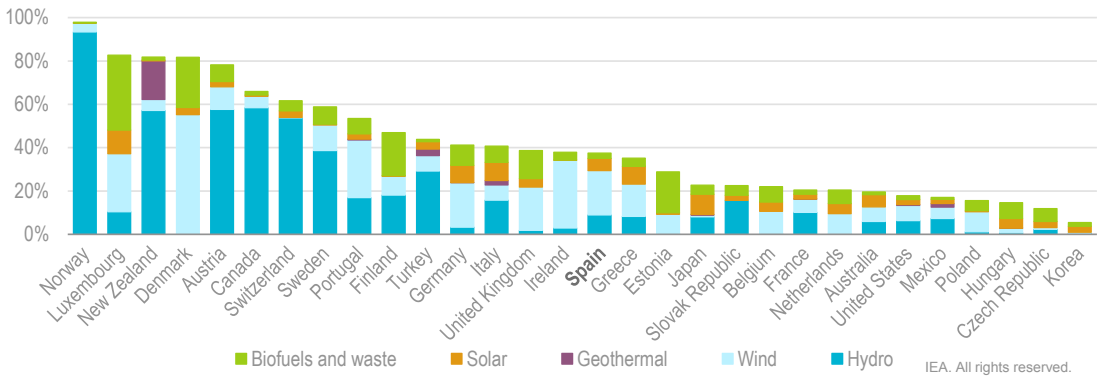
A significant increase in wind and solar has doubled the share of renewable electricity generation over the last decade.

* *Bioenergy* includes solid primary biofuels, liquid biofuels and biogases.

Note: TWh = terawatt hour.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 5.5 Renewable energy as a share of total electricity generation in IEA countries, 2019



The share of renewables in electricity generation in Spain is close to the IEA median. Spain ranks fifth in terms of its share of electricity generation from wind.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Institutional responsibilities

The Ministry for the Ecological Transition and the Demographic Challenge (MITERD), through the Secretary of State for Energy, is responsible for national renewable energy policy. Article 3 of Law 24/2013 on the Electricity Sector includes authority granted to the federal government in this matter, including the establishment and granting of remuneration for renewable electricity generation facilities. It also gives the central government authority over peninsular installations for electricity production with installed capacity greater than 50 MW, electricity installations greater than 50 MW of capacity located in non-peninsular territories whose electrical systems are effectively integrated

with the peninsular system, as well as facilities that exceed the territorial scope of an autonomous community and those located in the territorial sea.

The three main bodies under the Secretary of State for Energy for the development and implementation of renewable energy policy are: 1) the Directorate General for Energy Policy and Mines, which oversees regulatory issues: 2) the Institute for Diversification and Energy Savings (IDAE), whose main objective is to finance energy efficiency measures, including the integration of renewables; and 3) the Just Transition Institute, which finances alternative projects in regions impacted by the energy transition, including promoting renewables-based projects.

The autonomous communities can authorise new generation plants with capacity less than 50 MW, which in the past included most renewables projects, but in recent years, the average project size has increased considerably. The autonomous communities, together with local administrations, are involved in the development of policies and the implementation of programmes to support the use of renewable energy in heating and in isolated electricity networks.

The National Commission of Markets and Competition (CNMC) is the regulator, responsible for carrying out the remuneration payments for renewable electricity generation facilities. It is also responsible for managing the system of guarantees of origin of electricity from renewable sources and high-efficiency co-generation. Moreover, the CNMC was designated as the biofuel certification body, responsible for delivering certificates and verifying compliance with biofuels targets by obligated parties, though on 1 January 2021, this responsibility was transferred to MITERD.

Renewable energy policy

Renewable energy targets

Spain's renewable energy policy is aligned with EU 2020 targets, which set a binding national target for renewable energy to equal 20% of gross final consumption of energy (including 10% in transport). Spain's targets on renewable energy for 2020 and the policies and measures to meet them were initially laid out in the National Renewable Energy Action Plan 2011-2020, which set a national 2020 target of 20.8% of renewable energy in gross final energy consumption. Spain expects to reach a 20% share of renewables in gross final energy consumption in 2020, up from 18.4% in 2018.

Spain is now looking to its 2030 targets. Overall, its National Energy and Climate Plan (NECP) expects to achieve a 42% share of renewables in total end use of energy by 2030, well above the EU-wide target of 32%. This level will be led by the power sector, where the plan projects the share of renewables to grow from 42% in 2020 to 60% in 2025 and 74% in 2030. This will put Spain on a pathway toward achieving its 2050 objective to source 100% of its power from renewable sources, in line with its 2050 carbon neutrality goal. For heating and cooling, the NECP forecasts the share of renewables to grow from 18% in 2020 to 25% in 2025 and 31% in 2030. Lastly, the share of renewables in the transport sector is expected to grow from 10% in 2020 to 15% in 2025 and 28% in 2030.

Spain's domestic targets are embodied in the Bill on Climate Change and Energy Transition, which establishes targets for renewables in overall energy consumption and in

electricity generation that are similar to those outlined in the NECP. The Bill on Climate Change and Energy Transition was accepted by the government in May 2020 and is currently in parliament for debate and eventual approval.

Renewables in electricity

The overall penetration of renewables in energy will be led by the power sector, where the NECP projects the installation of about 60 GW of new renewable generation through 2030 (almost 6 GW annually), led by wind and solar, amounting to 74% of total electricity generation that year. For solar PV, the government anticipates capacity growth of around 30 GW, from 9 GW in 2020 to 21.7 GW in 2025 and 39.2 GW in 2030. For wind, the plan envisages total growth of 22 GW, from 28 GW in 2020 to 40.6 GW in 2025 and 50.3 GW in 2030.

Spain's support mechanisms for renewable electricity have seen significant changes in the past decade. After Spain introduced a Special Regime for the Promotion of Renewable Energy in 1997, wind installations picked up considerably. Following Royal Decree 661/2007, which granted priority access to the grid, more favourable conditions for larger facilities and a revision of feed-in tariff rates only every four years, solar PV installations also surged (Gürtler, Postpischill and Quitzow, 2019).

In 2012, the government began a comprehensive reform of the sector. The approval of various legislative texts, such as Law 24/302013 and Royal Decree 413/2014, resulted in a new income and expenditure regime for different actors in the electricity system and an adjustment in the remuneration for electricity from renewable energy sources, co-generation and waste, which discouraged new development. As a result, while the increase in wind generation was particularly strong between 2000 and 2013 when installed capacity rose from 2.2 GW to 23.0 GW, installed capacity stalled after 2013, and was still 23.4 GW in 2018. Solar PV followed a similar trend.

Based on Law 24/2013 on the electricity sector and Royal Decree 413/2014, the remuneration regime is made up of:

- an amount per unit of installed capacity that covers the investment costs for each installation that cannot be recovered by the sale of energy in the market
- an amount related to the operation of a facility to cover the difference between the operating costs and the standard operating income of a reference facility.

The remuneration parameters are periodically reviewed and revised to reflect market developments. Specifically, the operating remuneration of standard facilities, whose variable costs depend mainly on fuel costs, are updated at least annually. The income estimates of standard installations for the sale of energy valued at the market price, as well as the remuneration parameters directly related to these, may be reviewed every three years. The remaining (more stable) variables can be reviewed every six years, including reasonable profitability (which is modified by law). The initial standard value of investment and the useful life of an installation cannot be reviewed at any time once they are set for each installation.

Several auctions have been organised since 2015 to support the installation of new renewables facilities (Table 5.1).

Table 5.1 Renewables auction results in Spain

Year	Auction	Capacity in operation per technology (MW)				Total
		Biomass	Wind	PV	Other technologies	
2016 (January)	Wind and biomass auction 2016	195.41	458.39	–	–	653.81
2017 (May)	First renewables auction 2017	–	1 790.28	0.01	15.08	1 805.37
2017 (July)	Second renewables auction 2017	–	143.40	3 718.22	–	3 861.62
	TOTAL	195.41	2 392.07	3 718.23	15.08	6 320.79

Notes: MW = megawatt. PV = photovoltaics.

Renewable technologies in Spain participate in the market as conventional ones. The support that they receive is granted on top of their market revenues. Additionally, they have balancing obligations and can participate in ancillary services, receiving the market remuneration of those services on top of the previously mentioned revenues.

Looking ahead, to achieve its ambitious targets for renewables in electricity (74% in the NECP for 2030), Spain envisions a three-pronged strategy: 1) the promotion of large generation projects; 2) the deployment of own consumption and distributed consumption; and 3) measures to integrate renewables into the electricity system and market.

The market itself (merchant projects, power purchase agreements [PPAs], etc.) will not be sufficient to reach the ambitious capacity targets embodied in the NECP for the period 2021-30. As such, the NECP considers auctions to be the main policy support tool for the development of these technologies, in accordance with EU Directive 2018/2001 on the promotion of the use of energy from renewable sources.

Costs have dropped considerably for mature renewables technologies and they can compete with conventional technologies, but there is still sizeable uncertainty regarding the evolution of electricity spot market prices. The expected reduction of wholesale prices is having a negative impact on financing costs and conditions. Therefore, the government aims to minimise the amount of public expenditure required, but at the same time provide certainty to investors by approving a new support scheme based on competitive tendering mechanisms. Technologies that have not yet reached maturity (e.g. deepwater offshore wind, marine energy) can also opt for this public support mechanism that will be offered as part of the tendering process. The government also places a strong emphasis on community projects.

The Bill on Climate Change and Energy Transition initially called for at least 3 000 MW to be auctioned each year, with revised remuneration frameworks based on long-term recognition of a fixed price for the energy generated. However, this target was removed in the final version approved by the government in May 2020 to allow more flexibility on auction sizes based on market and technological conditions (Baratti, 2020a).

Overall, the government plans to auction around 5 GW of renewables capacity annually, though additional capacity will be needed to meet its targets, likely coming from corporate PPAs, utility bilateral contracts or self-consumption (see below). In December 2020, the government announced an indicative calendar of auctions for 2020-25, outlining minimum volumes of capacity for each technology. The calendar will be updated annually.

Table 5.2 Spain's renewable energy auction calendar

Technology	2020	2021	2022	2023	2024	2025
	Minimum total cumulative power (MW)					
Wind	1 000	2 500	4 000	5 500	7 000	8 500
Solar PV	1 000	2 800	4 600	6 400	8 200	10 000
Solar thermal		200	200	400	400	600
Biomass		140	140	260	260	380
Other (biogas, hydro, ocean, etc.)		20	20	40	40	60

Notes: MW = megawatt. PV = photovoltaics.

Source: Energías Renovables (2020), "Este es el calendario de subastas de renovables 2020-2025", www.energias-renovables.com/panorama/este-es-el-calendario-de-subastas-de-20201205.

New auctions will be conducted on electricity generation (MWh), capacity (MW) or a mix of the two. The new mechanism is based on a recognition of a price per unit of energy during a period of time and for a maximum amount of energy. In each tender, the product to be auctioned will be energy or capacity. It may be that a specific amount of energy and, additionally, certain capacity will be included in the same auction, but this would be done independently. The participant will not choose whether to bid for capacity or for energy. It will be predefined, although developers can participate in both options, for different projects. In cases where the auctioned product is capacity, the energy that will participate in the mechanism will be calculated by multiplying the capacity by an approved number of equivalent hours by the number of years. In tenders were participants bid for energy, the maximum number of equivalent hours will be used for calculating the minimum capacity that needs to be installed in order to minimise the risk of not delivering the minimum amount of energy. In principle, all renewable technologies could be supported, although specific auctions might be conducted for technologies that have certain characteristics (i.e. dispatchability, storage, etc.). Nevertheless, the majority of participation is expected to come from solar PV and wind, as stated in the NECP, due to their costs and the available resources in Spain.

In the latest renewable auction held in January 2021, the government awarded 2.036 GW of solar PV and 998 MW of wind capacity at an average price of EUR 24.47/MWh.

The government has also taken steps to address a grid access backlog that emerged in the past year with legislation passed in June 2020 (Royal Decree-Law 23/2020). A number of developers had been securing grid access without the requisite means to develop projects, creating a speculative secondary market for grid access permits. In response, the government issued a three-month time limit as part of the permitting process to advance a project; failure to do so will cause projects to lose permits and deposits (Djunisic, 2020). The changes allowed the government to clear an enormous and fictional backlog of around 430 GW of grid access applications (Baratti, 2020b).

Offshore wind, in particular, is seen as an important opportunity. Toward this end, the government is currently working on an offshore Wind Roadmap after completing a public consultation on 5 July 2020, spearheaded by the IDAE in collaboration with the Secretary of State for Energy. The main focus will be to enable technological and commercial maturity of floating technologies for application in deep waters in the Atlantic Ocean and the Mediterranean Sea. Research and innovation platforms are being developed (BIMEP in the Basque Country, PLOCAN in the Canary Islands), with a special focus on islands, which have isolated electricity systems, high costs of energy and low penetration of renewable energies. Already, plans in the Canary Islands have received international interest.

Order TED/1380/2018 established the regulatory basis for granting investment aid to installations that generate electricity using wind and PV located in non-peninsular territories, co-financed with ERDF and other regional funds. The IDAE is in charge of approving the calls under this programme and oversees EUR 170 million through four auctions: 1) wind facilities in the Canary Islands; 2) PV facilities in the Balearic Islands; 3) PV facilities in the Canary Islands; and 4) a second call for wind facilities in the Canary Islands.

The subsequent Order TED/766/2020 established a regulatory framework for granting support from the ERDF and other funds to renewable electricity facilities throughout the national territory, worth EUR 110 million in competitive tenders. The funds under these programmes are designated for facilities that do not participate in the general auctions.

Beyond auctions, Spain has also witnessed notable success with corporate and utility PPAs in the past three years, led by solar power, with some of the highest levels in Europe (Bektas, 2020). Though the government does not offer explicit support to promote PPAs, the overall climate change agenda and renewables targets set by the government have helped motivate corporate interest, as has the country's abundant resource endowment (especially solar).

Spain's targets for renewables in electricity will require a sizeable buildout of new generation facilities. However, like in many other countries, new renewables installations can face local opposition in Spain, notably for wind. The government sees the development of renewable energy communities as a way to increase public support for projects. Moreover, permitting procedures in Spain can be lengthy and uneven across regions, especially in cases where environmental opposition is strong. Though the Renewable Energy Directive recommends a two-year permitting cycle and the majority of viable projects take approximately that long, some projects facing challenges can take significantly longer.

In addition, the NECP includes planned measures to upgrade electrical networks for the integration of renewables by adapting transmission and distribution network planning through the creation of new transmission nodes and the strengthening of existing ones, as well as the development of new international interconnections and underwater lines (see Chapter 7). Grid codes are also expected to be updated to keep up with changing technological developments and digitalisation, as is the definition of network connection capacity.

The NECP also foresees 6 GW of electricity storage capacity to be in place by 2030. In February 2021, the government released a National Storage Strategy to support the goals of the NECP. The strategy expands the storage necessities of Spain's energy system; beyond the referred capacity envisaged in the NECP, the strategy includes capacity from the electric vehicle fleet, behind-the-meter energy storage systems and large-scale energy storage attached to concentrated solar plants, which could result in total storage capacity of around 20 GW in 2030.

Self-consumption and distributed generation

The government also plans to expand self-consumption of renewables and distributed generation, which it considers an important component in the growing share of renewables in electricity generation (see Chapter 7).

Notably, in 2018, the government abolished a so-called "sun tax", which was a levy applied on self-consumption installations of greater than 10 kilowatts (kW) of capacity connected to the grid. The tax was considered a major deterrent to rooftop solar installations in homes and small businesses. As a result, the business case for self-consumption has considerably improved compared to previous years, and is expected to be the main driver to boost uptake.

In addition, Spain recently updated its regulatory framework with respect to self-consumption in an effort to support growth. Royal Decree 244/2019 (to implement EU Directive 2018/2001 on the promotion of the use of energy from renewable sources) put in place clearer definitions of self-consumption, simplified compensation schemes, and streamlined technical and administrative requirements.

The royal decree defines both individual self-consumption and so-called collective self-consumption, which is comprised of several participants. The government sees collective self-consumption as an attractive opportunity to expand renewables capacity as it offers more efficient use of limited space in urban areas as well as lower investment costs per user and the ability to share technical, administrative and operational knowledge.

Moreover, the royal decree also enabled the participation of new agents in self-consumption schemes, notably energy service providers that have technical know-how in the field. The administration expects this measure to reduce previous barriers to entry for self-consumption, as energy service providers can offer the best and latest technical solutions.

Renewables in heating and cooling

Spain's NECP includes ambitious plans to double the contribution of renewables in the heating and cooling sector by 2030, from 16.8% in 2015. The Renewable Energy Directive calls on member states to increase the share of renewables in heating and cooling by 1.3% annually from the level achieved in 2020 (1.1% if residual heat is excluded). However, Spain expects that the measures outlined in the NECP would make it possible to exceed this level of penetration.

In particular, the government is looking to expand district heating and cooling installations that use renewable sources from currently low levels (see Chapter 4). At present, just 0.15% of the heating and cooling sector uses district heating and cooling networks.

The government is currently undertaking a study on the potential of energy from renewable sources in the sector and on the use of waste heating and cooling, which is expected to be completed in 2021. Among other things, the assessment will include: an estimate of heating and cooling demand by sector; an estimation of current heating and cooling supply by technology; identification of any installations that generate waste heat or cooling and their potential for providing heating or cooling; a forecast of demand trends for heating and cooling over the next 30 years; an analysis of the economic potential of various technologies, including heat pumps; and an overview of the legislative and non-legislative measures that will enable this economic potential. The result of this evaluation will inform future policy actions for renewables in the heating and cooling sector. The government also plans to impose a minimum share of renewables for heating and cooling, along with financial support for eligible entities.

Led by the Ministry of Transport, Mobility and Urban Agenda, the government also plans to review and increase the energy efficiency and renewable energy requirements in the Technical Building Code, as well as the minimum requirements to be met by thermal installations, by means of the Regulations on Thermal Installations in Buildings, for all new buildings and refurbishments.

According to the NECP, the government (through the Ministry of Transport, Mobility and Urban Agenda) plans to enact financial support schemes for renewables installations in buildings or heating networks, with a particular emphasis on: upgrading solar thermal facilities; high-efficiency ambient energy equipment; upgrading biomass equipment with other high-efficiency equipment; geothermal facilities with heat pumps and direct use; hybrid systems of renewables technologies to achieve nearly-zero energy buildings; and integrated, standardised and compact heating and cooling installations.

The Ministry of Finance will also analyse the impacts of possible changes to the fiscal framework that would help to incentivise electrification and the use of renewables for thermal requirements relative to fossil fuels.

In 2020, two ministerial orders were approved establishing the basis for granting aid under a competitive system to installations for the production of electricity and heat from renewable energy sources, capable of being co-financed with ERDF funds. The aid – EUR 300 million in total – will take the form of grants, which may be accorded to the beneficiary by means of an advance, in order to facilitate the financing of projects. The projects selected in each call may be co-financed with ERDF funds. Renewable energy communities and district heating and cooling projects can be considered as part of the programme. Implementation and the budgetary allocation of the programme is carried out in close collaboration with the autonomous communities. Biomass will receive the largest portion of the budget at 34%, followed by solar thermal at 26%, renewables gases/biogas at 20%, geothermal at 13%, aerothermal at 6%, and district heating and cooling at 1%.

Support for renewables in heating and cooling has also been provided in the form of financial support to new projects of thermal production from renewable energy sources managed by energy service companies.

Additionally, the government provides financial support for energy efficiency renovations through the Energy Rehabilitation of Existing Buildings (PAREER) programme (see Chapter 4). The PAREER programme has a group of measures to promote the development of solar, biomass and geothermal energy in the residential sector.

Renewables in transport

Since the adoption of EU Directive 2009/28 in April 2009 on the promotion of the use of energy from renewable sources, renewable energy has taken on a particularly relevant role in the transport sector. The directive set an objective for the transport sector, obliging each member state to achieve a minimum share of 10% of renewables in final energy consumption in the transport sector in 2020.

In Spain, the promotion of the use of biofuels was given fresh momentum most recently in late 2015 with Royal Decree 1085/2015, which set new minimum and mandatory annual sales and consumption targets (4.3%, 5%, 6%, 7% and 8.5%, for the years 2016, 2017, 2018, 2019 and 2020, respectively). Obligated parties – which include wholesale operators of petroleum products, retail distributors of petroleum products and consumers not covered

by the aforementioned parties – can achieve the targets in a flexible manner through biofuels certificates for either diesel or gasoline. There is also a cap of 7% for first-generation biofuels within the targets. Moreover, the regulation also introduced an indicative objective of 0.1% energy content for advanced biofuels in 2020.

Biofuels are, therefore, the primary means for meeting the targets of renewable energy in transport. Among the various types, biofuels blended with or substituting for diesel (biodiesel and hydrotreated vegetable oil) are especially significant, since they account for 91% of biofuels sold or consumed in the transport sector, while bioethanol represents only 9%.

The remaining 1% of renewables in transport is made up of electrical energy produced from renewable sources and consumed in transport. It is mainly provided (90%) by electrified rail transport, where the consumption of electricity in absolute terms is higher than electricity consumption in road transport vehicles.

To continue promoting the use of renewable fuels in transport, MITERD is working on the implementation of the second EU Renewables Directive, which establishes a final objective for the penetration of renewables in transport of 14% in 2030. Furthermore, specific objectives for advanced biofuels were set for 2022 (0.2%), 2025 (1%) and 2030 (3.5%). In April 2020, the ministry launched a public consultation in order to transpose part of this directive, which was completed in September 2020. The new regulation will establish updated obligations for the share of biofuels in the transport sector, in line with the requirements of the directive. For 2021 and 2022, the government has already proposed mandatory blending levels of 9.5% (with a 0.1% indicative target by energy content for advanced biofuels) and 10% (0.2% for advanced biofuels), respectively, in order to send a clear signal to the industry. The 7% cap on first-generation biofuels will remain in place, and a 1.7% cap on biofuels from unused cooking oil and animal fats was introduced.

The overall objective for renewable energy, in line with goals to decarbonise transport, will be achieved by reducing consumption (such as by promoting modal shifts) and with the contribution of different technologies (mainly biofuels and renewable electricity).

To increase the use of renewables-based electricity in the transport sector, the government established a target to put 5 million electric vehicles (EVs) on the road by 2030. Policies to this end include lower vehicle registration taxes for EVs and financial support to the domestic automotive sector to increase the production of electric models. To further support the uptake of EVs, Spain is actively promoting the deployment of electric charging infrastructure from relatively low levels at present (see Chapter 4).

Spain's NECP promotes the use of advanced biofuels in the transport sector as one of the measures to decarbonise the energy system. In particular, biofuels will likely be the most viable solution to decarbonise several subsectors in the medium term, such as heavy vehicles and aviation.

At present, however, advanced biofuels production in Spain is very low, in some cases constrained by the limited availability of feedstocks and technological difficulties in achieving commercial-scale production. In order to increase the penetration of advanced biofuels beyond the general obligation for the sale and consumption of biofuels, the NECP foresees several measures, including: adapting the certificate system to cover advanced biofuels and biomethane; providing financial aid for advanced biofuel production facilities;

promoting facilities that produce renewable fuels with non-biological feedstocks; establishing a discrete obligation for the sale and consumption of advanced biofuels in 2021-30; promoting labelling of biofuels blends at retail stations; and establishing specific obligations for biofuels in aviation.

As a result of the measures adopted in the NECP, a 28% share of renewable energy sources is projected in transport through electrification and biofuels, well above the 14% required by the EU in 2030.

Renewable gases

Spain sees renewable gases as an important future source and carrier of energy given that it can be used across multiple sectors, including electricity, transport and industrial processes. To this end, the government has plans to promote the use of biogas, biomethane and hydrogen from renewable sources.

To date, the main renewable gas in Spain's energy system has been biogas. However, the government finds that Spain has fallen short of its biogas potential, accounting for just 1.4% of European biogas supply. Existing remuneration schemes for electricity generation at biogas plants in Spain have not proven effective at boosting its uptake. More recently, Spain has been looking into the option of upgrading biogas into biomethane to inject into natural gas networks. Of over 500 biomethane plants in Europe, only 2 of them are in Spain. In the short and medium term, the government's focus will be on boosting the production and consumption of biogas and biomethane, while it sees renewables-based hydrogen as an important longer term opportunity.

According to "Measure 1.8: Promotion of renewable gases" of the NECP, several technical and administrative barriers and mechanisms to boost the use of renewable gas exist today. Among the main barriers, the NECP identifies:

- the high cost of producing gas from renewable sources compared to gas produced from fossil fuels
- no system of guarantees of origin to trace the source of renewable gas
- the need to clarify the rights, obligations and responsibilities of all agents participating in the production, transport and marketing of renewable gas
- the need to clarify connection and access conditions
- lack of awareness among end consumers regarding equipment safety
- limited renewable gas stations.

To tackle these barriers, the plan calls for the development of road maps for renewables gases to assess their potential in Spain. The road maps will include projecting supply potential and demand, assessing technological viability and economic feasibility, as well as considering benefits to system flexibility and potential use in existing natural gas networks. The road maps are also expected to propose aid mechanisms, a system of guarantees of origin, removal of regulatory barriers and regulations related to injection into gas networks.

To this end, the government is in the process of developing a Biogas Roadmap. An initial public consultation ended in June 2020 and several working groups are currently putting together a draft road map, which will then be released for public comment before being finalised. The issue of injecting biogas/biomethane into existing grids was a particular focus area on which the government requested stakeholders' inputs.

For hydrogen, Spain currently has a consumption of around 500 000 tonnes/year of mostly grey hydrogen (made from fossil fuels), which is mainly used as a raw material in refineries (around 70%) and chemical product manufacturing (25%).

In October 2020 the government approved a Hydrogen Roadmap "A Commitment to Renewable Hydrogen". The Hydrogen Roadmap is the main tool to guide and promote the development of renewable hydrogen in Spain, taking into account the major role that it can play in the energy transition towards a decarbonised economy in 2050 as a flexible energy vector. This road map is consistent with the European Hydrogen Strategy and in line with the Bill on Climate Change and Energy Transition and the Long-Term Strategy of Spain in terms of the promotion of renewable gases, especially renewable hydrogen. The road map clearly identifies the environmental, economic and social benefits of hydrogen and indicates which sectors will offer attractive opportunities for hydrogen deployment. It provides a vision for 2030 and 2050 with specific targets, mainly focused on the installation of electrolysers as well as hydrogen use in industry and mobility. The targets will be revised every three years in order to adapt the plan to technological developments and market evolution.

Moreover, two hydrogen projects are currently in the implementation phase in Spain, one in the fertiliser sector and one to convert an old cement plant to produce hydrogen for use in mobility and thermal applications oriented toward tourism.

Assessment

In its NECP, Spain has set ambitious targets for renewables in its energy mix, aiming at installing 122.7 GW of renewable electricity capacity by 2030, primarily wind and solar. Overall, it aims for renewables to make up 42% of final energy consumption, 74% of electricity generation and 28% in transport by 2030. In line with the EU's climate-neutral strategy, Spain also aims to achieve a 100% renewables share in the electricity sector by 2050.

The share of renewables in electricity generation was 37% in 2019, on track to meet the 2020 target of 42%. Overall production of renewable energy increased by 47% between 2009 and 2019 to cover more than half of total domestic production in 2019. It should be noted that renewables targets will be easier to achieve if Spain promotes the "energy efficiency first" principle, and successfully implements its ambitious energy efficiency target of reducing primary energy consumption by 39.5% by 2030.

However, so far the uptake of renewables has mostly been limited to the electricity sector. Spain expects to reach a 20% share of renewables in gross final energy consumption in 2020, up from 18.4% in 2019. Reaching the 2030 target of 42% will require additional efforts in the transport and heating/cooling sectors, in particular.

Spain envisages installing 60 GW of renewables capacity from 2021 to 2030 (6 GW every year via auctions), together with measures to facilitate the penetration of renewables in the grid, such as increasing storage capacity by 6 GW and facilitating demand response through demand aggregators. The NECP sees auctions as the main tool for the development of renewable electricity. After a feed-in tariff scheme led to very strong growth in wind and solar installations in the first decade or so of the 2000s, subsequent changes in remuneration to existing facilities saw a marked slowdown in 2013, which continued until

2018. However, in addition to corporate PPAs, recent auctions (based on a framework introduced in 2014) have proven successful in boosting renewables capacity, including achieving significant cost reductions thanks to competitive auctions. Most of these projects have proceeded to enter into service after securing financing. As a result, installed wind capacity reached 25.5 GW in 2019, an increase of 9% compared to 2018. PV staged even more impressive growth after a period of stagnation over the last few years to increase installed capacity by 88% in 2019 compared to 2018, to reach 8.9 GW.

However, going forward, sizeable additional capacity from wind and solar will be required to reach the 2030 target. Overall, renewable capacity growth could be higher than the targets if the full schedule of annual auctions proposed are implemented and the differential between wholesale electricity prices and renewable generation costs increases enough to trigger faster corporate PPA growth and even pure merchant plant deployment. The new framework of a support scheme through auctions will help in this regard, as will recent changes to address grid access backlogs. The government should strictly implement its calendar of planned auctions to further improve investment clarity.

Given the scale of required deployment – most notably of wind – the Spanish government should not underestimate other barriers. Onshore wind and other large-scale projects are facing increasing social acceptance and land-use challenges. Addressing these issues will require inclusive and transparent stakeholder consultation processes, along with allocating some benefits of the energy transition to local communities and ensuring minimal environmental disruptions. Planned new auction frameworks that include renewable energy communities will help in this regard. Co-ordination between regional governments and the central government will also be critical to ensuring local approval.

The development of renewable energy has been a priority of Spanish energy policy, though the accelerated development of renewables generation that has taken place has presented some challenges for the management of the operation of the electricity system, especially given a very high number of small units of production scattered throughout the country. That is why in February 2021 Spain released an Energy Storage Strategy, which will help guide this important component that will improve flexibility in the electricity system to support the increasing share of variable renewables. Other flexibility resources that warrant increased attention are demand response programmes and increased interconnection capacity to neighbouring countries, notably France.

The contribution of renewable energy in heating and cooling was around 16% in 2018. To achieve the objectives set out in the NECP, it will be necessary to double this contribution by 2030. Renewable heat faces several barriers, reflecting the complexity of the sector. Achieving this ambitious target will require subsector strategies for different end uses in buildings and industry. Several policy instruments are in place to support renewables in buildings, but their ambition needs to be significantly strengthened. A number of options could be considered to accelerate renewable heat expansion, including offering tax deductions for deep renovations, putting a carbon price on non-ETS sectors, redistributing revenues to incentivise energy efficiency and renewables deployment, and/or imposing quota obligations. In a similar vein to the transport sector, the uneven distribution of taxes on electricity versus oil and gas serves as a disincentive to electrification efforts in the heating and cooling sector, and should be revisited. The government's planned National Fund for the Sustainability of the Electric System, which would reallocate the levies associated with subsidies for renewables, co-generation and waste – currently borne

entirely by electricity consumers – to energy companies across the energy system, will be an important step in this regard.

In the transport sector, the largest energy-consuming sector in 2019, more than 90% of consumption was mineral oil, with only a small share of biofuels (5%) and a smaller share of electricity (1%). The government set a mandatory blending target for biofuels in road transport fuels over 2016-20 to reach 8.5% in 2020. The government is in the process of translating NECP targets for 2030 into additional blending requirements for the coming years. However, given limits on the use of first-generation biofuels and challenges securing advanced biofuels at scale, electrification of the transport sector is also a critical component of Spain's plans to reach its renewables target of 28% by 2030. To this end, the government has laid out a target of putting 5 million EVs on the roads by 2030, supported by a buildout of electric charging infrastructure. While these measures will go a long way towards reaching the targets, the government should consider changes to its taxation schemes to lower the price of electricity compared to fossil fuels as a further incentive for successful electrification of the transport sector.

In October 2020, the Spanish government approved the "Hydrogen Roadmap: A Commitment to Renewable Hydrogen", a strategic document completely aligned with the EU strategy. Spain plans to support the production of hydrogen with regulatory and sectoral instruments. Two projects are already in the implementation phase.

Recommendations

The government of Spain should:

- Closely follow the calendar of planned auctions for new renewable generation capacity to further improve investment clarity and transparency for all participants; address local opposition to siting of projects as part of the process.
- Develop additional tools to support the production and use of advanced biofuels and provide financial support for households to switch to non-fossil heating options, such as solar heating; encourage these options to be part of all building renovation policies.
- Prioritise "energy efficiency first" to help achieve a higher renewables share in the heating/cooling and transport sectors; explore the full range of cost-effective renewable heating/cooling options and further promote sector coupling to benefit from renewable gas in the energy transition.
- Elaborate road maps and implement supporting measures in a timely fashion to support innovation of renewable energies and raise awareness for the necessity of the energy transition.

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6. Energy research, development and innovation

Key data

(2018)

Public energy RD&D budget: EUR 103 million

Energy RD&D budget per GDP:* 0.085 per 1 000 GDP units (IEA median:** 0.316)

Energy RD&D budget per capita: EUR 2.21 (IEA median:** EUR 12.9)

* Gross domestic product in 2019 prices and exchange rates.

** Median of 27 IEA member countries for which 2018 data are available.

Overview

Spain has a long-standing and well-developed national innovation system for energy technology, and has been a very active participant in European Union (EU) energy research programmes. Since 1990, fossil fuel research has represented less than 5% on average of the annual public budget for energy research and development (R&D), and this level has been at 1% since 2010, indicating an energy innovation system firmly focused on clean energy technologies.

The central policy instruments are funding programmes for multi-year applied research projects at public universities and in collaboration with the private sector. These programmes are primarily managed by the Ministry of Science and Innovation, and have been complemented over the past decade by various initiatives to support early-stage companies, engage relevant stakeholders in the decision-making process and assist large-scale demonstration projects.

Spain's National Energy and Climate Plan (NECP) identifies R&D, innovation and competitiveness as one of its five pillars, set out in accordance with the European Energy Union principle, aiming to capitalise on opportunities for economic development and job creation arising from innovation activities (EC, 2020a). The NECP acknowledges that since 2007, Spain's institutional framework for innovation policy is designed to match that of the European Commission, and has recently been updated to reflect the structure of the European Commission's next research framework programme, Horizon Europe. This mirroring of the EU framework indicates the priority given to participation of Spanish entities in competitive EU projects and securing the associated funding.

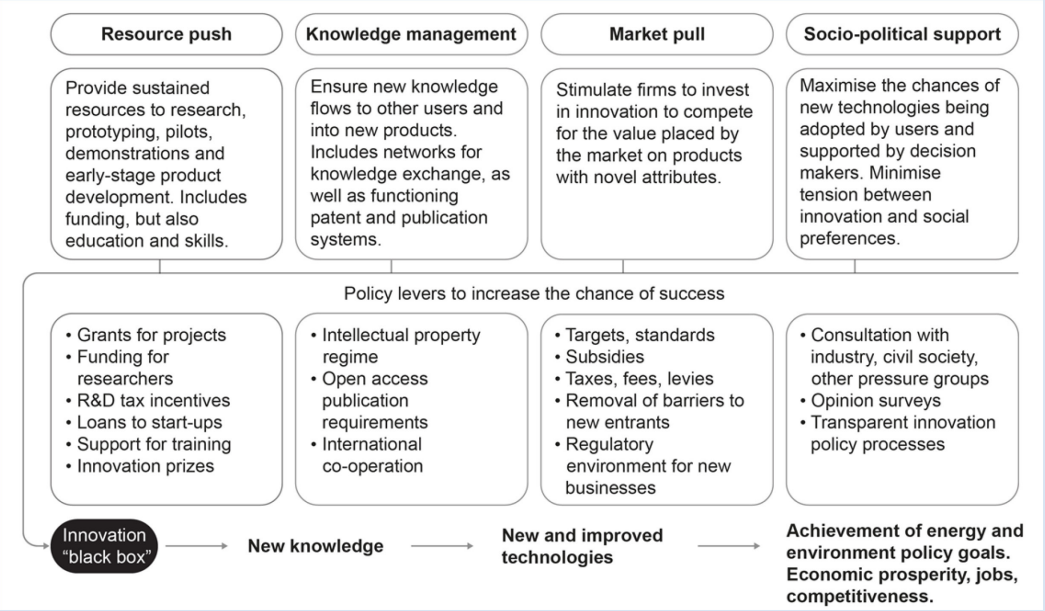
A new National RD&D Strategy was approved in September 2020, which recognises the current national energy transition ambitions as a key opportunity for innovation, and designates climate, energy and mobility as one of its six pillars. This pillar of the strategy has been designed to align with the NECP, and with other strategic policy documents, including the Long-Term Strategy (LTS).

This chapter introduces the primary priority-setting documents, followed by the main actors in Spain's energy innovation ecosystem. The implementing actions and funding are then described in sections organised by the pillars of the IEA framework for assessing energy innovation policies (Box 6.1). The chapter closes with a review of Spain's approach to monitoring and evaluation of innovation performance and an overall assessment, followed by five recommendations.

Box 6.1 IEA framework for energy innovation policies

Technology innovation processes are complex and decision makers must pay attention to a variety of elements that characterise successful energy innovation systems (IEA, 2020a). The IEA groups these elements into four core functions: 1) resource push; 2) knowledge management; 3) market pull; and 4) socio-political support (Figure 6.1).

Figure 6.1 The IEA's four functions of a successful innovation ecosystem for energy



Source: IEA (2020a), *Tracking Clean Energy Innovation*, www.iea.org/reports/tracking-clean-energy-innovation.

While the appropriate policy measures to address each function can vary widely with the size of a country's economy, the technologies it prioritises and the strength of its existing R&D base, successful energy innovation ecosystems have effective policies in each of the

four areas. In some cases, the policies might operate at different levels, such as local, national or municipal levels.

- **Resource push:** A sustained flow of R&D funding, a skilled workforce (e.g. researchers and engineers) and research infrastructure (laboratories, research institutes and universities) are required. These resources can come from private, public or even charitable sources, and can be directed to specific problems or basic research.
- **Knowledge management:** Knowledge should flow smoothly between researchers, academia, companies, policy makers and international partners, among others.
- **Market pull:** The expected market value of new products or services must be big enough to make the R&D risks worthwhile, and this is often a function of market rules and incentives established by legislation. If the market incentives are high, then much of the risk of developing a new idea can be borne by the private sector.
- **Socio-political support:** There needs to be broad socio-political support for new products or services, despite potential opposition from those whose interests might be threatened.

Energy innovation priorities and guiding documents

Spain's energy R&D priorities are set out in a number of different documents, including the NECP; the National RD&D Strategy; the Spanish Science, Technology and Innovation Strategy; the national and regional scientific and technical research and innovation plans; and the LTS.

The NECP groups priorities by thematic areas:

- energy efficiency, recognised as a transversal research area impacting multiple sectors
- renewable energy technologies, particularly those where Spain has a relatively advantageous position (wind, solar PV and solar thermal electricity), or those where Spain has "significant natural resources or a significant local implementation potential to impact learning curves" (wave and marine energy, biomass, waste to energy, and enhanced geothermal)
- flexibility and energy system optimisation, including electricity and thermal storage and hydrogen
- electric vehicle battery and infrastructure optimisation.

The current Science, Technology and Innovation Strategy 2021-2027, and the state (national) and regional scientific and technical research and innovation plans establish the RD&D and innovation activities to be developed. The national and regional plans are in turn aligned with the EU agenda defined in collaboration with member states, especially the Strategic Energy Technology Plan (SET-Plan). The objectives outlined in the documents align with those set by the European Union under the framework programmes for the financing of the R&D and innovation activities "Horizon 2020" (2014-20) and "Horizon Europe" (2021-27).

The National RD&D Strategy recognises a degree of thematic and regional fragmentation of RD&D programmes and priority setting. To address this, Spain has stated a goal of aligning RD&D across "strategic lines", i.e. adopting a more mission-oriented approach to

its innovation programmes, including through national science and innovation missions, in "micro-missions" to address knowledge gaps, and through large-scale demonstrations in selected thematic areas.

The LTS, published in November 2020, also outlines how energy innovation priority setting needs to evolve to suit the broader energy sector transformation, towards processes able to "identify priority research tracks and articulate them around missions." The innovation ecosystem needs to evolve at the European and Spanish national levels, "towards one adapted to the uncertainties of an environmental and energy transition of the proposed magnitude", and better "oriented towards intelligent management" of associated risks.

Renewable energy has been a long-standing priority of Spanish RD&D activity, accounting for around half of all energy RD&D spending since 2004 and for 63% in 2018. The NECP affords priority to energy generation from renewable sources in which there is already a competitive or leadership position, and where Spanish companies actively participate in the market. However, the National RD&D Strategy identifies the need to evolve renewable generation into new areas and applications, and places a strong focus on green hydrogen, energy storage, and renewable energy innovation in mobility and industry.

The National RD&D Strategy and NECP place a strong focus on general purpose technologies and technology areas that cut across the economy like the Internet of Things, artificial intelligence, blockchain, ICT technologies, and biotechnology and nanotechnology. Special emphasis is placed on the need to accelerate innovation in technologies and solutions that increase flexibility and facilitate the management of a system that aims "towards 100% renewables" by 2050.

In this sense, it highlights the inspiration that the Hydrogen Roadmap, published in October 2020, has taken in its own priority setting from the European Commission's Hydrogen Strategy, and notes the strategic importance for Spain of hydrogen value chains being included as Important Projects of Common European Interest. Hydrogen presently accounts for 4% of energy R&D expenditure (EUR 5 million in 2018), down from a peak of 7% in 2010 (EUR 12 million).

A number of priority areas have also been established in accordance with the country's relative advantages in "natural resources, industry and Spanish geography": improvements to facilitate deployments of heat and cold generation systems; increasing the share of renewables in urban heating networks and refrigeration, in buildings and in communities; active and passive solutions in the energy rehabilitation of buildings; and in industry, a focus on process efficiency and waste heat recovery and on the development of industrial renewables and CO_2 capture technologies.

Other power and storage technologies accounted for 17% of energy R&D expenditure in 2018, and total spending in the area has nearly quadrupled in the last ten years. Electrical storage systems and their optimisation are highlighted in the NECP, including the interface of vehicle and stationary batteries, an area where the plan underlines the importance of Spanish industry and academia. System approaches to R&D prioritisation in electricity are also highlighted in the plan, including smart grids, increased flexibility from electricity assets and renewable integration.

Nuclear R&D has been scaled down from a third of overall R&D spending in the 2000s to under 1%. Given the orderly phase-out of nuclear envisaged, the NECP notes the

importance of refocusing nuclear R&D towards securing long-term operation, and managing irradiated fuel and waste.

Digitalisation is also at the forefront of a number of prioritisation documents. The LTS includes a mention of both the impacts digitalisation is likely to have on the innovation strategy and some recommendations for accelerating digital innovation in energy. It highlights the IEA's own recommendations of establishing a level regulatory playing field for new digital technologies; guaranteeing broad access to data and data privacy; and the promotion of joint public-private initiatives in the areas of smart grids, demand response and the identification of new business models. Concrete actions on further digitalising energy systems remain to be clarified, however. The National AI RD&D Strategy, published in November 2020, does not delineate specific actions, milestones or objectives for artificial intelligence innovation in energy beyond outlining opportunities.

Spain also envisages the development of a National Industrial Plan, where the energy transition would take a central role. The plan intends to maximise the economic development and job creation potential from the energy transition.

Key actors in Spain's energy innovation ecosystem

Spain has a long-standing energy innovation system, that is currently undergoing a process of transformation and enhancement to support energy sector and other related policy objectives. The Ministry of Science and Innovation is the main delegated body for implementing government RD&D strategy, in co-ordination with the Ministry for the Ecological Transition and the Demographic Challenge and other agents.

These agents include the State Research Agency, created in 2015, which oversees the financing, tracking and evaluation in science and engineering. Among the State Research Agency's activities, the technology platforms are of particular relevance to energy. These are public-private frameworks that cut across the full innovation ecosystem, concentrate innovation efforts, and aid in priority identification and setting. Technology platforms with a direct impact on energy innovation include solar photovoltaics (FOTOPLAT), wind (REOLTEC), nuclear fission (CEIDEN), concentrated solar (Solar Concentra), mobility (Move to Future), rail (PTFE), geothermal (GEOPLAT), biomass (BIOPLAT), smart cities (SmartLiving), storage (BATTERYPLAT), hydrogen and fuel cells, and energy efficiency.

Programme implementation is facilitated by public research organisations like the Spanish National Research Council or the Centre for Energy, Environment and Technology Research (CIEMAT). Their activities are complemented by 26 technology centres and support centres for technology innovation related to energy and climate. Spanish implementation organisations, chiefly CIEMAT, are heavily involved in European R&D policy making, including through participation in all of the 14 temporary working groups constituted as part of the SET-Plan's priority-setting exercises, and intended to elaborate implementation plans for each thematic area. CIEMAT also led the Concentrated Solar Temporary Working Group.

The Centre for Industrial Technological Development (CDTI) institute helps connect basic RD&D efforts with market deployment, with the explicit aim of increasing the competitiveness of private sector enterprises. The CDTI fulfils its remit through a range of programmes that includes the new Cervera efforts for Spanish small and medium-sized

enterprises and technology and innovation centres. Finally, ALINNE (Alliance for Energy Research and Innovation), founded by the government in 2011, helps pool stakeholders and co-ordinate efforts between all the agents of the energy RD&D value chain.

Resource push

Spain ranks 33rd in the world in RD&D expenditure as a share of GDP at 1.24%, under the EU-28 average of 1.98% and the OECD average of 2.34%. In September 2020, the National RD&D Strategy set the aim of bringing this share to 2.12% by 2027. The NECP sets the long-term objective of reaching overall spending in innovation above 2.5% of GDP, and maintaining these levels regardless of economic cycles. The specific contribution of energy RD&D has been under evaluation since the publication of the NECP, intended to reflect the weight of energy in overall EU innovation ambitions. This new framework represents a key opportunity to expand RD&D research in energy, and to direct funds to strategic priority innovation areas that are key to Spain's energy policy objectives.

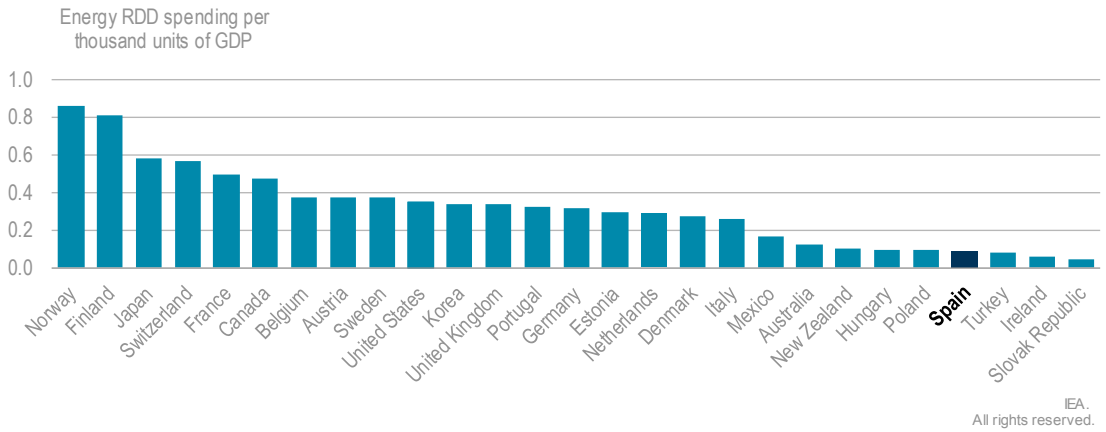
Spain's central approach to financial support for energy R&D is based on a range of public funding mechanisms, which include two flagship programmes, "Retos de Investigación" and "Retos de Colaboración". Together these accounted for EUR 154 million, almost 40% of RD&D expenditure during the period. These are largely "bottom-up" programmes in which project proposals from institutes and companies are evaluated against common criteria.

The recently approved economy-wide RD&D Strategy includes several considerations related to the establishment of a mission-oriented approach to RD&D, including the development of so-called "tractor" flagship demonstration projects in thematic areas key to the energy transition and the establishment of success indicators. Such an approach could potentially support strategic clean energy technologies and provide resources for co-ordination and long-term planning. However, the extent to which energy technologies will feature in the state and regional plans remains undecided.

Public spending on energy R&D

In 2018, the Spanish government spent EUR 103.2 million on energy-related RD&D, a 32% increase from the previous year. Despite the increase, Spain spends the fourth-lowest share of GDP of all IEA member countries on energy-related RD&D (0.0085%). Reported RD&D budgets have also fluctuated considerably. Public expenditure reached a high in 2011 at EUR 323 million, and has since declined and remained around EUR 100 million since 2014.

Figure 6.2 Energy-related public RD&D spending per GDP in IEA countries, 2018

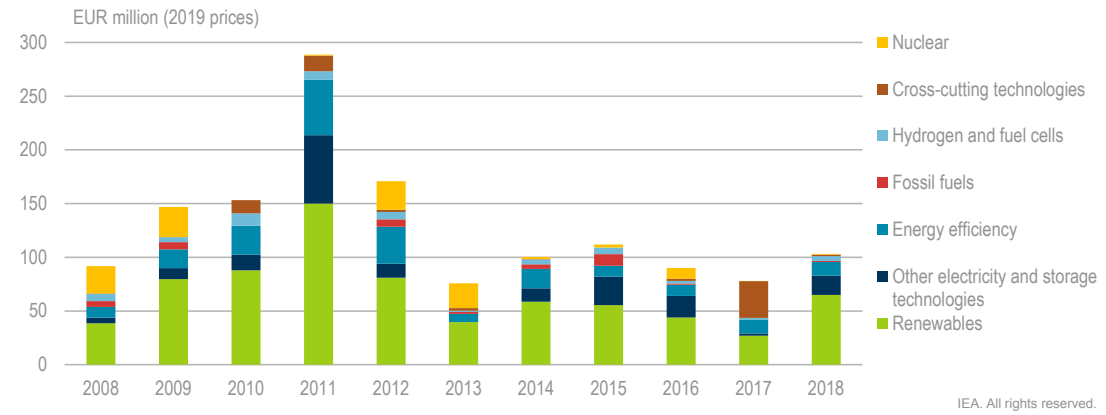


Among IEA countries, Spain ranked the fourth-lowest on energy-related public RD&D spending per thousand units of GDP.

Note: Missing data for the Czech Republic, Greece and Luxembourg.
Source: IEA (2020b), *Energy Technology RD&D 2020*, www.iea.org/statistics.

Among the key thematic areas, renewables received the largest share of expenditure, accounting for 63% of the total, half of which was allocated to wind energy. The remaining funding for renewables went to solar (26%), ocean energy (8%) and biofuels (6%). Other electricity and storage technologies received 17%. However, these were mostly directed at electricity transmission and distribution (12% of the total), with energy storage receiving just over 3%. Energy efficiency received 12%, mainly directed towards projects in the industry sector.

Figure 6.3 Energy-related public RD&D spending in Spain by category, 2000-18



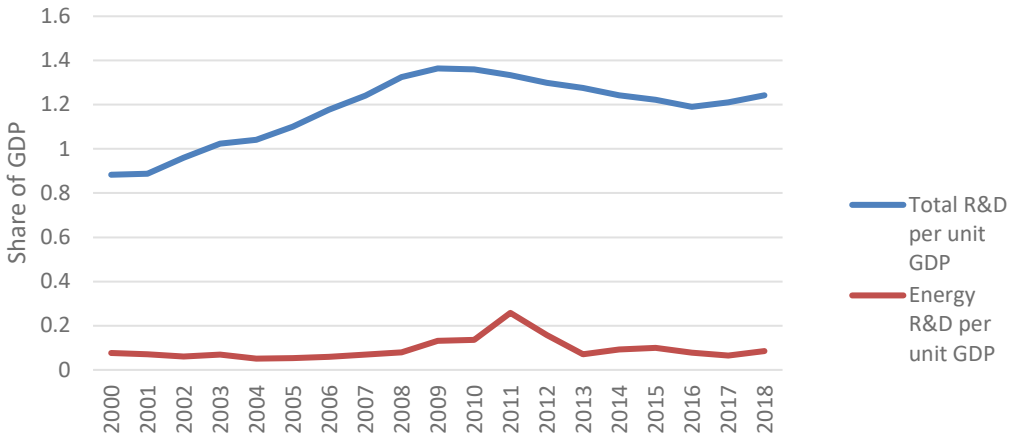
Energy-related RD&D was EUR 103 million in 2018, most of which went to renewables.

Source: IEA (2020b), *Energy Technology RD&D 2020*, www.iea.org/statistics.

Spain's innovation system experienced one of the largest reductions in government funding for R&D among OECD countries over the period 2008-15, with a decline of nearly

30% in real terms (OECD, 2017). The OECD notes low levels of execution of some parts of the public R&D budgets due to limited demand from private firms and complex management procedures.

Figure 6.4 Spain's gross domestic expenditure on total R&D, 2000-18



Source: OECD (2020), *Gross Domestic Expenditure on R&D*, https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm.

Private spending on energy R&D

In 2017, private spending on "Energy Union" R&D in Spain stood at 0.01% of GDP, slightly below the average value for the European countries with available data of 0.026%. The share of spending has remained relatively constant since 2010, declining by 0.01% (EC, 2020b).

In 2015, Spain issued 3.35 patents per million inhabitants toward Energy Union priorities, ranking 15th out of 27 EU member states. The EU estimates that Spain's private R&D efforts added 19.5% of value added in terms of real energy costs to the country in 2015, increasing by 31% since 2005 (EC, 2020b).

Education and skills

Public spending in higher education in Spain is about 20% below the OECD average, most of this coming from regional governments, which are both the main initial source and the main final spender of education funds in Spain. Spain has 30 officially recognised master's degree programmes related to energy. Master's or equivalent degrees account for the largest share of adults with a tertiary education, reflecting a stronger tradition of long first degree programmes that lead directly to a master's qualification. However, the country is below the average of students benefiting from grants, loans or other financial assistance at 43%.

Of particular relevance for the energy economy, Spain ranks 28th among OECD countries in the share of upper secondary graduates in the fields of engineering and manufacturing, with only 12% of those being women. While Spain ranks 2nd in the OECD in patenting activity by women inventors across all fields, and has a share of women researchers above the European average, their presence is concentrated in other economic sectors led by

health and welfare. While Spain ranks 18th in the OECD in the share of doctorate holders in the general population (OECD, 2019), it currently has the second-highest rate of entry into doctoral programmes and ranks above the OECD average in higher education. However, this may reflect other underlying socio-economic trends: the share of employed young adults not in education is 21 percentage points lower than in 2008, while the share of the same age group in education is about 18 percentage points higher. The National R&D Strategy also highlights a lack of internationalisation of doctoral programmes.

Analysis by the Spanish government has shown that achieving strategic energy transition objectives will require the creation of between 235 000 to 348 000 new jobs. The NECP establishes a measure to identify academic and professional knowledge formation gaps to reach these objectives, to be implemented through the Ministry of Education, the Ministry of Universities, the Ministry of Science and Innovation, and the Ministry for the Ecological Transition and the Demographic Challenge, in collaboration with the IDAE, other institutions and the autonomous communities.

Knowledge management

The NECP orients the knowledge dimension of the energy innovation system according to three guiding principles: 1) co-ordination, i.e. sectoral and regional priorities for RD&D have to be co-ordinated and aligned to maximise policy impact; 2) co-responsibility, implying that knowledge has to be absorbed by national and local government entities, the private sector, and civil society as a whole; and 3) interdisciplinarity, which underscores the cross-cutting nature of the energy transition challenge and the need to generate knowledge across different scientific and technical thematic areas.

In the area of international knowledge exchange, Spain currently participates in 19 (out of a total of 38) IEA technology collaboration programmes. One of them relates to end use in buildings while two are related to end use in electricity and four to end use in transport. Spain also participates in two fossil fuel-related programmes, six renewable energy and hydrogen technology collaboration programmes, and one cross-cutting programme. Spain is also a long-standing member of the Clean Energy Ministerial since its establishment and has led the work on renewable energy as well as participated in work on smart grids and flexible power systems. Spain is not a member of Mission Innovation, although, according to the NECP, it intends to join.

Spanish institutions are a particularly active partner under the SET-Plan and Horizon 2020 activities, particularly in the areas of solar photovoltaic and solar thermal electricity, and in energy efficiency. CIEMAT is the national representative in a number of European initiatives and takes an important role in co-ordinating international energy innovation activities. It is the national representative in the European Energy Research Alliance, one of the central SET-Plan instruments for increasing European clean energy innovation capacities. The new RD&D Strategy contemplates expanding existing instruments like the European Commission's "Intelligent Specialisation" framework, aimed at identifying priority areas of specialisation that could receive EU Cohesion Funds. The S3-Energy "Intelligent Specialisation" platform includes existing co-ordination functions on bioenergy, marine energy, smart grids, solar energy and sustainable buildings.

Finally, the Spanish innovation system has important links with Latin American countries, particularly in the areas of renewables, microgrids and energy storage. The Iberoamerican

Programme for Science and Technology for Development and the EU-Latin American and Caribbean States common interest group both develop jointly financed programmes. CIEMAT also has knowledge exchange links with UNIDO focusing on knowledge transfer for island energy solutions.

Market pull

Spain has a long-standing track record of incentivising clean energy deployment through market pull instruments, including support for variable renewables, buildings efficiency programmes, targeted support for low-carbon fuels or flagship low-carbon technology demonstrations. Framework market conditions have helped position several Spanish utilities and energy equipment manufacturers in key sectors as European and global leaders, which in turn has increased the level of corporate R&D in these sectors and enhanced the incentives for innovators. These companies include Iberdrola, Gamesa (now Siemens Gamesa), Abengoa, Acciona and Power Electronics.

The CDTI institute helps connect basic RD&D efforts with the innovation stages closer to commercialisation through a range of programmes that includes the new Cervera efforts for Spanish small and medium-sized enterprises and technology and innovation centres. In 2017, the CDTI approved 84 projects, amounting to investments of EUR 109 million and a further EUR 76 million in public commitments. Renewable energies and emerging technologies accounted for 68% of these investments. Demonstration efforts in key technology areas are carried out through initiatives like the “Plan de desarrollo de proyectos singulares”, where the national energy efficiency institute, IDAE, can participate in flagship demonstrations. These efforts are currently being furthered to create “tractor” flagship demonstration projects, as part of Spain’s recent drive towards a more mission-oriented approach to innovation.

The National RD&D Strategy, however, calls attention to a number of weaknesses in connecting the innovation push to the market; chief among these are: the relatively “low innovation capacity of Spanish companies and institutions”, despite a critical mass of innovators; relatively low levels of public-private collaboration both in terms of co-financing and implementation; low levels of knowledge transfer between industry and society at large, and protection of inventions; and a need to increase new technology capacities in Spanish companies, including related to digitalisation.

The latest *OECD Economic Survey* (OECD, 2018a) outlines several barriers to co-ordination that remain in the latter stages of the innovation process, a number of them echoed in the NECP and the National R&D Strategy. Despite progress made in simplifying and streamlining start-up requirements, the *OECD Economic Survey* notes that Spanish entrepreneurs still have to undergo a large number of different procedures, notably when they wish to activate a public limited company. Moreover, opening up and running a retail business is still difficult, with relatively restrictive licensing requirements. OECD entrepreneurship rates reveal potential entrepreneurs (those expecting to start a new venture in the next three years) are relatively scarce in Spain compared to the EU average (6.9% vs. 12.6%).

The OECD notes that further openness is required in access to the “liberal professions”, many of which are central to energy sector operations. A large number of exclusive rights

continue to be granted to professionals in areas such as accounting, the built environment, engineering and legal services. These barriers serve to increase the rigidity and inefficiency of the market for professional services in energy, imposing extra costs on firms and consumers – particularly onerous at a time of increased pressure to reduce costs.

The NECP acknowledges the need to address these barriers, and proposes two main work areas: 1) increasing the flexibility of hiring practices, including adapting them to the duration of innovation initiatives; and 2) streamlining the financial management of projects and initiatives through internal accounting.

"Market pull" needs to also drive new, key technology areas outlined in the strategy where current efforts appear insufficient. A recent OECD report on private equity investment in Spain (OECD, 2018b, highlights how only 3% of all capital invested in start-ups in Spain between 2011 and 2018 focused on digital and artificial intelligence technologies, far behind France (13%), Germany (14%) and the United Kingdom (55%).

The recently published National AI RD&D Strategy notes that current start-up activity in this space is lacking, while also listing co-ordination barriers preventing a better match of investment capital to small and medium-sized enterprises. A 2019 study by the McKinsey Global Institute that ranked European countries according to their market readiness to adopt new digital and artificial intelligence technologies ranked Spain in 11th position. The Spanish National AI Strategy notes an expected mismatch between current market readiness and the demand for these technologies, highlighting an expected 66% increase in demand for digital technology capacities by 2030.

Finally, the NECP also recognises the need for new approaches towards innovation in stages closer to the market. The central regulatory body, the National Commission of Markets and Competition, has put forward an overarching electricity market design regulation that includes a provision to support demonstrations. The NECP recognises in this measure the possibility of creating regulatory sandboxes in electricity, which other countries in Europe have been actively pursuing. These platforms are effective and desirable, as they fulfil many of the objectives of national R&D and climate strategies: they promote strong co-ordination across public and private stakeholders, and between local, regional and national levels of government; they signal opportunities for focusing industrial value creation efforts, particularly in areas the government has identified as central for the transition, including variable renewables deployment, system integration or demand-side electrification; and they attract innovation talent within the ecosystem created for testing and demonstration.

Socio-political support

Institutional governance

Spain features a relatively high degree of decentralisation of innovation activity, and the need to enhance national-regional co-ordination, as well as co-ordination across regions, is well articulated in the NECP and other strategic documents. Regions have an outsized institutional role in higher education relative to other OECD and EU countries, constituting the majority of education spending. The National RD&D Strategy underlines the important differences in RD&D spending intensity, and the high level of regional fragmentation of

RD&D programmes with over 70 public funding entities present in the autonomous communities, a number that has grown by 23% since 2017.

Efforts are underway to improve national-regional co-ordination. The process of elaborating the National RD&D Strategy included a National Science, Innovation and Technology Policy Council, whose Executive Commission was formed by regional government stakeholders and contributed to collecting and co-ordinating regional RD&D needs. The council will also have a designated role in co-ordinating regional inputs from the autonomous communities into the European S3 "Smart Specialisation programmes", a pre-condition for receiving EU Cohesion Funds for innovation.

A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis carried out to inform the National RD&D Strategy revealed that while public perception of science and innovation in Spain is high, a widespread opinion that Spain lacks a strong culture of innovation remains. It also identified rising interest in energy technologies and the transition as a key opportunity to improve social awareness and support for innovation. The NECP proposes a number of measures to address this gap, including public awareness and training campaigns or improving access to energy sector information and data.

Given the wide-ranging transformational ambitions in its energy RD&D strategy, the government of Spain is accelerating social innovation to secure further socio-political support – an area that the previous IEA review of Spanish energy policies had signalled for improvement. Within its NECP and RD&D strategies, Spain plans to support the development of social and urban innovation projects; increasing awareness and dissemination; and encouraging attitudes and behaviour that promote sustainability, efficiency and emissions reductions. Among these the government envisages more participative R&D programmes, gamification and design thinking, crowdfunding and creating an association that aggregates researchers, entrepreneurs and energy sector stakeholders to promote social innovation.

Finally, the NECP and the National RD&D Strategy articulate a shift towards a more programmatic and mission-oriented approach to innovation, including through the establishment of concrete research "lines" that encompass various programmes across institutions, flagship demonstration projects or "micro-missions" to tackle concrete techno-economic constraints. While the approach is commendable, institutional governance needs to be adapted to be able to execute such an approach efficiently. Identifying priority areas for demonstrations and technical constraints requires a system perspective and a top-down, inter-ministerial approach to priority setting – a departure from the current, bottom-up approach of rewarding excellence through pre-established programmes.

Monitoring, evaluation and tracking of results

The current bottom-up approach to rewarding excellence could significantly benefit from being coupled with efforts to improve co-ordination and alignment with energy and other national policy priorities. The 2015 IEA review of Spanish energy policies stressed the need to strengthen monitoring, evaluation and tracking systems. While efforts have not advanced significantly, a number of efforts are being strengthened or are in the planning stages.

The NECP envisages a measure for strengthening a tracking mechanism for all public aid granted under the state plans for scientific and technical research and innovation. The

state plans are intended to include the monitoring indicators for these actions, including key performance indicators for the degree of achievement of the objectives defined for each action across different execution time frames.

Assessment

Spain's recently articulated National RD&D Strategy, the NECP and LTS together form a robust framework to accelerate Spain's energy innovation capabilities and fulfil its energy transition ambitions, as well as those in other transversal policy areas, including its digital and industrial strategies or its territorial balancing efforts. As plans and programmes further unfold, a clear, coherent government-wide priority setting that is well communicated to stakeholders will be critical, one that is consistent across different strategic and programmatic documents from the different ministries involved in the energy transition. Aligning research priorities with new clean energy transition challenges is essential to ensure that the various measures and programmes are effective. Moreover, tracking and evaluation mechanisms that are able to feed back into policy and programme directions should be at the core of every programmatic effort to ensure consistency and effectiveness of RD&D efforts.

Spain's public expenditure on overall RD&D as a share of its economic output, and on energy RD&D in particular, both rank well below the EU and OECD averages, placing Spain 33rd in the world in overall RD&D intensity and 4th lowest in the IEA in energy RD&D intensity. The new overall innovation strategy aims to bring RD&D as a share of GDP to 2.12% by 2027, which while ambitious and commendable, would still fall short of the OECD average. Given the central role the Spanish government affords the clean energy transition and its strong links with and potential spill-overs into other flagship policy areas aimed at revitalising territories and boosting industrial capacities, it would seem consistent that RD&D expenditures exceed the OECD average.

The previous IEA review of Spain's energy policies in 2015 recommended the establishment of an energy RD&D strategy and agenda to aid in the prioritisation and co-ordination of programmes. Since then, ALINNE has further developed its analysis of priority technologies and started a new prioritisation exercise; however, its role is mainly an informative one. The NECP "recognises and acknowledges" the role of ALINNE, however it falls short of laying out more explicit functions and responsibilities for priority setting.

The Cervera programme has been developed in part to target specific priority technologies. Most policies and programmes, however, are not directed towards pre-identified priority areas for the Spanish economy. In the "Retos de Investigación y Colaboración" programmes, for instance, wind and solar dominate, reflecting the Spanish industry and market, but future innovation needs, for which there is no market today, have less weight (e.g. storage or hydrogen, both of which account for around 3% of funds).

Spain should be commended for aiming to restructure its innovation activities around high-level programmatic research directions, with a mission-oriented approach. Mission-oriented research is proving to be a strong tool in several countries to align actors across research, academia and the private sector, promoting the effective transfer, co-operation and sharing of knowledge, and developing and strengthening supply chains

creating opportunities for industrial development, and boosting entrepreneurship. The national RD&D Innovation Strategy stresses the need of missions to address all stages of the value chain, from bench to market scale.

The current bottom-up approach to rewarding excellence should be coupled with wider-reaching efforts to improve co-ordination and alignment with energy and other national policy priorities. The Hydrogen Roadmap is an excellent example of a broad technology area at an early stage in which several technology areas could be selected for future RD&D to match local strengths and future market potential, both internal and export-oriented. The government of Spain could consider evolving ALINNE's role into a more formal or programmatic one. Flagship demonstrations should also be pursued and targeted towards areas the government has identified as of strategic importance to energy (storage, hydrogen, circular economy, digitalisation, etc.).

Spain's objectives in RD&D, particularly those in cross-cutting areas like hydrogen, grid integration or storage where other countries are very actively developing capabilities, would benefit from a continued effort in enhancing international collaboration. Spain already actively participates in European innovation initiatives; however, its participation would benefit from increasing awareness within the energy industry and better communicating Spain's roles and achievements within EU framework programmes, including through enhancing ministerial websites. Where EU and Spanish interests overlap, participation in the EU Innovation Fund is a notable opportunity to secure co-funding.

Spain is not a member of Mission Innovation, but has stated its goal of joining it in the NECP. The thematic areas of the recently relaunched Mission Innovation programmes (which include renewables, storage and smart grids, and alternative fuels) are well aligned with national RD&D priorities and Spain's participation would be beneficial to its RD&D objectives. Finally, Spain's industrial strategy and stated NECP objectives to expand the reach of Spanish companies in novel clean technology areas could be catalysed by strengthening its innovation co-operation activity with Latin American countries. There is currently a strong presence in the region of Spanish electric utilities and energy multinationals, and beyond enhancing it, facilitating the participation of start-ups and small business in developing, demonstrating and deploying new and low-carbon technologies could yield compound benefits to innovation.

Recommendations

The government of Spain should:

- Adopt an objective-oriented approach to clean energy innovation policy, with aspirational targets for the outputs and outcomes in line with other areas of energy policy making, and monitoring and evaluation instruments using key performance indicators.
- Further develop the strategic prioritisation of technology areas in which Spain could pursue its comparative advantage and contribute to the NECP's goals (e.g. renewables integration or hydrogen).

- Engage with other governments in Europe and beyond to share and adopt best practices for governance structures that can ensure smooth flows of information between research funding bodies, technology platforms and different ministries.
- Seek to increase the energy component of the new Spanish Science, Technology and Innovation Strategy 2021-2027 spending at least in line with the overall objective to double public and private innovation spending per unit of GDP.
- Seek to adopt a survey method or other technique to track private sector energy R&D spending that is currently unavailable to government.

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7. Electricity

Key data

(2019)

Electricity generation: 271.0 TWh (natural gas 30.9%, nuclear 21.5%, wind 20.5%, hydro 9.1%, solar 5.6%, coal 5.2%, oil 4.8%, bioenergy and waste 2.4%) -7.1% since 2009

Electricity net import: 6.9 TWh (imports 18.7 TWh, exports 11.9 TWh)

Electricity consumption: 242.2 TWh (services/other 33.7%, industry 31.4%, residential 30.1%, energy sector 3.2%, transport 1.6%)

Overview

Electricity accounted for 24% of total final consumption (TFC) in Spain in 2019, the second-largest energy source after oil. Demand for electricity is increasing across all sectors, particularly in the buildings sector. In the last decade, electricity generation in Spain has seen notable decarbonisation, as the share of electricity generation from fossil fuels decreased from 56% in 2009 to 41% in 2019, while electricity generation from renewable energy sources (including non-renewable waste) increased from 24% in 2009 to 38% in 2019. The phase-out of coal has already started, with the amount of electricity from coal more than halving in one year between 2018 and 2019, mainly compensated by natural gas.

Looking ahead, the government is planning a sizeable integration of renewables, mainly wind and solar, in the electricity mix, with the target of a 74% share of renewables in 2030. In addition to a complete coal phase-out, the country is planning to start phasing out nuclear power in 2027. The forthcoming changes in the electricity mix will require an increased focus on system flexibility. To this end, the government is planning to increase interconnection capacity, mainly with France, in the coming years. Currently, the levels of electricity interconnection are still below the 10% required by the EU for 2020. Increased international interconnectivity will also need to be accompanied by upgraded national grids.

In recent years, Spain's policy for the electricity sector has emphasised the importance of affordability and addressing energy poverty. Notably, since 2018, the Spanish government has stepped up measures to ensure energy access to vulnerable customers, which became instrumental to assist households to manage the economic fallout from the COVID-19 pandemic.

Electricity supply and demand

Electricity generation

Total electricity generation in Spain was 271.0 terawatt hours (TWh) in 2019, and has gradually decreased since its peak in 2008 of 311.0 TWh (Figure 7.1). Spain has a nuclear fleet providing a constant base load of about 60 TWh/year since 1990, corresponding to 22% of total electricity generation in 2019. Fuel oil and diesel electricity generators are used mainly in the islands, and together accounted for 5% of total generation in Spain in 2019. Electricity generation from coal has decreased, especially in recent years, representing the start of a coal phase-out. In 2019, coal represented only 5% of total electricity generation, a significant decrease from 14% in the previous year.

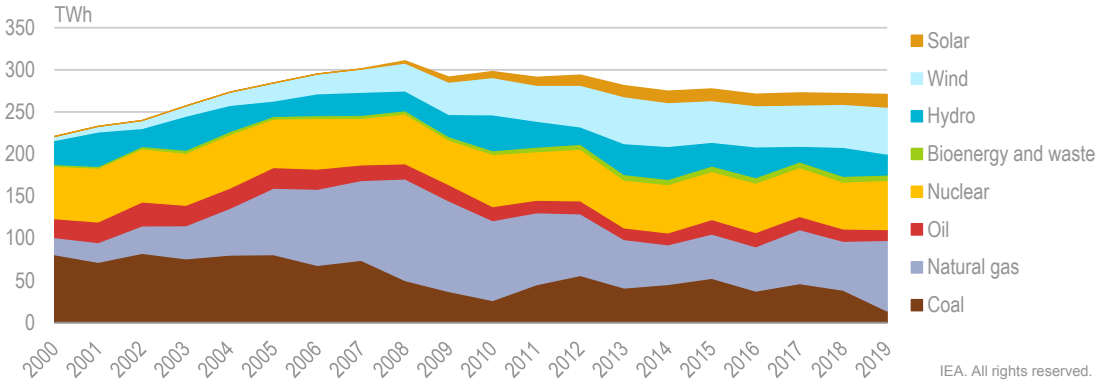
Natural gas plays a major role in the country's electricity mix, accounting for almost one-third of electricity generation in 2019. The flexibility of natural gas power plants is used to balance the coal phase-out and variability of electricity generation from renewable energy sources such as wind and solar, but also the fluctuating annual generation from hydro power plants.

Renewables have become an increasingly important source of electricity generation in the country, amounting to 38% in 2019, including wind, hydro, solar, and bioenergy and waste. Within renewables, wind (20.5%) and hydro power (9.1%) had the largest shares in 2019, while solar power (both photovoltaic and concentrated solar power) experienced a quick rise between 2008 and 2014, to later stabilise at around 5.6%. Bioenergy sources consisted mainly of solid biomass, with some shares of renewable waste and biogas, and accounted for 2.4% of total generation in 2019.

In terms of installed capacity, in 2019, Spain relied on 25 gigawatts (GW) of gas-fired power plants, 26 GW of wind capacity, 13 GW of hydro (excluding pumping), 7.9 GW of coal-fired plants, 7.1 GW of nuclear and 8.9 GW of photovoltaic panels connected to the grid, in addition to 2.3 GW of concentrated solar power. Spain also has a small installed capacity of electricity generation using tidal energy, amounting to 4.8 megawatts (MW) in 2019. Relative to peak demand, Spain currently has an overcapacity of generation in its electricity system, even in a context of recent coal plant closures.

Thanks to growth in both wind and solar generation since 2000, in an IEA comparison, Spain falls slightly below the average in terms of the share of fossil fuels in its electricity mix, while it ranked 13th highest in terms of the share of renewables in 2019 (Figure 7.2).

Figure 7.1 Spain's electricity supply by source, 2000-19

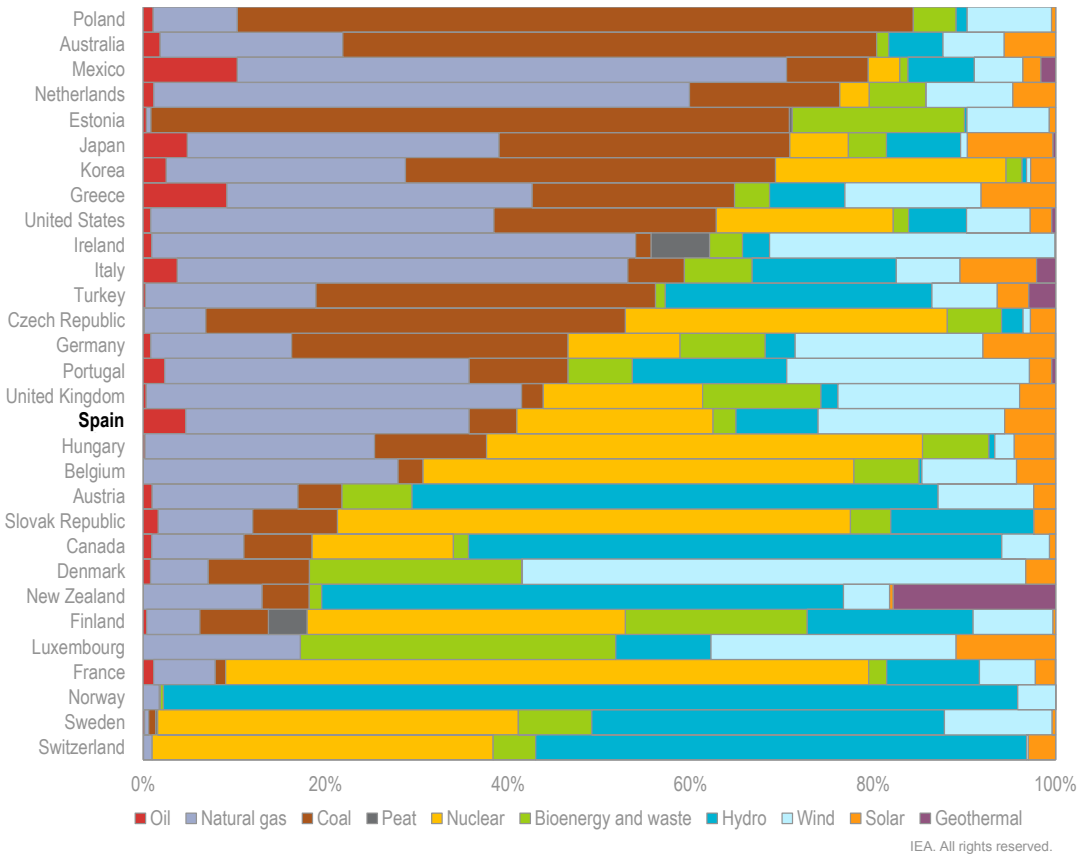


Spain's electricity supply comes mainly from natural gas and nuclear, as well as hydro and wind.

Notes: TWh = terawatt hour. Bioenergy and waste includes non-renewable waste. Considering the marginal difference between waste from renewables exclusively and waste including non-renewable sources, the present review incorporates non-renewable waste.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 7.2 Electricity generation by source in IEA member countries, 2019



Spain's share of renewables in electricity generation is slightly below the IEA average.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

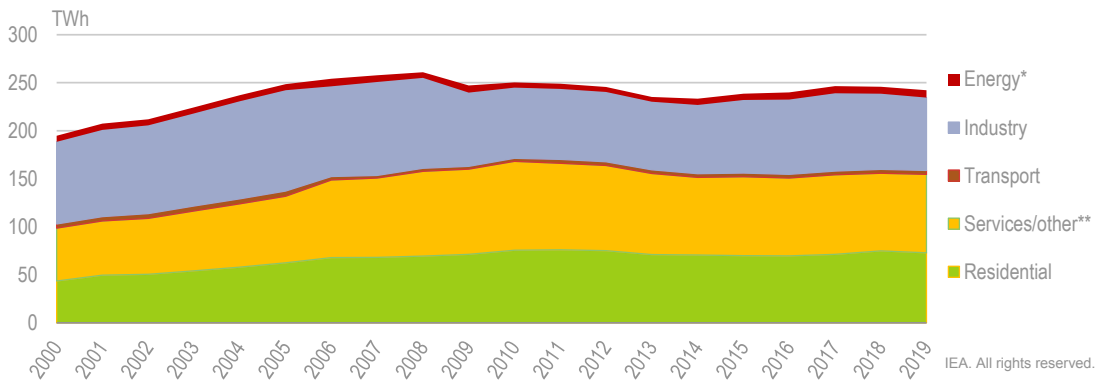
Electricity demand

Industry, residential and services are the main electricity-consuming sectors in Spain, accounting for about one-third each (Figure 7.3). In 2019, most electricity (82 TWh) was used in the services/other sector, which includes commercial and public services, as well as agriculture, forestry and fishing. The share of electricity in energy demand in these sectors increased significantly from 2000 to 2009, but fell again in the following years. For example, the share of electricity in the energy demand of commercial and public services decreased from 74% in 2009 to 53% in 2019.

The residential sector consumed 73 TWh of electricity in 2019. The share of electricity in the sector's energy demand has increased in recent years, from 39% in 2009 to 43% in 2019, reflecting an increase in electricity demand from residential appliances. In contrast, in the industry sector, the share of electricity in energy demand fell from 31% in 2009 to 26% in 2019. Electricity demand from industry was 76 TWh in 2019.

The use of electricity in the transport sector is still low, at 4 TWh in 2019. Despite recent efforts to increase the electrification of road transport, most of the electricity consumption in the transport sector comes from rail.

Figure 7.3 Electricity consumption in Spain by consuming sector, 2000-19



Electricity consumption in Spain is largely concentrated in the residential, services and industry sectors.

* *Energy* includes petroleum refineries and coal mines.

** *Services/other* includes commercial and public services, and agriculture and forestry.

Note: TWh = terawatt hour.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Electricity market structure

The Spanish wholesale market is part of the common European market through the Iberian power market (Mercado Ibérico de Electricidad, MIBEL), created in 2007. OMIE, the nominated electricity market operator (or exchange) in Spain, manages the spot market (day-ahead and intraday markets) while OMIP in Portugal manages the futures market. Both are part of the Operador del Mercado Ibérico (OMI, Iberian Market Operator) business group which is 50/50 owned by the Spanish (OMEL) and Portuguese (OMIP SGPS) wholesale market operators from pre-MIBEL times.

The two system operators, Red Eléctrica de España (REE) in Spain and Redes Energéticas Nacionais (REN) in Portugal, are responsible for technical management, including system security and ancillary services. MIBEL has two bidding zones, and when interconnections are congested, the markets on the Spanish and Portuguese sides see different prices. The wholesale market is competitive.

Law 24/2013 established REE as the manager of the transmission grid and granted it the function of sole transmission operator. REE was certified in 2012 by the National Commission of Markets and Competition (CNMC) as an ownership unbundled transmission system operator (TSO), and currently oversees more than 44 000 km of transmission lines. As manager of the transmission network, REE is responsible for developing and enlarging the grid, carrying out its maintenance, co-ordinating the physical flow of electricity between external systems and the Iberian peninsula, and guaranteeing third-party access to the transmission grid under equal conditions. The transmission grid is planned over six-year periods and approved by the government with a spending limit tied to gross domestic product (GDP). Spain will also be included in the European Ten-Year Network Development Plan, which feeds into the Spanish planning process.

REE is a publicly listed company, and to guarantee its independence, ownership in it is limited by law. The state must own at least 10% of shares, while other entities may hold no more than 5% of shares or use no more than 3% of voting rights. For electricity companies, the limit is 1% of voting rights. The state, via the Sociedad Estatal de Participaciones Industriales (SEPI), owns 20% of shares, while the other 80% is well diversified, with the largest owners being several investment funds with a stake of around 3% each. By law, REE cannot own any shares in companies involved in the generation or supply of electricity or gas.

Spain's electricity market is dominated by three main generators: Grupo Endesa, Iberdrola and Naturgy. Combined, they account for an estimated 50% of the Spanish electricity market by consumption volume. Their market concentration has fallen in recent years as electricity is increasingly generated by renewable energy sources, whose ownership is relatively fragmented.

Distribution companies are responsible for operating, maintaining and developing the distribution network. They are also the owners of the distribution networks. In Spain, there are 333 distribution companies; 5 of them are dominant. These 5 companies, with more than 100 000 consumers connected to their grids, are part of the main electricity companies in the country and carry out their activities in compliance with the unbundling requirements that are established in the electricity sector regulatory framework and in European law. The other companies are small ones linked to historical development of the local networks. As of 30 September 2019, the five largest suppliers supplied 84.9% of total supply points in the free market (three years earlier they had supplied 90.4%).

There is no centralised planning process for the distribution grid, although the government imposes a spending cap on distribution network plans, which are defined over periods of three years.

Electricity market operation

Wholesale markets

The wholesale electricity market is structured in forward markets, day-ahead markets, intraday markets and adjustment services (integrated by the solution of technical restrictions and balancing services). In addition to the organised markets, physical bilateral contracts are possible between qualified consumers and producers. This non-organised part of the market has increased rapidly since 2007.

The day-ahead and intraday markets (within which a distinction is made between the continuous intraday common European market, XBID, and the intraday market by auctions) cover the daily and hourly horizons, and are managed by the nominated electricity market operator for the Iberian market, OMIE.

In addition, in the day-ahead and intraday horizons, there is also bilateral contracting with freely established physical delivery between market subjects in unorganised markets.

Among the markets managed by the system operator (REE) are those related to system adjustment services, which comprise:

- Solution of technical restrictions: Adjustment service whose purpose is to resolve the technical restrictions of the system, by limiting and modifying, where appropriate, the production programmes of the generation and consumption units that resolve the identified technical restrictions with the lowest cost for the system, and the subsequent rebalancing of generation and demand to compensate for the incorporated programme modifications to resolve the identified technical restrictions (including curtailment and redispatch measures).
- Balancing services managed by market mechanisms:
  - Secondary regulation: Optional service that aims to maintain the generation-demand balance, automatically correcting deviations from the planned exchange programme of the “Spain” Control Block and deviations in frequency of the system. Its time horizon of action reaches from 20 seconds to 15 minutes. This service is remunerated through market mechanisms for two concepts: availability (regulation band) and utilisation (energy). The secondary dimming power corresponds to the European standard product of automatic reserve for frequency recovery.
  - Tertiary regulation: Service of a voluntary nature and compulsory offer managed and remunerated through market mechanisms that aims to resolve the deviations between generation and consumption and restore the secondary regulation reserve used. The tertiary regulation reserve is defined as the maximum variation of power that a production unit can make in a maximum time of 15 minutes, and that can be maintained for at least 2 hours. Tertiary regulation power corresponds to the European standard manual reserve product for frequency recovery.
  - Deviation management: The deviation management mechanism is a service of a voluntary nature managed and remunerated through market mechanisms that aims to resolve the deviations between generation and consumption that could be identified after the close of each session of the intraday market and up to the beginning of the horizon of effectiveness of the next session. Deviation management energy corresponds to the European standard balance energy product from replacement reserves.

In accordance with the provisions of EU Regulation 2017/2195, establishing a directive on the electricity balance, and in order to contribute to the development of the internal electricity market, the management of balancing markets, currently limited to the national level, will be managed through European balancing platforms for each of the services in the coming years.

The above markets are complemented by the forward markets, which are a set of markets in which, with years, months, weeks or days prior to the physical delivery of energy, electricity purchase and sales contracts are exchanged with delivery terms of more than 24 hours. These include bilateral contracts or contracting through organised markets, organised auctions or bilaterally between agents (the so-called "over-the-counter" market). In Spain, the organised electricity futures market of MIBEL is managed by OMIP.

In 2018, there were a total of 92 generators and 355 traders participating in the Spanish wholesale market. Additionally, according to the last annual report prepared by OMIE for the year 2019, the total energy traded in the day-ahead and intraday markets was 267 TWh (229 TWh on the day-ahead market and 38 TWh on intraday markets), 4% lower than in 2018.

Retail markets

According to data from the CNMC, as of 30 September 2019, the electricity market was made up of 29.5 million supply points, of which 11 million were supplied through a reference marketer (37.4%) while the remaining 18.5 million were supplied through a marketer in the free market (62.6%) (see section on regulated prices for details on reference marketers).

The same data show that five traditional suppliers supplied 84.9% of the total supply points in the free market (down from 90.4% three years prior). The other suppliers, so-called independent marketers, supplied 15.1% of supply points (up from 9.8% in three years). Among them, CIDE HC Energía (2.1% share), Fenie Energía (2%), Grupo Audax (1%), Clidom Energy/Holaluz (1%), Aldro Energía y Soluciones (0.7%) and Flip Energía (0.6%) were the largest.

On a sectoral basis, market concentration in both the small and medium-sized enterprise (SME) and industrial sectors is lower than that in the household sector. As of 31 March 2019, the share of the five main marketing groups in the household sector represented 85.9% of the total, while for the SME and industrial sectors, the shares were 64.8% and 70.3%, respectively.

The rate of switching suppliers for the quarter ending in September 2019 stood at 2.3% (by segments: 2.1% for households, 4.6% for SMEs and 6.2% for industrial consumers), representing a slight reduction during the most recent quarter ending in March 2019 of 0.2 percentage points.

The average change times of electricity suppliers were reduced to 7.4 days, compared to 7.7 days in the previous quarter (and compared to the third quarter of 2017 and 2018, when the average change time was 10.2 days and 8.5 days, respectively).

Electricity systems in non-peninsular territories

The non-peninsular territories in Spain are made up of the archipelagos of the Balearic Islands and the Canary Islands, and the autonomous cities of Ceuta and Melilla.

Production of electricity in non-peninsular electrical systems is subject to a single regulation, due to the particularities of these systems based on their size, reduced economies of scale and limited fuel supply.

For this reason, current regulations hold that electricity generation in non-peninsular territories is excluded from the peninsular supply system. It is remunerated by taking as a reference the price structure of the peninsular system, to which additional remuneration can be added to cover the specific costs of these systems that could not be covered by the income obtained. Additionally, regulations foresee the promotion of renewable energy in these systems, when technically acceptable, to reduce costs.

In this regard, the electricity generation in non-peninsular territories is excluded from participation in the liberalised peninsular electricity market (and the European internal market), and there is a mechanism for dispatching production units in order of economic merit to cover expected demand. The system operator oversees the economic dispatch of production units that must operate in each system, based on the variable costs of the generating facilities. All generation facilities participate in this dispatch, with priority dispatch granted, at equal dispatch variable cost, for facilities that use renewable energy sources.

Although production and dispatch activities in non-peninsular territories are regulated, electricity trading is an unregulated activity, with a large number of trading companies operating in these territories.

In 2019, the combined generation of non-peninsular territories was 13 712 gigawatt hours (GWh), about 5% of Spain's total.

Trade and interconnections

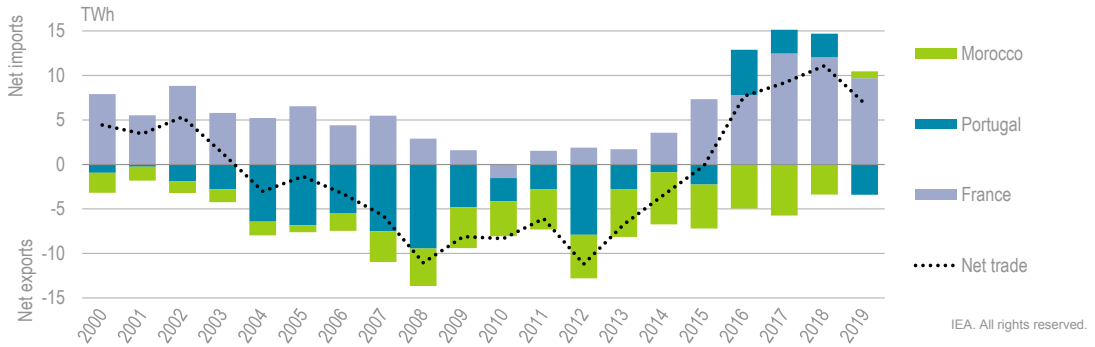
Currently, Spain is electrically interconnected with Andorra, France, Morocco and Portugal.

Figure 7.4 Spain's current interconnections with neighbouring countries

Source: REE (Red Eléctrica de España) (2021), "Map of current international electricity interconnections", Strengthening interconnections, Grupo Red Eléctrica, Madrid, www.ree.es/en/red21/strengthening-interconnections.

Spain's net trade includes imports and exports with neighbouring countries (France, Morocco and Portugal) (Figure 7.5). Spain imported 12.8 TWh from France in 2019 and exported 3.1 TWh, resulting in net trade with France of 9.7 TWh. Spain imported 4.7 TWh of electricity from Portugal and exported 8.1 TWh in 2019, resulting in 3.4 TWh net export in 2019. Lastly, it exported 0.4 TWh to Morocco in 2019 and imported 1.2 TWh. Spain's electricity trade in 2019 resulted in 6.9 TWh, with 18.7 TWh total imports in 2019 and 11.9 TWh in 2019 total exports.

Figure 7.5 Spain's electricity trade by country, 2000-19



In recent years, Spain has imported the most electricity from France, followed by Portugal; net exports were the greatest to Morocco.

Note: TWh = terawatt hour.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Interconnection with France is carried out through four direct current (DC) lines. Current interconnection capacity with France is 2 800 MW (representing a ratio to installed capacity of 2.8%), having doubled after the commissioning in 2015 of the Santa Llogaia-Baixas line. The DC interconnection project through the Gulf of Biscay, currently under construction, will nearly double interconnection capacity to France to 5 000 MW (5% of total installed capacity) once it is completed (expected in the third quarter of 2027). Given relatively low levels of interconnection at present, capacity with France was congested for 80% of hours in 2019.

Interconnection with Portugal is carried out through 11 alternating current (AC) lines. Current interconnection capacity with Portugal is 2 300 MW (2.3% of installed capacity). In contrast to France, interconnection capacity with Portugal in 2019 was congested only 5% of hours. The construction of a new interconnection between Vila Fria-Vila do Conde-Recarei (Portugal) and Beariz-Fontefría (Spain) is in the planning phase; once completed, it will increase the exchange capacity between Spain and Portugal to 3 000 MW (allowing Portugal to reach an interconnection level of 10%).

Interconnection capacity between Spain and Morocco is 900 MW in the Spain-Morocco direction and 600 MW in the Morocco-Spain direction by means of two DC submarine electrical cables.

Lastly, Spain's interconnection with Andorra is carried out through the Benós-Lac D'Oo line.

Once system operators agree – under the security criteria required by both systems – on how much interconnection capacity can be made available for commercial use, financial bidding is opened to agents, buyers and sellers, either through organised markets or through capacity auctions. The interconnection between Spain and Portugal is managed through MIBEL, whose market operator is OMIE. The commercial interconnection capacity between Spain and France is allocated through capacity auctions carried out by REE

in Spain and RTE in France for various time horizons: annual, monthly, daily and intraday. For interconnections with both Portugal and France, system security takes precedence over commercial exchanges of electricity.

The Spanish national master plans for transmission infrastructure are focused on identifying system needs in the medium term and defining sufficient and cost-efficient infrastructure projects and timelines. They are prepared in line with European planning processes (Europe's Ten-Year Network Development Plan) and incorporate ENTSO-E best practices.

Spain's interconnection capacity with the rest of continental Europe relative to its installed power capacity is still below the EU objective of 10% by 2020 and 15% by 2030. As such, Spain and the European Council continue to collaborate on the issue of electricity interconnections, including as it relates to the Madrid Declaration of 2015 between Spain, France, Portugal, the European Commission and the European Investment Bank. This is necessary to transition the Iberian peninsula away from being an energy island to create a true European energy market according to the EU Clean Energy Package published in June 2019.

After 2020, the planning annex includes the following interconnections with France:

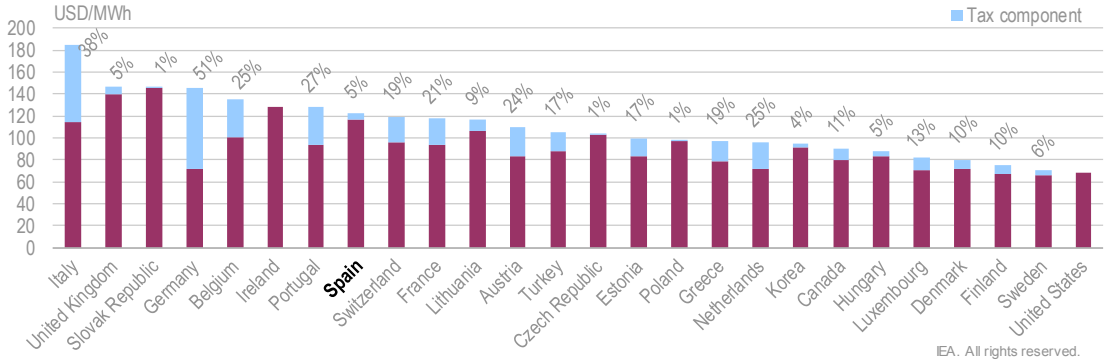
- Basque Country (Gatica) – France
- two alternatives: Basque Country (Ichaso) – France or Navarra (Muruarte) – France
- Aragón (Ejea de los Caballeros) – France.

Electricity prices

Spain's electricity prices for industry are above average among IEA countries, at 122.7 USD/MWh in 2019. However, its tax component is quite low, at 5%, in comparison to other countries (Figure 7.6).

For household electricity prices, Spain is also among the highest in IEA countries (fifth overall), at 287.7 USD/MWh in 2019, with taxes accounting for 21% (Figure 7.7).

Figure 7.6 Electricity price for industry in IEA member countries, 2019

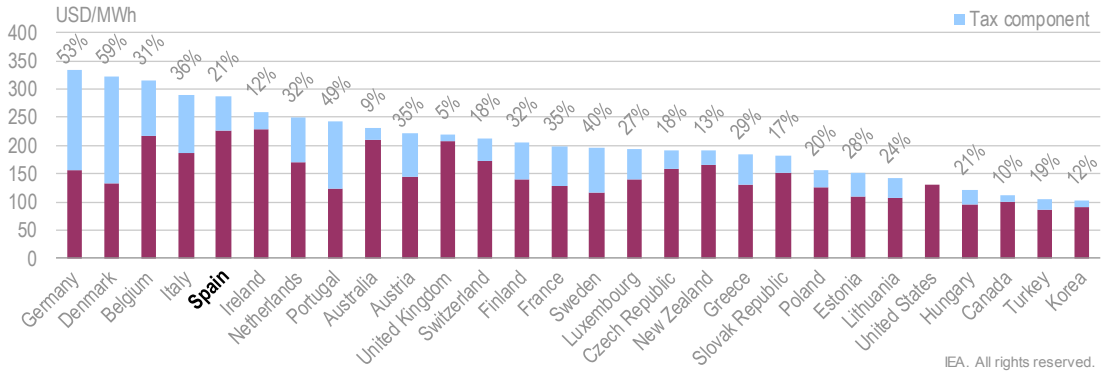


Spain's industry electricity prices are above the median price for IEA countries.

Notes: MWh = megawatt hour. For industry prices, data are not available for Australia, Japan, Mexico, New Zealand or Norway. Tax information is not available for the United States.

Source: IEA (2021b), *Energy Prices and Taxes 2019* (database), www.iea.org/statistics.

Figure 7.7 Electricity prices for households in IEA member countries, 2019



Spain's household electricity prices are among the highest within the IEA.

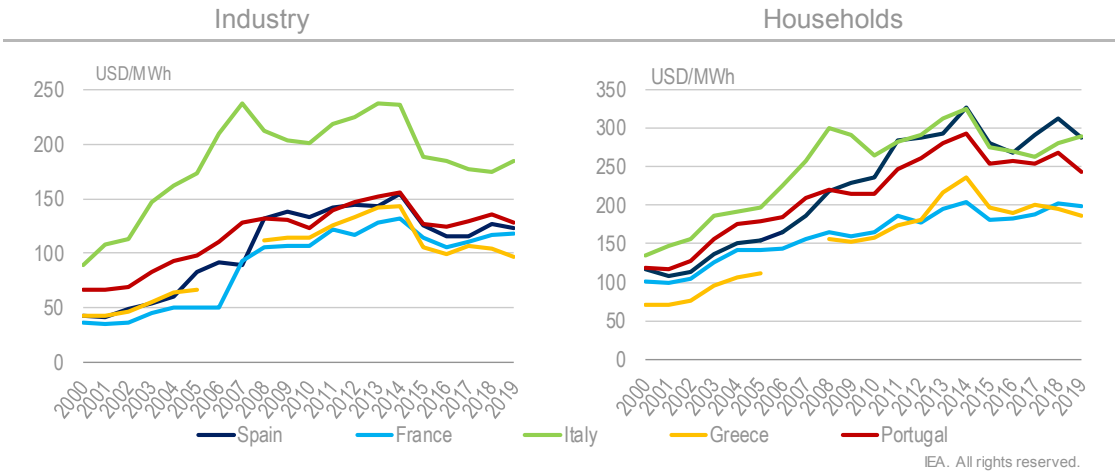
Notes: MWh = megawatt hour. For household prices, data are not available for Japan, Mexico or Norway. Tax information is not available for the United States.

Source: IEA (2021b), *Energy Prices and Taxes 2019* (database), www.iea.org/statistics.

Spain's industry and household electricity prices over the past two decades have followed trends similar to those of its neighbouring European countries, although from 2000 to 2009, Spain's electricity prices for industry increased more sharply than those of its neighbours, from 42.6 USD/MWh in 2000 to 91.3 USD/MWh in 2006 and 138.8 USD/MWh in 2009 (Figure 7.8). Spain's household prices have been higher on average than its neighbours since 2016, reaching 287.7 USD/MWh in 2019 (Italy was at 289.2 USD/MWh in 2019 and Portugal at 242.4 USD/MWh). However, the price differential between Spain and its neighbouring countries (France, Germany) has been closing thanks to the penetration of low-cost renewables in recent years, a trend that is expected to continue over the coming years to bring Spain's electricity prices below those of its neighbours, according to the European Energy Exchange's futures for 2022-23.

Notably, though electricity prices in Spain are above average in an EU comparison, prices for hydrocarbons are lower, with a disproportionate share of taxes and levies imposed on electricity relative to other forms of energy.

Figure 7.8 Electricity prices in Spain and selected IEA member countries, 2000-19



Spain's electricity prices are around average compared to prices in neighbouring European countries.

Notes: MWh = megawatt hour. Data are not available for Greece in 2006 and 2007.

Source: IEA (2021b), *Energy Prices and Taxes 2019* (database), www.iea.org/statistics.

Electricity market regulation

The Ministry for the Ecological Transition and the Demographic Challenge and within it, the Secretary of State for Energy, is the main energy authority in Spain, including as it relates to the electricity sector.

The national regulatory authority, the CNMC, is the regulator for several sectors, including electricity. In particular, it oversees daily and intraday market rules as well as operating procedures of system operation, including balancing markets and non-frequency markets, all governed by EU law. The CNMC also sets out the methodology for calculating network access tariffs according to transmission and distribution costs and supervises access to cross-border interconnections. At the EU level, the CNMC co-operates with other regulators through the Council of European Energy Regulators and the Agency for the Co-operation of Energy Regulators on developing network codes and implementing the internal electricity market.

The Spanish electricity sector has undergone a profound transformation since 1998, when it was characterised by a vertically integrated monopoly structure for various Spanish regions. Law 54/1997 on the Electricity Sector marked the beginning of the process of progressive liberalisation of the sector by opening networks to third parties, establishing an organised market for energy trading and reducing public intervention in the management of the system.

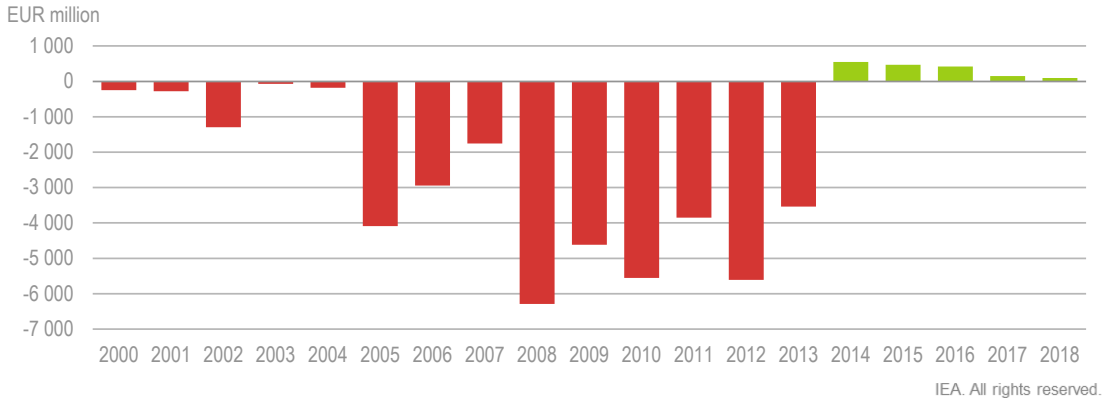
The basic rule that currently regulates the structure and operation of the sector is Law 24/2013 on the electricity sector, which maintains the distinction between regulated and non-regulated activities, while promoting effective competition in the sector by introducing, among other measures, increased competition of supplier companies, improved consumer access to information and facilitation of the supplier switch processes.

Spain's electricity sector is also guided by EU regulation, most recently updated as part of the Clean Energy Package. Spain is currently in the process of transposing EU directives and regulations (including the Directive on Common Rules for the Internal Market for Electricity, the Regulation on the Internal Market for Electricity, and the Regulation on Risk-preparedness in the Electricity Sector) into its national laws. Some important concepts, such as storage, independent aggregators and renewable communities, were recently introduced by Royal Decree-Law 23/2020, which approved measures in the field of energy and other areas of economic recovery from COVID-19.

Tariff deficit

Spain has made considerable headway in managing a tariff deficit in its electricity system caused by very generous subsidies for renewables, which reached a peak of EUR 6.3 billion in 2008 (Figure 7.9). Since reforms enacted in 2013, system costs have been balanced, and a small surplus was even recorded in the 2014-18 period. A small deficit is expected for 2019, though surpluses from previous years will cover it.

Figure 7.9 Spain's electricity system tariff balances, 2000-18



Source: Spanish government response to the IEA questionnaire.

Regulated prices

In accordance with Spain's current regulatory framework for the electricity sector, competition for electricity constitutes a liberalised activity in which consumers have the option to freely choose their provider among a wide range of electricity marketers. The conditions for the supply of electricity are determined through a supply contract agreed by both parties, fulfilling the obligations established by law regarding the contracting of electricity supply (the "free market").

However, smaller consumers – low voltage connected consumers with contracted power less than or equal to 10 kilowatts (kW) – also have the option of being supplied by one of eight reference suppliers, designated by the government in the "regulated market". In choosing one of these marketers, consumers can opt for the voluntary price for the small

consumer (the PVPC) or for a fixed price for one year. The PVPC is a price determined from the hourly prices indexed to the wholesale electricity market price, while the fixed price is established by the reference marketer (both figures are regulated in Royal Decree 216/2014, which establishes the methodology for calculating prices for the small consumer of electricity and its legal contracting regime).

The PVPC has a general structure that includes tolls and charges associated with the point of supply as well as the cost of the energy consumed, which refers to the cost of the day-ahead market for production of electricity. Additionally, the PVPC takes into account the marginal prices obtained in the intraday market auctions as well as all the costs associated with the supply of energy (remuneration of the OMIE, remuneration of REE, costs associated with payments for capacity mechanisms and interruptibility service, etc.). Therefore, although it is a regulated price, it is indexed to wholesale electricity market prices.

Alternatively, consumers can purchase energy directly from generators, as so-called direct consumers in the market. Since 2017, there has been an increase in the number of direct consumers, whose consumption in 2018 represented 2.5% of total energy, up from 1.6% in 2017.

According to the CNMC, on 31 December 2019, the Spanish retail market consisted of 28 314 200 consumers with an annual electricity consumption of 233 656 GWh. Of these, 94% were domestic consumers with power less than 10 kW, and the remaining 6% were domestic consumers of more than 10 kW, SMEs and industrial facilities. Of the 94% of smaller consumers, 38.3% were in the regulated market while 61.7% had a contract in the free market. Industry accounted for 54% of consumption, while consumers with power equal to or less than 10 kW accounted for 27.5%, and SMEs and households with more than 10 kW accounted for 18.5%.

Social bonus

Royal Decree 897/2017 set out measures to regulate vulnerable consumers, the social bonus and other protection measures for domestic consumers of electricity, with the goal of ensuring access to universal electricity supply as a general social good. In 2018, the government adopted Royal Decree 15/2018, which reinforced and expanded the assumptions to qualify for the electricity social bonus. The revisions also extended the programme to include a “thermal” social bonus, financed by the national budget (around EUR 100 million annually) to help vulnerable consumers pay for their heating needs.

Specifically, the designated reference suppliers (see above) are obligated to supply consumers that have been classified as vulnerable. In accordance with regulations, vulnerable individuals are those with a connection less than or equal to 10 kW and meet a series of socio-economic criteria, including: income criteria, being a large family, or pensioners of the Social Security System due to retirement or permanent disability, receiving a minimum amount. Those who meet these requirements can receive a discount of 25% on their electricity bill, called the social bonus.

Additionally, the decree created a category of severe vulnerable consumer, which requires compliance with more demanding income requirements than those for standard vulnerable consumers. Assuming compliance with these requirements, the social bonus discount on the electricity bill is 40%.

Finally, a category of consumer at risk of social exclusion was created, as a severely vulnerable consumer who is attended by the social services of an autonomous or local administration. In this case, at least 50% of the amount of his/her bill is covered.

Around 1.3 million consumers benefit from the social bonus in its various categories. As of 31 December 2018, 52% were classified as vulnerable, 47% as severely vulnerable and less than 1% as at risk of social exclusion. An estimated EUR 150 million/year in discounts are granted, with costs borne by the suppliers. These measures are part of Spain's National Energy Poverty Strategy 2019-2024, which will take a more comprehensive approach to addressing energy poverty over the medium and long term.

Due to the COVID-19 pandemic, a new category of vulnerable customers was identified as self-employed consumers whose income does not exceed certain thresholds and whose income has been reduced by the crisis (around 5 000 consumers). Moreover, in September 2020, the social bonus was extended by royal decree to people who have been temporarily laid off due to COVID-19.

National Fund for the Sustainability of the Electric System

In an effort to reduce electricity bills for consumers, in December 2020 the government issued the draft Law on establishing the National Fund for the Sustainability of the Electric System. Specifically, the policy would reallocate the levies associated with subsidies for renewables, co-generation and waste to energy companies across the energy system (oil, gas and electricity companies based on annual sales volumes). Previously, electricity end users assumed 100% of the costs associated with renewables payments, while conventional fuel consumers did not pay anything for these subsidies.

The law would serve three main purposes: 1) avoid increases in electricity prices; 2) provide clear signals regarding electrification of the economy; and 3) send appropriate price signals to investors to mobilise the necessary investments in the energy transition in the coming years. The amount that would be reallocated, which will take place over five years, represents approximately 16% of the current household electricity bills. To ensure fairness and redistribution, there will be exemptions and compensation for those sectors with less resilience and response to the new system.

Electricity market policies

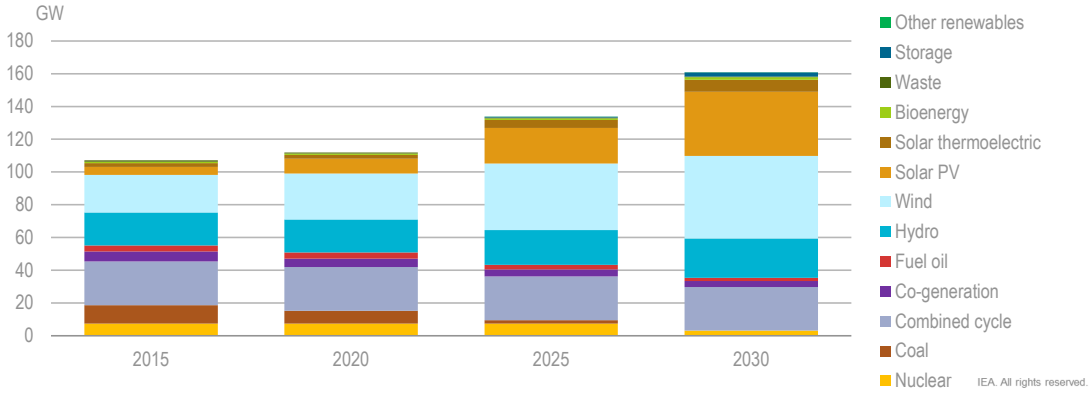
The development of renewable energy has been a priority commitment of Spanish energy policy, though the accelerated development of renewable generation that has taken place over the past decade has presented some challenges for managing the operation of the electricity system, especially given a very high number of small units of production scattered throughout the country.

Spain's National Energy and Climate Plan (NECP), submitted to the European Commission in January 2020, foresees for the year 2030 total installed power in the electricity sector of 161 GW, of which 50 GW will be wind power, 39 GW solar PV, 27 GW combined cycle gas (corresponding to existing combined cycle capacity), 15 GW hydraulic, 9.5 GW pumping, 7 GW solar thermoelectric and 3 GW nuclear, as well as minor capacities of other technologies (EC, 2020). As a result, renewable generation in 2030 will be 74% of total electricity generation, toward a trajectory of 100% renewable electricity in 2050. Though the total annual installed capacity of renewables committed in the NECP is fixed,

the precise breakdown between technologies will vary based on the costs and assumptions considered in the modelling exercises.

The outlook envisaged in the NECP assumes 6 GW of storage capacity by 2030, provided by pumping and batteries, which together with other sources of system flexibility and demand management will allow for greater integration of variable renewable generation into the system, ensuring continued security of supply. The recently approved Energy Storage Strategy extends the target for storage capacity requirements to around 20 GW in 2030.

Figure 7.10 Installed power capacity in Spain's NECP's target scenario



Notes: GW = gigawatt. PV = photovoltaic.
Source: Spanish government response to IEA questionnaire.

Since the start of its electricity market liberalisation in 1998, Spain has maintained capacity payments for conventional generation, including a subsidy for hydropower, natural gas, fuel-oil and coal-fired generators for their availability to the system. This incentive has been suspended since June 2018 and formally derogated since January 2019. The government is currently considering the possibility of a new capacity mechanism based on concerns about ensuring sufficient flexible gas-fired generation in the system, compliant with EU law. A public consultation on the issue was launched in September 2020, though a final decision on whether a capacity mechanism is needed has not been taken.

Spain also offered an investment subsidy to hydropower, natural gas, fuel-oil and coal-fired plants built after 1997 with more than 50 MW installed capacity that sold to wholesale power markets. Currently, no investment incentives are available for new conventional plants and total payments under the previous scheme are decreasing every year. However, coal power plants receive payments in order to finance upgrades aimed at reducing their environmental impact (e.g. sulphur-scrubbing units). These payments were scheduled to end in 2020.

Coal phase-out

As part of its climate change and energy transition agenda, Spain has a plan to phase out the use of all coal-fired electricity, driven by unfavourable market conditions rather than policy mandates.

The NECP expects that up to 9 of Spain's 15 coal-fired power plants (as of 2019) will no longer be in service by 2021. Already, based on market conditions, on 30 June 2020, 8 of

Spain's operational 14 coal-fired plants with around 4.6 GW of capacity shut down. Three more have asked for permission to close in 2021 and another one is expected to close in 2022. Moreover, one plant in Majorca only operates on a limited basis (around 500 hours annually after 2021).

Spain expects that by 2030, coal-fired power plants will no longer be competitive and coal will be fully phased out of the power sector. Accordingly, the government plans to offer support measures to affected regions to help them adjust to the transition (see Chapter 9).

Nuclear phase-out

Spain's NECP also foresees an orderly and staggered closure of the country's nuclear power plants within the 2027-35 time frame. The planned retirements of Spain's existing fleet of seven reactors (7.4 GW of installed capacity) will begin in 2027, and by 2030, around 4 GW of installed nuclear capacity is planned for an orderly final shutdown (see Chapter 8).

Following the coal and nuclear closures, natural gas-fired generation will become the predominant source of dispatchable power in Spain's electricity system to balance out the growth in variable renewables generation.

Renewables

Spain's NECP expects to achieve a 42% share of renewables in total end use of energy by 2030. This level will be led by the electricity sector, where the plan projects the installation of about 59 GW of new renewables generation through 2030, led by wind and solar, amounting to 74% of total electricity generation that year. This will put Spain on a pathway toward achieving its 2050 objective to source 100% of its power from renewable sources, in line with its 2050 carbon neutrality goal.

To achieve its ambitious targets for renewables in electricity, Spain envisions a three-pronged strategy: 1) the promotion of large generation projects; 2) the deployment of own consumption and distributed consumption; and 3) measures to integrate renewables into the electricity system and market (see Chapter 5). The NECP considers auctions to be the main tool for developing these technologies, in accordance with EU Directive 2018/2001 on the promotion of the use of energy from renewable sources.

Self-consumption and distributed generation

Spain is also seeing a growing number of self-consumers (notably rooftop PV and co-generation, and, to a lesser extent, small-scale wind), defined as consumers who generate electricity for their own consumption. The government considers self-consumption to be an important component in the growing share of renewables in electricity generation.

Spain recently updated its regulatory framework with respect to self-consumption in an effort to boost its uptake. The first regulation put in place in 2015 required self-consumers to pay a small fee for self-generated energy, even if they did not feed any power into the grid and required power generated to be less than or equal to power consumed. Since then, Royal Decree 244/2019 (to implement EU Directive 2018/2001 on the promotion of the use of energy from renewable sources) put in place clearer definitions of self-consumption, simplified compensation schemes, and streamlined technical and administrative requirements.

The royal decree defines both individual self-consumption and so-called collective self-consumption, which is comprised of several participants (the 2015 regulation was centred on individual self-consumption). The government sees collective self-consumption as an attractive opportunity to expand renewables capacity as it offers more efficient use of limited space in urban areas as well as lower investment costs per user and the ability to share technical, administrative and operational knowledge.

Moreover, the royal decree also enabled the participation of new agents in self-consumption schemes, notably energy service providers that have technical know-how in the field. The required knowledge to operate a self-consumption initiative was one of the main entry barriers that the new regulation sought to eliminate. In this regard, energy service providers can offer the best and latest technical solutions to self-consumers as well as run and manage the schemes from an operational perspective.

Other potential participants in self-consumption schemes are local administrations and non-governmental organisations, which can help organise people with fewer resources. Moreover, self-consumption schemes can be used as a testing ground for larger schemes, such as renewable energy communities.

Self-consumption is also expected to be a driver for other technologies and actions, including storage initiatives, grid modernisation and expansions, as well as electricity meter upgrades.

At the same time, self-consumption can lead to technical challenges for integrating a large number of generation points onto the distribution grid. In particular, the increasing number of self-consumers means that more and more generation will be connected to distribution grids and distributions service operators (DSOs) will have to adapt these grids to meet the technical demands this change requires. The government expects to meet this challenge by adopting the latest grid-edge technologies as well as by undertaking investments to strengthen grid resilience and flexibility, especially on distribution networks.

System integration of renewables

In recent years, Spain has made headway in improving its system flexibility to integrate more variable renewables, including: allowing renewable energy and co-generation facilities to participate in balancing services; technical and regulatory work at the national and European level for the development of pan-European imbalance netting services (REE began participating in the IGCC imbalance netting platform in September 2020); regulation to allow demand-side response to participate in balancing markets; and updating network connection codes.

Looking ahead, Spain's ambitious target to source 74% of electricity generation from renewables by 2030 will require additional measures to ensure smooth system integration of variable renewables, notably solar and wind. To this end, Spain's NECP includes several measures to facilitate the integration of renewables, including measures on "demand management, storage and flexibility" and on "adaptation of electrical networks for the integration of renewables" (EC, 2020).

With respect to demand response, the NECP foresees the introduction of economic incentives, more efficient technologies and changing consumer habits to promote demand management. In this regard, the government is planning to facilitate the development of demand aggregators and demand management plans as avenues for various players to

participate in demand response services. The concept of the aggregator was introduced in Royal Decree-Law 23/2020 and more detailed regulation is expected to follow.

Moreover, the NECP foresees 6 GW of electricity storage capacity to be in place by 2030. The specific type of storage will be informed by technological developments over the coming decade. The Ministry for the Ecological Transition and the Demographic Challenge has developed the Energy Storage Strategy to support the goals of the NECP. The strategy was approved by the Council of Ministers in February 2021. The Energy Storage Strategy expands the storage necessities of Spain's energy system; beyond the referred capacity envisaged in the NECP, the strategy includes capacity from the electric vehicle fleet, behind-the-meter energy storage systems and large-scale energy storage attached to concentrated solar power plants, which would result in total storage capacity of around 20 GW in 2030. Royal Decree-Law 23/2020 also introduced the concept of storage as a regulated activity, which is now pending more detailed regulation. The royal decree also granted permission for hybrid storage and renewables facilities.

Lastly, the government also sees expansion of grids and interconnectors as an important component in managing the integration of larger levels of variable renewables. The upcoming Network Plan, covering the period 2021-26, is aligned with the NECP's targets and is mainly focused on renewable energy integration, which will require additional network development as well as improving the optimisation of the existing grid. A public consultation process on the proposed Network Plan was launched in February 2021, with a target to approve the plan by the end of 2021. Though renewables curtailment levels are relatively low at present, at 0.23% in 2019, the government expects them to rise to 14.8% in 2026 based on a business-as-usual scenario for the transmission network. However, it projects that curtailment would drop to 4.5% in 2026 based on the network plans under development. In a similar vein, interconnectors, especially with France, will also play an important role in balancing the growth in variable renewables generation across a broader geographic footprint (see above section on interconnections).

Smart meters

Spain first put in place a Smart Meter Plan back in 2007, which has been updated several times since then. As a result, at the end of 2019, 99.64% of electric meters had been replaced with smart meters for consumers with contracted power of less than 15 kW, and 99.38% of them have been effectively integrated into remote controlling systems.

A new operating procedure was approved on 11 December 2019 that obliges distribution companies to provide their customers with the measurement data from their smart meters, especially the hourly consumption curve. In addition, though not currently compulsory, over 75% of metering systems for consumers with contracted power between 15 kW and 50 kW have been replaced by smart meters (and 95% integrated into remote control systems).

The government expects that the current regulation for smart meters will be updated to define new functionalities and protocols, deployment plans, as well as data management and data-sharing rules. These can then serve as leverage for the development of various energy services, business models and increased behavioural change in prosumers.

COVID-19 measures

As Spain addresses the economic implications of the COVID-19 pandemic and related lockdowns, the government approved several measures to assist the electricity sector and consumers. In particular, Royal Decree-Law 11/2020 from 31 March, which adopted urgent social and economic measures to deal with COVID-19, included the following measures related to the electricity sector:

- Supply guarantee measures: supply guarantees prohibited the interruption of supply of electricity, natural gas and water to consumers.
- New category of vulnerable consumer: a new category of vulnerable consumers was created with the option of claiming the social bonus, constituted as a discount on the electricity bill. This category corresponds to self-employed workers affected by the closure measures of establishments that meet certain income requirements.
- Contract flexibility measures: any company could temporarily suspend supply contracts, or modify them to adapt to new consumption patterns, without any surcharge as a consequence of these alterations in the contracts.
- Bill suspension measure: applicable only to small and medium-sized enterprises, allowing the option to temporarily suspend bills for electricity and natural gas consumption for a period of six months following the end of the state of emergency due to COVID-19.

Moreover, Royal Decree-Law 23/2020, also aimed at stimulating the economy, includes measures to maintain and revitalise investments in transmission and distribution network assets, which were previously defined in regulation as a share of GDP. In doing so, the government aimed to prevent a sizeable drop in grid investments and digital upgrades that will be instrumental to the energy transition.

Electricity security

Risk preparedness

The legislative framework for electricity security at the national level consists of EU Regulation 2019/941 on risk preparedness in the electricity sector and Spain's Law 8/2011, which establishes measures for the protection of critical infrastructure in Spain.

Currently, and in collaboration with the TSO REE, the national analysis of the regional crisis scenarios identified by ENTSO-E is being carried out by the Directorate General for Energy Policy and Mines. The analysis is in accordance with the methodology approved by the Agency for the Co-operation of Energy Regulators, in compliance with Article 6 of EU Regulation 2019/941. Among these regional crisis scenarios, at least two are related to cybersecurity. In a second stage, and once the analysis of the impact at the national level of the regional crisis scenarios has been completed, the most relevant national electricity crisis scenarios will be identified, in compliance with Article 7 of EU Regulation 2019/941.

The identified national crisis scenarios will be reviewed at least every four years. Based on the identified regional and national crisis scenarios, the Directorate General for Energy Policy and Mines, in collaboration with REE, will prepare a risk preparedness plan, which will include all those measures necessary to prevent electricity crises, prepare for them or mitigate them.

Measuring outages

With respect to outages on the transmission network, three indexes measure the quality of electric supply service due to incidents on the grid:

1. Energy not supplied (ENS): measures the energy cut from the electricity system due to incidents in the electricity system transmission. It is measured in MWh.

2. Average interruption time (AIT): the relation between the energy not supplied and the average power of the system. It is measured in minutes. The reference value established in current legislation is set at 15 minutes.

3. Non-availability rate: indicates the percentage of total time of the year during which transmission lines have not been available for service due to outages and maintenance.

Reliability planning

Operating Procedure 13.1 (OP 13.1), approved by the Resolution of 22 March 2005 by the General Secretariat of Energy, establishes the technical criteria for development of the transmission network. Among the criteria developed by OP 13.1 is a set of reliability criteria, including the technical criteria, reinforcement criteria and network meshing criteria.

The technical criteria established in OP 13.1 are of great importance due to their direct relationship with the reliability and quality of supply, making it possible to face events of different types that pose risks to security of supply. Among these criteria are the suitability criteria of the system, which determine the contingency situations that the system must endure in a permanent regime. In this regard, the transmission network is designed to withstand two different contingency levels: Level 1 (N-1) and Level 2 (N-2), where demand varies.

Compliance with the N-1 level takes into account all the individual incidents of lines and transformers in the transmission network and the largest generation groups in an area. In case of non-compliance, this level will require network development. In the N-1 situation, the system must be designed to not cause market outages or to permanently overload lines and transformers.

In an N-2 situation, contingencies that affect two elements of the network are taken into account, making sure that in this circumstance, the behaviour of the system is adequate, not allowing any market losses or permanent overloads above a certain level. The analyses at the N-2 level include loss of multiple lines, as well as the loss of nodes of high concentration of transformation (> 1 500 megavolt amperes [MVA]), high concentration of generation (> 1 000 MW) and nodes considered critical from the safety perspective of the system against fault clearance (the critical time is the maximum time that the system withstands a permanent three-phase fault meeting the safety criteria). Level N-2 security can be achieved with network development or other operational measures based on the cost/risk assessment of the different alternatives.

In addition to the suitability criteria, the technical criteria that the Spanish grid network must meet in accordance with the provisions of OP 13.1 include criteria associated with dynamic behaviour, maximum short-circuit currents, and maximum generation and supply capacity in a node, among others. Likewise, the network design criteria impose

other obligations, such as limiting the number of unmeshed nodes between meshed nodes, thereby increasing security.

Moreover, the Spanish TSO employs several measures, processes and tools in its resilience strategy to face potential disruptions, including:

- operating the system through two control centres that operate in parallel with the ability to provide symmetric backup between them
- special protection schemes, which include a set of co-ordinated and mostly automatic measures to ensure fast reaction to large disturbances and to avoid their propagation through the system
- the interruptibility service, which is a demand management tool to provide a rapid and efficient response to the electric system's needs according to technical and economic criteria
- the load shedding strategy used in cases in which, due to a severe incident, the balance between generation and demand cannot be maintained through the foreseen control measures
- specific plans called "emergency/safeguard plans" for those cases in which an outage requires special measures to fulfil security criteria and the continuity of electricity supply
- the restoration process and its plans, corresponding to different geographical areas that aim to return the system to normal after a severe incident that causes load disconnection
- regular training of operators and common trainings and simulations with the other electricity system stakeholders, including neighbouring TSOs
- contingency plans in the maintenance of the transmission infrastructure to resolve urgently any failure.

Electricity system resilience

Though the government considers the overall Spanish electricity network to be resilient in situations of permanent or temporary loss of its elements, non-peninsular areas can face more challenges. In response, in recent years, the government has made a significant effort to reinforce interconnection levels between islands in the non-peninsular territories, and for the Balearic Islands, a connection with the peninsular territory.

The current transmission network plan includes two new links between islands in the Canary archipelago:

- Lanzarote-Fuerteventura 132 kV link
- Tenerife-La Gomera double circuit 66 kV link.

The Balearic system plan includes:

- Mallorca-Ibiza 132 kV link that gives rise to the union of the two current subsystems Mallorca-Menorca and Ibiza-Formentera
- Ibiza-Formentera 132 kV link
- a second link Mallorca-Menorca 132 kV.

On the other hand, the resilience of the transmission network is limited by the low interconnection capacity with France. Higher exchange capacity values, combined with proper system design, would further improve the capacity of this network to withstand contingencies that may occur.

Moreover, regarding the impact of climate change and extreme weather events on power infrastructure, Spain is currently preparing its updated National Plan for Adaptation to Climate Change. It contemplates several lines of action, including to prevent the impacts of climate change on the transport, storage and distribution of energy. This will include analysis on the impact of climate change on the functionality and resilience of electricity transmission and distribution networks and define consequent adaptation measures. It will also identify energy infrastructure that is highly vulnerable to extreme events and promote specific adaptation programmes as well as integrate the results into successive planning of the electricity transmission network.

Assessment

Spain's electricity sector will be subject to major reforms in the next decade as part of the implementation of the government's NECP. The plan includes an ambitious target of a 74% share of renewables in electricity generation out of a forecasted installed capacity of 161 GW by 2030, which will be needed to enable the expected sizeable electrification of the economy. The massive development of renewable energy up to 2030, particularly solar and wind, will form the basis for reaching the 2050 objective of a 100% renewable electricity mix. This huge increase of renewables will go hand-in-hand with the ongoing rapid phase-out of coal power plants and the foreseen closure of nuclear power plants after 2027. The only conventional generation that is projected to maintain a considerable share in the generation mix in the next decade is combined-cycle gas generation, with an expected capacity of 27 GW in 2030.

The Spanish electricity market is part of the common European market through the Iberian wholesale power market, with full price convergence in the peninsula, except during rare periods of congestion. Spain has interconnections with all of its neighbours (Andorra, France, Morocco and Portugal) and is a net importer with France and a net exporter to Portugal. Currently, the Spanish electricity sector is still dominated by three main generating companies, but market concentration has fallen in recent years and is expected to decrease further due to the surge of renewable sources, whose ownership is much more fragmented.

In recent years, the Spanish government has successfully implemented reforms to restore the financial stability of the electricity system. The reduction of subsidies for investments in renewable generation and increased taxes and levies have contributed to bringing costs and revenues of the sector back in balance. Moreover, the December 2020 announcement to create the National Fund for the Sustainability of the Electricity System, which will reallocate the costs of renewables subsidies across the energy system rather than solely on electricity end users, represents a major step toward rebalancing system costs to align with longer term goals of electrification and energy transitions. The commissioning of a new interconnector between Spain and France in 2015 (Santa Llogaia-Baixas line) was also an important step and has almost doubled the previous capacity for cross-border trade of electricity with France.

Moreover, Spain has made considerable improvements in its wholesale electricity market during the last few years, notably with the start of continuous intraday trading in the XBID market and the recently installed opportunities for cross-border exchanges of balancing reserves (TERRE-project). The liquidity of the wholesale electricity market will be further enhanced by finalising the implementation of European network codes and guidelines, including through the participation of demand-side response resources in balancing markets, and the emergence of different regional platforms for electricity balancing in which the Spanish TSO (REE) will participate. The IEA commends Spain for all of the above-mentioned developments since its last in-depth review.

The retail market for electricity in Spain is highly concentrated in comparison to other IEA countries. The traditional five big suppliers are responsible for supplying 85% of consumers (and even 92% at the household level), although their market share has been decreasing over the last few years. These same companies own and operate distribution networks while carrying out all their activities in compliance with the unbundling requirements as set in the regulatory framework. Also, quarterly switching rates of electricity consumers are very low, at just 2.3%, and Spain has relatively high electricity prices for end users compared to other EU countries, partly due to significant tax components in consumer prices. These characteristics seem to indicate a fairly low level of retail market competition. However, on a positive note, at the end of 2019, almost 100% of Spanish households had installed a smart meter.

Moreover 38% of the Spanish market (about 11 million consumers) is covered by a regulated price regime run by the eight reference suppliers designated by the government. These consumers pay a so-called voluntary price for small consumers that is based on the wholesale market electricity price, and marked up with grid costs, taxes and a distribution margin. This system of regulated prices tends to impede the development of stronger competition in the Spanish retail market. Price regulation discourages consumers to shop around and switch supplier. A phase-out of the regulated regime for a large group of consumers, combined with increased consumer awareness and the introduction of price comparison tools, will surely open up the retail market and reduce market concentration. Increased competition is also expected to lower electricity prices for end consumers. To this same end, the government should also look at the role of relatively high taxes and levies in the electricity price and evaluate whether these are still appropriate, notably in comparison to the fiscal treatment of other fuels and the policy to decarbonise and electrify the energy system.

In addition, Spain has an energy poverty policy in place, which puts an obligation on reference suppliers to provide a discount to consumers with a vulnerable status, divided into three categories with increasing discounts. Currently, about 1.3 million Spanish households benefit from this social tariff. The social tariff (reportedly a total of around EUR 150 million/year in discounts) is financed by the suppliers. While poverty reduction for low-income households is an understandable priority, the IEA notes that providing electricity below cost results in inefficient and non-transparent reallocation, as the reference suppliers receive no compensation for their losses on these contracts and have to cross-subsidise these losses with higher prices for other customers. The government should therefore consider alternative ways to address energy poverty, such as through social and fiscal policies, or through support for energy efficiency measures. Such reforms could be embedded in the recently adopted National Energy Poverty Strategy.

The level of interconnectivity is relatively low and Spain is still far from reaching the political target of 15% by 2030. In 2019, in particular, the interconnections with France were recorded to be congested almost every day of the year, with Spain being a net importer 80% of the time. Therefore, a priority of the government is to enhance cross-border capacities with France to the benefit of the consumers and to increase the resilience of the Spanish electricity system. The completion of the interconnection through the Gulf of Biscay will be a valuable step toward this end. Concurrently, the government should reinforce national grids to ensure that Spain can accommodate increased flows to and from France.

Increasing opportunities for cross-border trade will also stimulate the further integration of regional markets and will increase flexibility in the Spanish electricity system, which is needed to facilitate the rising share of variable renewable energy sources in the market. Furthermore, a high level of interconnectivity combined with liquid and well-functioning wholesale markets (including the foreseen cross-border balancing platforms), as well as the further deployment of demand-side response and electricity storage resources will considerably contribute to adequacy.

Despite the current overcapacity in the market, different groups of conventional electricity producers have expressed serious concerns about medium- and long-term adequacy in Spain. The obvious reason for this is the augmenting share of variable renewables (notably wind and solar) together with the phase-out of coal and nuclear power plants in the coming years. The government is currently conducting a consultation on the possible need for a capacity mechanism to ensure that sufficient backup generation capacity will remain available to the market during and after the transition. As in many EU countries, this issue will no doubt be thoroughly debated in Spain in the coming years.

For efficiency reasons, it would not make much sense to create capacity subsidies to prolong the life cycle of coal and/or nuclear power capacities that are currently scheduled for closure. It could be argued, though, that a capacity remuneration scheme would help safeguard the availability of gas-fired power plants until the long-term objective of a fully decarbonised power market is reached. Still, the IEA does not recommend a capacity mechanism as a standard solution, due to its typically high costs and tendency to distort markets and electricity price formation. The Spanish government should instead concentrate on improving flexibility in the market and creating proper price signals for investments. In fact, all the components referred to in the previous paragraphs may contribute to that. At the same time, it remains important for Spain to work on a clear and effective regulatory framework to accommodate the foreseen closure of coal and nuclear plants at a pace that meets the needs of the system, while avoiding unnecessary red tape and added decommissioning costs.

Spain has installed an appropriate framework for strategic network planning that needs to prepare the grid for facilitating the objectives set by the government in the NECP. The Spanish TSO, REE, is responsible for operating over 44 000 km of transmission lines. Grid development is planned every six years and approved by the government. The network plan that is currently under development will include grid enforcements needed to allow the integration of a high share of variable renewable energy, while applying the EU planning process (the Ten-Year Network Development Plan) and ensuring security of electricity supply. As the time from initial design to commissioning of large infrastructure projects can be longer than six years, and the next nuclear plants are supposed to close

in 2027, just beyond the six-year horizon, the government should consider extending the planning process to ten years.

At the distribution level (below 220 kV), by far the largest part of the network is operated by the five major DSOs in Spain. Equally, the distribution grids have a major role to play in the transition toward a decarbonised energy market and a more flexible system. Distributed generation (including solar PV) is expected to increase rapidly in the coming years and DSOs will have a pivotal role in enabling self-consumption, smart grid services and demand-side management, and in facilitating the emergence of aggregators and the expansion of the electric vehicle charging network.

Nonetheless, contrary to REE's transmission plan, the DSOs' network investment plans, which have a scope of three years, are not approved by the government. Reportedly, the CNMC is consulted, but the role of the regulator seems to be limited merely to monitoring that the planned investments do not exceed a maximum level so that the network tariffs can be kept within bounds. Thus, there does not appear to exist a mechanism for the government or the regulator to properly evaluate possible underinvestment or overinvestment in the distribution grids. Such a mechanism could be useful with a view to the rapidly growing number of facilities to be connected to distribution grids and the reported lack of connection points to connect new renewables installations, notably solar PV.

Recommendations

The government of Spain should:

- Raise the level of retail market competition by gradually removing regulated prices and raising consumer awareness, including through consumer campaigns and facilitating price comparisons.
- Consider adapting its policy for vulnerable consumers by combating energy poverty in a more efficient manner through social welfare measures and support for energy efficiency programmes such as the insulation of homes.
- Reinforce efforts to create more flexibility in the electricity market and to ensure proper price signals for investments in generation, through increased interconnectivity, continued integration of regional markets, and the development of demand-side response and storage.
- Given current overcapacity, reconsider the option of introducing a capacity mechanism to address adequacy concerns, yet closely monitor dispatchable generation capacity to safeguard its role in the future renewables-based electricity system.
- Create a mechanism for appropriate assessments of distribution network plans to ensure that distribution grids can accommodate distributed energy resources and higher shares of variable renewable energy in line with the NECP's targets.

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IEA (2021b), *Energy Prices and Taxes 2019* (database), www.iea.org/statistics.

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8. Nuclear

Key data (2019)

Number of operating reactors: 7 reactors

Installed capacity: 7.1 GW (net capacity)

Electricity generation: 58.4 TWh

Share of nuclear: 21.5% of the total electricity generation

Overview

Spain has seven operating light water reactors, representing an installed net capacity of 7.1 gigawatts (GW) in total, which in 2019 provided 58.4 terawatt hours (TWh), or 21.5%, of total electricity generation. Nuclear power plants (NPPs) contribute to decarbonising the electricity system, and in Spain they accounted for the largest share (approximately 35%) of low-carbon electricity in 2019, closely followed by wind.

Spain's National Energy and Climate Plan 2021-2030 (NECP) submitted to the European Commission foresees a sequential reduction of the country's nuclear power capacity from 2027 to 2035. According to this plan, nuclear generation capacity will be reduced to around 3.2 GW by 2030 and to 0 by 2035.

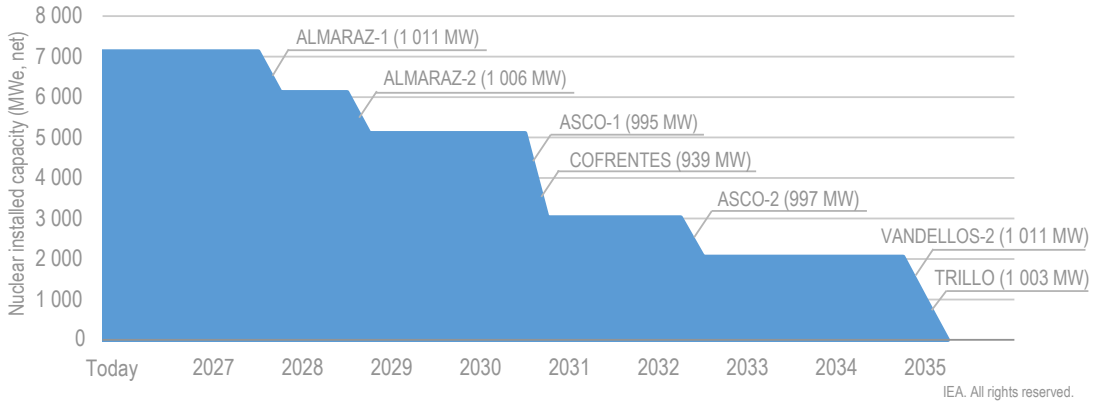
As of 2020, three NPPs in Spain have been permanently shut down: Vandellos 1 in 1990, Jose Cabrera in 2006 and Santa Maria de Garona in 2012. Two of them are being decommissioned by Enresa, a state-owned company, and Santa Maria de Garona is now under pre-dismantling works by the operation licensee before moving to decommissioning by Enresa.

In Spain, state-owned Enresa is responsible for the management of radioactive waste, including spent nuclear fuel (SNF) as well as the decommissioning of nuclear facilities. All low- and intermediate-level waste (LILW) is managed and disposed of in El Cabril disposal facility. It is expected that additional capacity for LILW disposal will be required by 2028. Radioactive waste that cannot be managed as LILW and SNF are categorised as high-level waste (HLW), to be disposed of in a deep geological repository (DGR) in the future. A centralised storage facility (CSF) as temporary storage for SNF was proposed in 2014, but the licensing process has been suspended since 2018. SNF is currently stored in the plant pools or dry cask storage at each plant site.

Nuclear policy

The development of nuclear power in Spain began in the mid-1960s, with three small reactors of different designs, none of which is currently in operation. The bulk of existing nuclear capacity was started in the 1970s and came into commercial operation in the 1980s. Following a 1983 moratorium, confirmed in 1994, the plants under construction at that time were abandoned, and no new nuclear reactors have been built in Spain since.

Figure 8.1 Final shutdown schedule of nuclear power plants in Spain according to the NECP



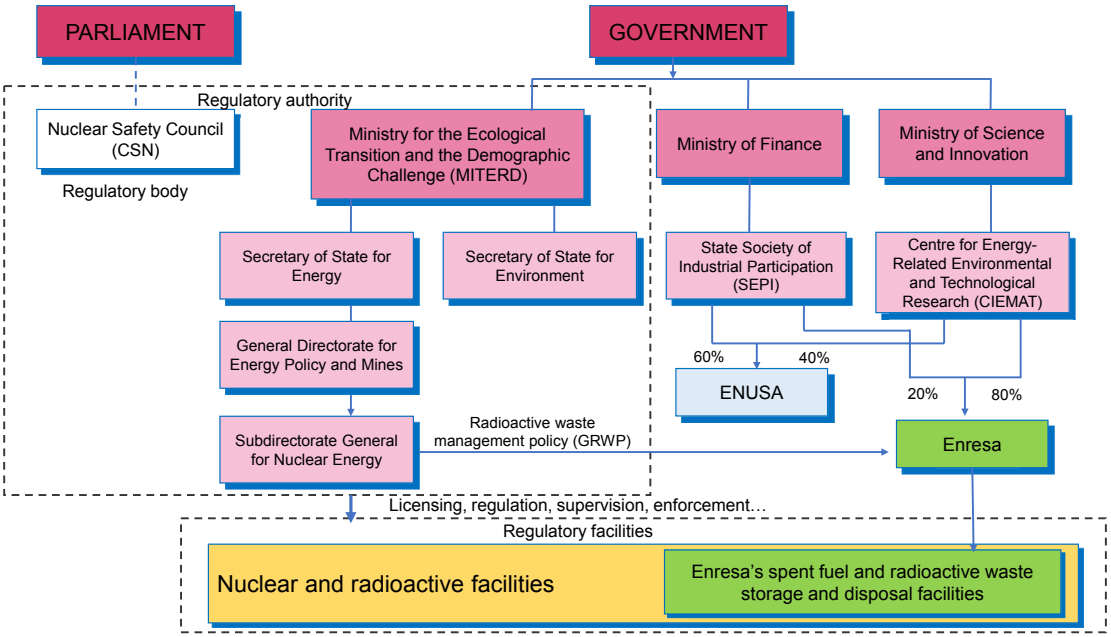
Note: MW_e = megawatt electrical.

Source: Government of Spain's response to the IEA questionnaire.

In 2020, the Spanish government submitted its NECP to the European Commission, which established the expectations for the evolution of nuclear energy's contribution to the energy mix in Spain. It foresees an orderly final shutdown of Spanish NPPs within the 2027-35 time frame. According to the NECP, the current nuclear generation capacity of 7.1 GW will fall to 3.0 GW by 2030, and to 0 by 2035 (Figure 8.1). Based on the draft NECP, in March 2019, the owners of Spain's NPPs and Enresa signed a protocol of intentions specifying a final shutdown schedule for the NPPs.

Regulatory framework

Figure 8.2 Institutional structure of nuclear energy in Spain



Sources: Government of Spain during IEA visit; IAEA (2018), *Country Nuclear Power Profiles: Spain*, https://cnpp.iaea.org/countryprofiles/Spain/Spain.htm.

The Ministry for the Ecological Transition and the Demographic Challenge (MITERD) is in charge of nuclear energy and radioactive waste management policies. It is responsible for issuing operating licences for nuclear facilities, subject to mandatory reports from the Spanish nuclear safety authorities, submitting regulatory proposals for legislation development, adopting provisions to implement current regulations and applying the disciplinary regime with regard to nuclear energy. The government is also responsible for defining the radioactive waste management policy, including SNF, and monitoring compliance with international commitments in the field of nuclear energy.

The Nuclear Safety Council (CSN) is legally and financially independent from the State General Administration. It has a role of ensuring nuclear safety and radiation protection of all nuclear facilities in Spain. It submits reports to MITERD on issuing and renewing licences for the operation of plants and other facilities handling radioactive material. These reports are binding with specific safety requirements. The CSN may suspend the operation of facilities for safety reasons and initiate procedures to impose sanctions on operators.

ENUSA Industrias Avanzadas, S.A., S.M.E. (ENUSA) and Empresa Nacional de Residuos Radiactivos, S.A., S.M.E. (Enresa) are state-owned companies responsible for the front- and back-end activities of the nuclear fuel cycle, respectively. ENUSA is in charge of procurement of enriched uranium and nuclear fuel fabrication while Enresa is responsible for nuclear decommissioning, management, and disposal of radioactive waste and SNF.

Nuclear power plant operation

As of 2020, there are seven reactors operating in Spain, all of them privately owned. Their cumulative net generation capacity is 7.1 GW, providing around 21% of total electricity generation in Spain in 2019. Their operational lifetimes are over 30 years, with an average of 35.5 years (Table 8.1). They have maintained remarkable capacity factors, around 90%, in the last decade (Figure 8.3).

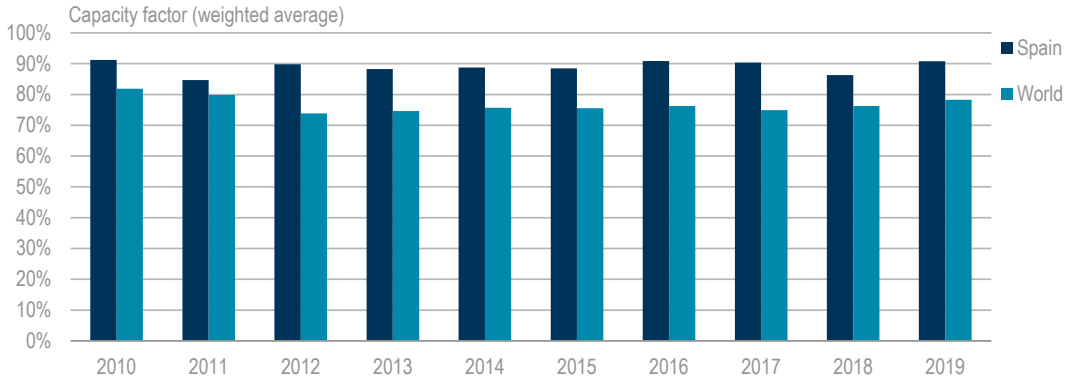
Table 8.1 Operating nuclear power plants in Spain in 2020

Reactor unit	Type	Net capacity (MW_e)	Commercial operation	Years of operation	Licensed to	Shutdown scheduled in NECP	Owner
ALMARAZ -1	PWR	1 011	Sept. 1983	38	Nov. 2027	Nov. 2027	Iberdrola (52.7%) Endesa (36%) Naturgy (11.3%)
ALMARAZ -2	PWR	1 006	July 1984	37	Oct. 2028	Oct. 2028	Iberdrola (52.7%) Endesa (36%) Naturgy (11.3%)
ASCO-1	PWR	995	Dec. 1984	37	Sept. 2021	Oct. 2030	Endesa
ASCO-2	PWR	997	March 1986	35	Sept. 2021	Sept. 2032	Endesa (85%) Iberdrola (15%)
COFRENTES	BWR	1 064	March 1985	36	March 2021	Nov. 2030	Iberdrola
TRILLO	PWR	1 003	Aug. 1988	33	Nov. 2024	May 2035	Iberdrola (49%) Naturgy (34.5%) Hidrocantábrico (15.5%) Endesa (1%)
VANDELLOS-2	PWR	1 045	March 1988	33	July 2030	Feb. 2035	Endesa (72%) Iberdrola (28%)

Notes: MW_e = megawatt electrical. PWR = pressurised water reactor. BWR = boiling water reactor.

Sources: IAEA (2020), *Power Reactor Information System (PRIS)* (database), https://pris.iaea.org/PRIS/home.aspx; WNA (2020), *Country Profiles: Nuclear Power in Spain*, www.world-nuclear.org/information-library/country-profiles/countries-o-s/spain.aspx.

Figure 8.3 Capacity factors of nuclear power plants in Spain and the world



Source: IAEA (2020), *Power Reactor Information System (PRIS)* (database), https://pris.iaea.org/PRIS/home.aspx.

While the NECP and the subsequent protocol set the upper limit of operational years, the actual operational lifetime of NPPs is still subject to nuclear safety regulations as well as to their owners' decisions for investment. Operating licences for Spanish NPPs are granted for a ten-year period by MITERD, following a binding report on nuclear and radiological safety from the CSN. Application for the renewal of an operating licence must include the results of the periodic safety review, and, for applications beyond 40 years of operation, an integrated ageing assessment and management plan with appropriate ageing analysis has to also be included to ensure that the system and equipment can be operated safely beyond 40 years. Therefore, the seven Spanish reactors have to renew their operation licences beyond 40 years of operation in order to continue operation until their final shutdown year outlined in the NECP. Two of these licences (corresponding to three reactors) have already been granted.

On the other hand, nuclear operators claim that the market environment for NPPs is not favourable due to high taxation on nuclear generation and low electricity market prices. According to a calculation by Endesa, current nuclear generation costs are well over EUR 50/MWh, around 40% of which are taxes and fees for radioactive waste management (Table 8.2). The company claims to operate NPPs with economic losses under the prevailing MIBEL (Iberian power market or Mercado Ibérico de Electricidad) market price, which has dropped due to the impacts of the COVID-19 pandemic. Indeed, average MIBEL prices were around EUR 40/MWh or less during the third quarter of 2020 (AleaSoft, 2020), much lower than the nuclear generation cost.

Table 8.2 The cost structure of nuclear power generation in Endesa

	EUR/MWh
Variable operating cost	**14.0**
Fuel expenses	5.3
Electricity purchases and generation tolls	0.7
Nuclear waste fees*	8.0
Fixed operating costs and recurring costs	**17.6**
Fixed operating costs	13.1
Investments	4.5
Tax Law 15/2012 and autonomous communities	**13.4**
Electricity generation tax (7%)*	3.2
Nuclear fuel tax*	5.2
Autonomous communities' nuclear tax	5.0
Capital cost	**11.1**
Total generation cost	**56.1**
(Taxes and nuclear waste fees)	(21.4)

* Taxes or fees for nuclear waste management.

Note: MWh = megawatt hour.

Source: Endesa during IDR visit.

Nuclear fuel supply

The state-owned company ENUSA is in charge of nuclear fuel supply for NPPs in Spain, which includes the procurement of enriched uranium and nuclear fuel fabrication. No facilities are operating in Spain for mining, milling, conversion and enrichment of uranium. ENUSA imports enriched uranium for nuclear fuel from several countries, including the Russian Federation, Uzbekistan, Niger, Canada, Namibia, Kazakhstan and Australia. The company operates a nuclear fuel fabrication facility located in Juzbado. This facility, while producing all nuclear fuel assemblies necessary for NPPs in Spain, except the Trillo NPP, also manufactures fuel assemblies for exports to other countries such as Belgium, France and Germany. Exports accounted for 50% of total production in 2019.

Decommissioning and radioactive waste management

The policy for managing radioactive waste, including SNF, and for decommissioning nuclear facilities, including NPPs, is established in the General Radioactive Waste Plan (GRWP). The GRWP is intended to address not only the strategies, necessary actions and technical solutions to be developed in the short, medium and long terms for decommissioning nuclear facilities and managing radioactive waste, but also the economic and financial measures necessary to carry them out. Enresa is responsible for drafting and reviewing the GRWP every four years or upon request of MITERD, and for submitting it to MITERD, who reviews a revision of the GRWP and submits a proposal for its approval to the Council of Ministers. As a part of the approval procedure, MITERD conducts a consultation of the general public and relevant stakeholders, including the autonomous

communities. The CSN provides a report on the nuclear safety and radiation protection aspects. The approved GRWP is reported to the Spanish parliament. The approval process, until the plan is approved by the Council of Ministers, may take about two years. The seventh revision of the GRWP was proposed in March 2020 and reflected the sequential final shutdown schedule of NPPs stated in the aforementioned protocol, as well as updates of necessary actions and technical solutions.

While Enresa is responsible for decommissioning and radioactive waste management according to the GRWP, its activities and performance are monitored and controlled by the Secretary of State for Energy of MITERD. To that end, Enresa periodically submits reports to MITERD that include technical and economic aspects of the activities it has carried out, issues related to budgets, updated economic and financial studies on the costs of the activities set in the GRWP, and an evaluation of the adequacy of the existing financial mechanism for the GRWP.

Decommissioning

As of 2020, three NPPs have been shut down in Spain; two of them, Vandellos-1 and Jose Cabrera, are being decommissioned by Enresa. The third plant, Santa Maria de Garona, is now under pre-dismantling works by the operation licensee before moving to decommissioning by Enresa.

Table 8.3 Status of the decommissioning process of nuclear power plants in Spain, 2020

Reactor unit	Type	Net capacity (MW_e)	Shut-down	Decommissioning strategy	Current phase
Vandellos-1	GCR	4	July 1990	Deferred dismantling, including partial dismantling. The remaining radiological areas have been safely enclosed (SAFSTOR).	Dormancy period. The final dismantling phase will start around 2028.
Jose Cabrera	PWR	141	April 2006	Immediate dismantling and removal of all radioactive materials.	Final dismantling.
Santa Maria de Garona	BWR	446	Aug. 2017	–	Pre-dismantling.

Notes: MW_e = megawatt electrical. GCR = gas cooled reactor. PWR = pressurised water reactor. BWR = boiling water reactor.

Sources: IAEA (2020), *Power Reactor Information System (PRIS)* (database), https://pris.iaea.org/PRIS/home.aspx; Enresa website: www.enresa.es/eng.

Once an NPP is shut down permanently, the operating licensee of the NPP is required to condition the radioactive waste generated during its operation and to discharge the SNF from the reactor and the storage pools or, alternatively, to have an SNF management plan approved by MITERD, upon a report by the CSN. The decommissioning licence is issued by MITERD upon a report by the CSN. The licence is then transferred to Enresa to proceed with the decommissioning of the NPP. The decommissioning authorisation procedure requires an environmental impact assessment and a public consultation to be carried out.

Radioactive waste management

In Spain, radioactive waste is classified into three groups: low- and intermediate-level waste, special waste (SW) and high-level waste. LILW represents radioactive waste with a half-life under 30 years and minimal content in long-lived radioisotopes. This group includes very low-level waste (VLLW) as a subgroup. SW, waste that cannot be disposed of as LILW at El Cabril due to its higher radioactivity, will be managed and disposed of at the future DGR. HLW contains radioisotopes with over a 30-year half-life, including SNF.

Low- and intermediate-level waste

All LILW and VLLW generated from nuclear facilities in Spain are to be disposed of at the El Cabril facility by Enresa. As of the end of 2018, 33 602 cubic metres (m^3) of LILW were disposed of in this facility, representing 77.2% of its capacity of around 45 000 m^3 (Enresa, 2018; Zuloaga, 2006). VLLW is to be disposed of in four dedicated vaults, whose total capacity will be about 130 000 m^3. Currently, two of them are operating, storing 15 491 m^3 of VLLW at the end of 2018 (*Ibid*.).

According to Enresa's latest forecasts, the total amount of radioactive waste to be disposed of at this facility will be around 96 500 m^3 of LILW and 123 500 m^3 VLLW. Additional capacity for the disposal of LILW will be needed by around 2028 to avoid impacts on the operation and decommissioning of NPPs. In 2018, Enresa started engineering works for the construction and licensing of the required capacity expansion, so that it can be completed in due time.

High-level and special waste and spent nuclear fuel

In Spain, SNF is to be disposed of as HLW. In operating NPPs, SNF is temporarily stored in on-site storage pools, or in dry casks in the individual storage facilities built at the plant site. As of September 2020, among the five NPP sites, three had individual storage facilities in operation and one more was under construction. SNF is to be transferred to the CSF in the future, where it will be stored for about 60 years until the DGR becomes available. Decommissioning waste with relatively high levels of radioactivity is classified as SW.

The CSF is expected to have sufficient capacity to accommodate all SNF and SW generated from the operation and decommissioning of Spanish NPPs. The facility, as a strategic option foreseen in the 7th GRWP, is targeted to be put into service in 2028. The site selection process for the CSF was completed and the designation of the municipality of Villar de Canas was approved by the Council of Ministers in 2011. Enresa submitted to the then Ministry of Industry, Energy and Tourism the application for the preliminary and construction authorisations in January 2014. Additionally, in August 2013, Enresa submitted to the then Ministry of Agriculture, Food and Environment the application to initiate the required environmental impact assessment for the project. The CSN issued a favourable report for preliminary authorisation in July 2015. However, in 2018, the Secretary of State for Energy requested that the CSN put on hold issuance of the mandatory report of the regulatory body regarding the construction authorisation. That request was based on the need for a more detailed assessment of the situation, the pending processing and approval of a new revision of the GRWP, and on new factors that could have changed in the time that had elapsed since January 2014. Additionally, the granting of the environmental impact assessment, whose issuance affects the preliminary authorisation, was also put on hold. The environmental documentation that accompanies the draft 7th GRWP considers and analyses multiple distributed storage facilities as technically and environmentally viable and

rational alternatives to the CSF. The government is expected to take a decision on the strategy for SNF storage during the approval process of the proposed GRWP.

Regarding the DGR, the site selection process has not yet started. The draft of the 7th GRWP establishes a tentative programme for the availability of the facility in order to attain the objective of beginning its operation in 2073 (Table 8.4). This tentative programme focuses on developing the technological capabilities and social acceptance necessary to guide and implement the DGR, and proposes to start the site selection process around 2030. This programme will be further analysed during the approval process of the 7th GRWP.

Table 8.4 Phases to implement the deep geological repository proposed in the draft 7th GRWP

Phase	Activity
Phase 1 (until 2024): Updating of knowledge	• Enresa will prepare a report including: ▪ the updated status of the information and capacities available ▪ a proposal for the site designation process ▪ the basic information for the planning process.
Phase 2 (3 years): Assessment of the report	• The government will analyse the report and guide the following phases based on the assessment. • The generic project for the deep geological repository (DGR) will be evaluated by the Nuclear Safety Council (CSN). • The R&D plans and programmes will be developed.
Phase 3 (4 years): Site selection process	• The procedure for the selection of the site will be prepared and implemented. • Some candidate sites will be identified. • A proposal for basic design criteria for the DGR and the preliminary site characterisation plan will be submitted to the CSN for evaluation.
Phase 4 (7 years): Analysis of candidate sites and selection of definitive candidate	• Preliminary works will be undertaken to characterise the different candidate sites, applying near surface technologies. • The CSN will evaluate the detailed plan for the characterisation of the site. • The underground laboratory and surface support facilities project, and the environmental evaluation of the project will start.
Phase 5 (20 years): Characterisation of site and verification of suitability	• An underground laboratory will be constructed and detailed characterisation will be carried out. • The detailed design of the DGR and the corresponding safety and environmental impact studies will be elaborated. • The documents for site and the construction authorisation will be prepared and submitted, and authorisations will be granted.
Phase 6 (12 years): Licensing and construction	• The construction of the DGR will start. • The documents for the operating authorisation will be prepared and submitted, and the authorisation will be granted. • Long-term testing data collection will start. • A demonstration pilot facility for verification of the facility's engineering barrier system will be built.
Phase 7: Initial operation and tests	• The spent nuclear fuel and high-level waste will begin to be stored in the DGR for a first stage of nuclear tests.
Phase 8: Normal operation	• The DGR will start normal operation.

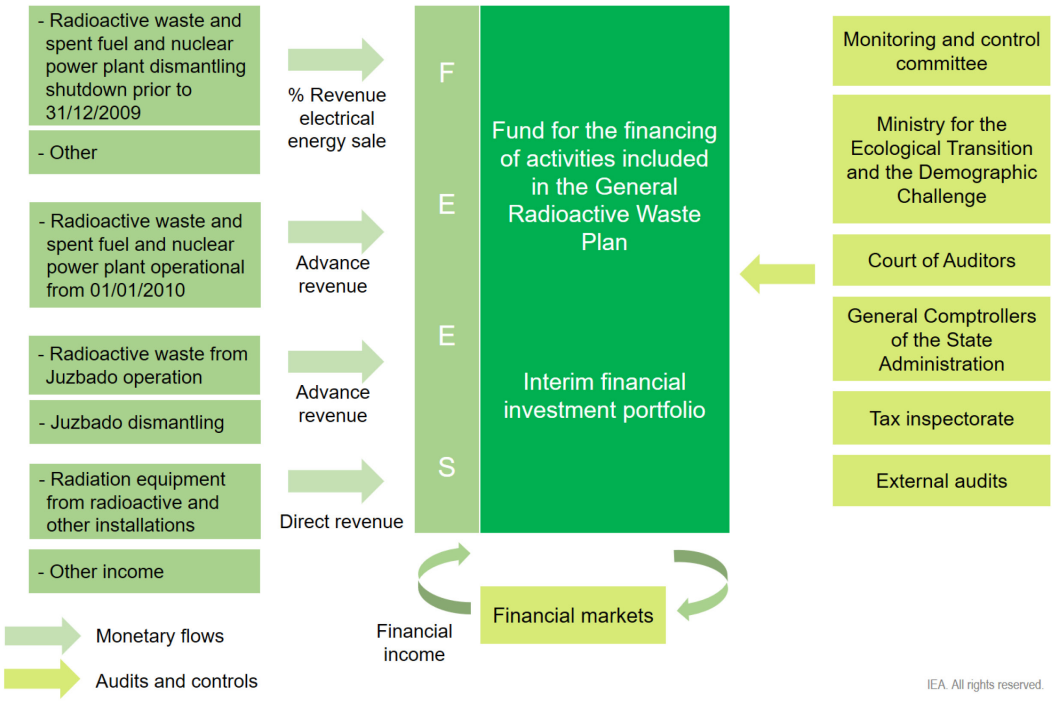
Notes: DGR = deep geological repository. CSN = Nuclear Safety Council.

Source: Government of Spain's response to the IEA questionnaire.

Funding for decommissioning and radioactive waste management

The Spanish scheme for the financing of decommissioning and radioactive waste management is based on the polluter-pays principle (EC, 2019). To finance the costs for decommissioning and radioactive waste management by Enresa, licence holders of nuclear facilities are required to pay fees into the dedicated "Fund for the Financing of the Activities included in the General Radioactive Waste Plan" (GRWP Fund), which is held and managed by Enresa (Figure 8.4).

Figure 8.4 The funding system for decommissioning of nuclear facilities and radioactive waste management



Source: MITERD (2020), *Country Case Study Spain*.

These fees finance both present and future costs according to the cost estimations in the GRWP. The decommissioning and radioactive waste management of nuclear facilities that were operational on 1 January 2010 are financed by a fee from licensees, which is collected exclusively during the operation of the plants. A small share of the revenues comes from a part of the electricity tariff to cover the costs associated with the NPPs that were permanently shut down before 1 January 2010 or those that were not foreseen during the operation of the NPPs. Fees must be covered by the license holders throughout the entire operational lifetime of their facilities. If they decide on early final shutdown of their facilities, they are also liable to pay extra fees. Enresa determines the amounts that are payable to the fund and annually reports them to the Spanish government which, in turn, can adjust the unit rates by regulatory means so that the fund is sufficient. The supervision and control of the transitory investments of the GRWP Fund are carried out by an inter-ministerial Monitoring and Control Committee that is attached to MITERD.

Research and development

In Spain, the Centre for Energy Related, Environmental and Technological Research (CIEMAT), Enresa, and the CSN are the main entities involved in nuclear research and development (R&D) activities. CIEMAT focuses on nuclear safety, nuclear innovation and radioactive waste management, as well as nuclear fusion technology (IAEA, 2018). Enresa carries out R&D activities related to decommissioning of nuclear facilities and radioactive waste management based on its multiannual R&D Plan (NEA, 2018). The current 8th revision of Enresa's R&D Plan for 2019-23 sets up five research areas: 1) waste technology and know-how; 2) technology for treatment, conditioning and dismantling processes; 3) confinement materials and systems; 4) safety assessment, performance assessment, radiological protection and associated modelling; and 5) cross-cutting activities (knowledge management and co-ordination). The CSN carries out R&D activities according to its R&D Plan for 2016-20 (CSN, 2016). The plan focuses on nuclear safety and radiation protection and sets a number of projects to be undertaken in collaboration with different national and international organisations, such as universities, public and private companies, and government agencies.

In addition to the activities undertaken by these entities, there are two major platforms for nuclear R&D. The Nuclear Fission Energy Technology Platform (CEIDEN) aims to co-ordinate the different national programmes and plans for nuclear R&D and to foster the participation of Spanish companies and institutions in international R&D activities (CEIDEN, n.d.). The programmes involved in CEIDEN are: 1) the Accident Tolerant Fuel Group; 2) the Socio-technical Research Working Group; 3) the Knowledge Management and Training Group (KEEP+); 4) the Materials Group; and 5) the Jules Horowitz Reactor Project. The other platform, the National Platform of R&D on Radiological Protection (PEPRI), aims to foster R&D activities in the field of radiation protection and to co-ordinate Spain's participation in international R&D programmes in this domain, including Horizon 2020 (PEPRI, n.d.).

Assessment

Over the past half-century, Spain has developed a well-integrated and efficient nuclear infrastructure including seven operating NPPs, a fuel manufacturing facility, solutions for decommissioning of nuclear facilities and the management of radioactive waste and spent nuclear fuel, and efficient regulatory institutions. The performance of operating NPPs is excellent, maintaining high-capacity factors of around 90% for the last decade. Currently, nuclear energy produces about 20% of Spain's total electricity, contributing to the security of supply, reduction of greenhouse gas emissions and diversification of energy sources.

The NECP foresees a sequential shutdown of the Spanish nuclear power capacity from 2027 to 2035. According to this plan, nuclear generation capacity will be reduced to around 3.2 GW by 2030 and to 0 by 2035. This orderly final shutdown was agreed in 2019 by the owners of Spanish NPPs and Enresa. The operational period of each NPP is still subject to compliance with the limits and conditions on nuclear safety imposed by the CSN, including approval of their Integrated Ageing Assessment and Management Plan for operation beyond 40 years, as well as the licensee's decision to invest in such a plan for continuing operation. According to some of the licensees, they currently operate their NPPs at a loss due to high taxation on nuclear generation and low electricity market prices,

so they might opt to exit the market sooner; this would imply changes in the electricity mix. There is also concern for the large impact on employment of the highly skilled workforce by the final shutdown of nuclear power plants. However, no concrete measures have been put in place for transitional support so far.

Spain has developed a well-integrated scheme for decommissioning of nuclear facilities and radioactive waste management including SNF under the clear and predominant responsibility of the government. The GRWP, established after a comprehensive process including public consultation, safety review by the CSN and approval by the Council of Ministers, provides the reference framework for national strategies and actions for decommissioning and radioactive waste management. According to the GRWP, the state-owned company Enresa carries out activities, and MITERD oversees both technical and financial activities and the performance of Enresa. Enresa is expected to decommission ten NPPs in Spain over the next few decades. This could give the company a competitive advantage in the NPP decommissioning business in other countries, through economies of scale and knowledge centralisation. Currently, there is no consideration for Enresa to expand its decommissioning business to other countries, except for possible technical co-operation under international organisations such as the International Atomic Energy Agency, the Nuclear Energy Agency and the European Atomic Energy Community.

Spain has a well-structured centralised funding scheme in place to finance costs for decommissioning of nuclear facilities and management of radioactive waste. There is a single external joint fund to cover the costs (the GRWP Fund). The GRWP Fund is regulated by law, and held and managed by Enresa. The management of the fund is supervised and controlled by an inter-ministerial Monitoring and Control Committee attached to MITERD. Fees for the fund are to be satisfied by the license holders throughout the entire operational lifetime of their facilities and can be revised by means of royal decree. This scheme gives Spain an advantage, the ability to closely align legislative projects with long-term decommissioning and radioactive waste management strategies, while holding license holders financially responsible for the costs. On the other hand, the effectiveness of this scheme requires a realistic and comprehensive estimation of future costs. Otherwise, it could impose residual or unforeseen financial responsibilities on the state, and thus ultimately on taxpayers. Currently, the regulatory process for developing the centralised storage facility for SNF is suspended, and the site selection process for the DGR has not yet been established. The government contends that the delay in CSF implementation would not affect NPP operation and decommissioning, as individual storage facilities at each site will have sufficient capacity to accommodate the SNF and SW that will be generated in the future. However, the delay in implementing the CSF and the DGR could impose additional costs on decommissioning and radioactive waste management in the future. The existing funding scheme includes a mechanism to collect fees from a percentage of the electricity tariff, which currently aims to finance the costs associated with the NPPs that were permanently shut down prior to 1 January 2010 and those costs that were not foreseen during the operation of the NPPs. While this mechanism could be used to address uncertainties in the estimation of future costs, it could amount to transferring these costs to the future generation of electricity consumers.

Spain has developed a wide range of nuclear technological competencies since the 1960s, from nuclear power plant construction and operation or nuclear fuel fabrication to radioactive waste and SNF management. Its current national nuclear R&D activities focus on radioactive waste management and decommissioning, in line with its policy to phase out nuclear by 2035. On the other hand, nuclear technology is considered to have great

potential to contribute to decarbonisation of not only the electricity system, but also hard-to-abate sectors, such as manufacturing and transport, through high-temperature heat supply and hydrogen production (NEA, 2020). Given the great challenge for achieving carbon neutrality in 2050, the high level of nuclear technology infrastructure and skilled professionals in Spain could be utilised more effectively for developing and implementing long-term energy strategies.

Recommendations

The government of Spain should:

- Closely monitor the financial situation of nuclear power plants to prevent unforeseen or sudden final shutdown that could significantly deteriorate the security of electricity supply.
- Pursue timely implementation of the back-end strategy, including the centralised storage facility and the deep geological reporsitory, to avoid unnecessary cost escalation for decommissioning of NPPs and radioactive waste management, including final waste disposal.
- Develop projects that could enable the effective preservation and transfer of knowledge and expertise using current technical infrastructure and highly skilled workers as well as the institutional advantages of Enresa in the NPP decommissioning business.
- Consider the usefulness of nuclear energy, including for non-electricity applications, for diversifying technical options to achieve long-term carbon neutrality by 2050.

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9. Coal

Key data

(2019)

Coal net imports: 7.2 Mt/4.5 Mtoe (5.5 Mtoe imports, 1.0 Mtoe exports), -50% since 2009

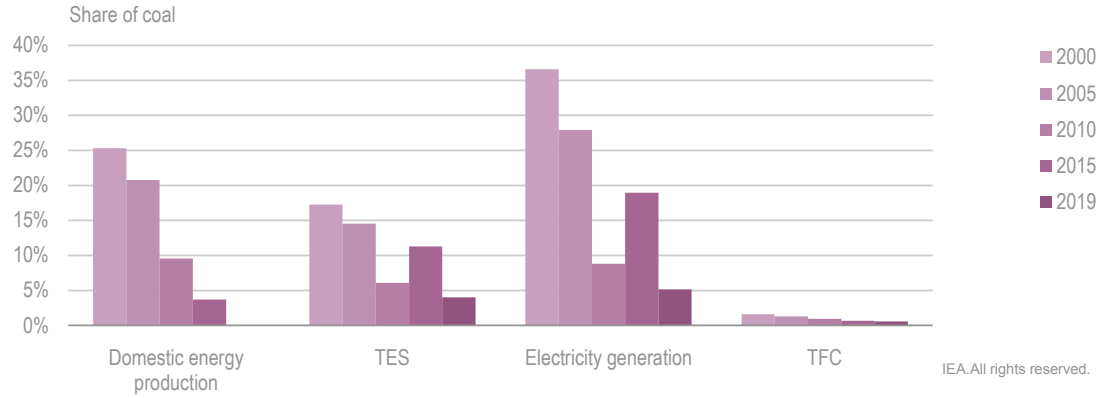
Share of coal: 4% of total energy supply and 5% of electricity generation

Consumption by sector: 4.9 Mtoe (power and heat generation 70.2%, other industry 26.8%, energy 19.3%, services 1.6%, residential 1.4%)

Overview

Following the closure of all its coal mines, Spain in 2019 reported for the first time no domestic coal production. Coal was the fifth-largest primary energy source in Spain, representing 4% of total energy supply (TES) in 2019 after oil, natural gas, renewables and nuclear (Figure 9.1). The share of coal in electricity generation significantly decreased between 2000 and 2010 due to an increased share of renewable energy sources. Later, between 2010 and 2018, coal for power production fluctuated between 9% and 19% of total electricity generation, then dropped significantly to 5% in 2019. Coal's share in total final consumption (TFC) slightly decreased, from 1.6% in 2000 to 0.6% in 2019. Net imports halved in the decade between 2009 and 2019.

Figure 9.1 Share of coal in different energy supplies in Spain, 2000-19



Between 2000 and 2019, the share of coal significantly decreased from 25% to 0% of domestic energy production and from 37% to 5% of electricity generation.

Notes: TES = total energy supply. TFC = total final consumption.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

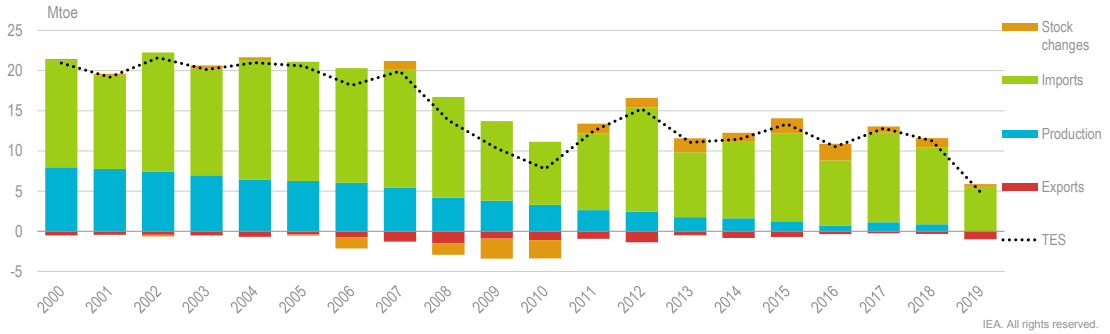
The government of Spain plans to close all coal-fired power plants by 2030 in order to accelerate the energy transition towards a low-carbon economy. Coal's declining share in energy supply is expected to continue. As a result, imports will also decline rapidly. Depending on market circumstances, such as the price for CO_2 emissions allowances under the EU Emissions Trading System (ETS), coal-fired power generation in Spain might end well before 2030.

Supply and demand

In 2019, Spain's coal supply amounted to 4.5 million tonnes of oil equivalent (Mtoe), 90% of which was steam coal and 10% coking coal (Figure 9.2). Total coal supply dropped by 77% between 2000 and 2019, in line with decreasing domestic demand. Domestic coal production has steadily decreased from 7.9 Mtoe in 2000 to 0 in 2019, as a result of the closure of domestic coal mines. All coal supply was imported in 2019, but coal imports have also decreased, from 13 Mtoe to 4.5 Mtoe between 2000 and 2019.

Spain imported 8.5 million tonnes (Mt) of steam (90%) and coking (10%) coal, and exported 1.5 Mt of steam coal in 2019. Coal was mainly imported from Indonesia (27%), the Russian Federation (32%), Colombia (13%), Australia (10%) and the United States (8%) (Figure 9.3). Spain exported coal, mostly to neighbouring European countries, including Italy, Portugal and the United Kingdom.

Figure 9.2 Spain's coal supply by source, 2000-19

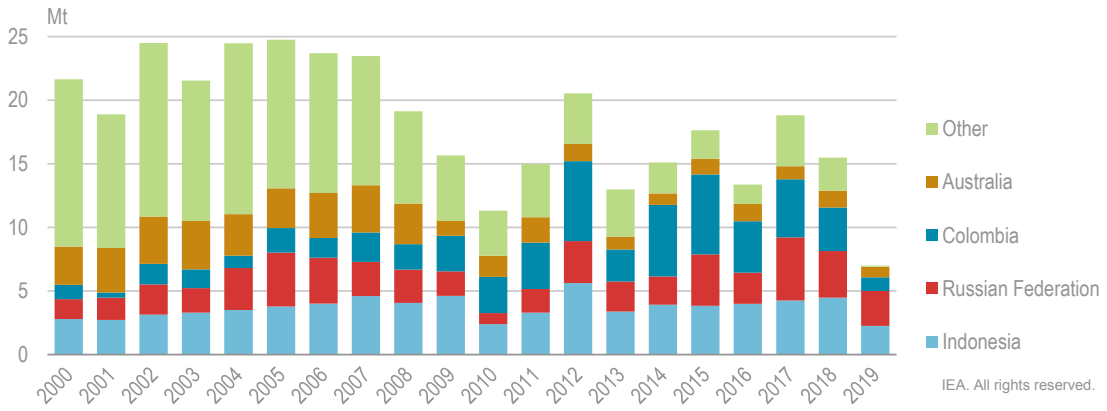


Most coal in Spain is imported, as production stopped in 2019. In the last decade, and especially in 2019, the total supply of coal significantly declined.

Notes: Mtoe = million tonnes of oil equivalent. TES = total energy supply.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 9.3 Spain's coal net imports by country, 2000-19



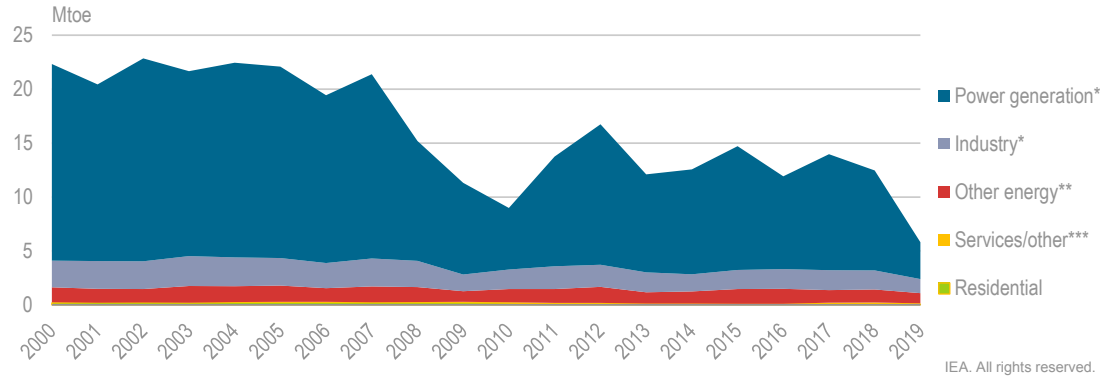
Indonesia, Russia and Colombia are the major coal importing countries to Spain, accounting for 59% of the total in 2019.

Notes: Mt = million tonnes. Includes only hard coal.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Total coal demand in Spain was 4.9 Mtoe in 2019, which is 77% lower than in 2000. Coal consumption has fluctuated year-on-year, mostly depending on its use in electricity generation (Figure 9.4). Between 2007 and 2010, coal demand for electricity generation significantly decreased to around 6 Mtoe, to increase again in the following years, but still remained at about half of demand in the first years of the century. Meanwhile, coal consumption in other sectors has remained relatively stable over the last decade. In 2019, 70% of total coal consumption in Spain was used for power generation, followed by industry (27%), other energy (19%), and minor shares for residential and services.

Figure 9.4 Coal consumption in Spain by sector, 2000-19



Coal used for power generation in 2019 accounted for 70% of the total, and has decreased by 60% compared to 2000.

* *Power generation* includes a minor share of district heat production.

** *Other energy* includes energy use in transformation in coke ovens and blast furnaces.

*** *Services/other* includes commercial and public services.

Note: Mtoe = million tonnes of oil equivalent.

Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Coal policy

Coal phase-out

As part of its climate change and energy transition agenda, Spain has a plan to phase out the use of coal in its electricity sector. However, unlike in some countries that have imposed specific mandates for the industry to shut down coal-fired generation capacity, Spain expects that market conditions will drive coal closures.

The National Energy and Climate Plan (NECP) expects that up to 9 of Spain's 15 coal-fired power plants (as of 2019) will no longer be operational by 2021. Already, based on market conditions and requirements under the EU Industrial Emissions Directive for large combustion facilities, on 30 June 2020, 8 of Spain's fully operational 14 coal-fired plants with around 4.6 gigawatts (GW) of capacity shut down. Three more have asked for permission to close in 2021 and another one is expected to close in 2022. Moreover, one plant in Majorca only operates on a limited basis (around 500 hours annually after 2021).

By 2030, the government expects that coal-fired power plants will no longer be competitive based on an EU EEmissions Trading System price of EUR 35/tonne, along with continued cost reductions for renewables technologies and relatively low prices for natural gas. As such, it expects coal to be fully phased out of the power sector by 2030.

Large-scale generation facilities need authorisation from the government before they can be decommissioned. The approval procedures can be lengthy and numerous. In the time it takes for the government to grant approval, companies need to maintain their power plants and be prepared to start generation within a given time frame, adding to the costs of decommissioning.

Currently, Spain does not have policies in place or under development to advance carbon capture, utilisation and storage.

Coal subsidies

Over the last few decades, coal mining in Spain was directly subsidised as it was not competitive with imported coal. However, the government gradually decreased subsidies from EUR 314 million (EUR 37 per tonne) in 2010. In line with EU requirements, it stopped them completely by the end of 2018. Consequently, domestic coal supply declined from around 23 Mt in 2000, to 8 Mt in 2010, to 0 at present.

As such, neither coal mining nor coal-fired generation currently receive any subsidies in Spain.

Transitional assistance

Based on the expected coal phase-out, the government plans to offer support measures to affected regions to help them adjust to the transition.

The government has already announced the closure of coal mining operations and the redirection of coal mining subsidies to restructuring coal mining regions. Royal Decree-Law 25/2018 extended the closure plan for coal mining by two years, originally scheduled for 31 December, 2018. However, most domestic mining has already been shut down.

As part of this effort, the government has released two action frameworks: the "Framework for Action for Coal Mining and Mining Areas in the 2013-2018 Period" and the new "Framework Agreement for a Fair Transition of Coal Mining and the Sustainable Development of Mining Areas 2019-2027". Different regulations have been published under these action frameworks to regulate aid for coal mine closures, aid for exceptional costs and aid to boost mining areas, as established in EU Directive 2010/787. The work is spearheaded by the Just Transition Institute.

Addressing the detrimental impact of coal mine closures on labour markets is a focal point of the frameworks. To this end, they include measures to promote the development of projects that generate employment and support the construction of related infrastructures while encouraging the hiring of unemployed workers as a result of the cessation of mining activities.

Aid to promote new economic activities and/or the expansion of existing ones as alternatives to coal mining may be carried out by granting incentives through:

- business projects with investments greater than EUR 100 000 and job creation commitments equal to or greater than three jobs
- aid for small investment projects
- aid for the alternative development of mining areas.

These grants are aimed at promoting the alternative development of mining districts through the execution of infrastructure projects and restoration of areas degraded by mining activity.

The development of infrastructure will be primarily directed to the following activities:

- improvement, restoration, recovery and revaluation of dumps, degraded areas and spaces affected by coal mining operations
- improvement of equipment related to transformation and electrification centres, gas supply, lighting, and hydraulic infrastructures
- forest recovery and management of areas degraded by mining activities, as well as actions related to atmospheric sanitation aimed at improving air quality, reducing noise levels and the regeneration of wastewater treatment plants
- provision and renovation of telecommunication lines, optimisation and energy diversification with renewable energy supply in public buildings
- creation and equipping of business incubators, technological development centres.

Aid corresponding to infrastructure and restoration projects amounts to around EUR 125 million, and will be articulated in 103 collaboration agreements between the Just Transition Institute and the autonomous communities.

Regionally, the relevant areas are those belonging to the autonomous communities of Aragón, Principado de Asturias, Castilla y León and Castilla La Mancha.

Mine closures have not significantly impacted Spain's supply of coal, as the coal that was being used for thermal energy generation was already mostly sourced from imports.

Assessment

In a dramatic change from history, and as part of its climate change and energy transition agenda, Spain is closing down its coal mining sector and phasing out the use of coal in its energy sector. However, unlike in some countries that have imposed specific mandates for the industry to shut down coal-fired generation capacity, Spain expects regulations and market conditions to drive the closure of the 14 coal-fired power plants (total capacity around 10 GW) that were still in operation at the start of 2020.

Over the last decades, coal mining in Spain was directly subsidised as it was not competitive with imported coal. However, the government gradually decreased subsidies, and in line with EU requirements stopped them by the end of 2018 completely. Consequently, domestic coal supply declined from around 46 Mt in 2000 to almost 0 in 2020. In 2019, Spain still imported 8.5 Mt of coal, but imports are also declining fast with the closure of coal-fired power plants. Some 1.4 Mtoe of coal is used outside of the electricity sector.

The government set up a programme to offer support measures to affected regions to help them adjust to the transition. As part of this effort, it has released two action frameworks: the "Framework for Action for Coal Mining and Mining Areas in the 2013-2018 Period" (extended for two years to the end of 2020) and the "Framework Agreement for a Fair Transition of Coal Mining and the Sustainable Development of Mining Areas 2019-2027". Different measures were taken under these frameworks to provide aid for coal mine closures; aid for exceptional costs; and aid to boost employment in the mining areas of Aragón, Asturias, Castilla y León and Castilla La Mancha. All domestic coal mines have already shut down.

Since 30 June 2020, coal-fired plants have to comply with EU environmental regulations for emissions of large industrial installations and power plants. For many of the coal-fired power plants in Spain, such compliance is not economically feasible, and as a consequence, on 30 June 2020, eight plants with around 4.6 GW of capacity shut down and four more, representing 3.1 GW, announced closure in 2021 or 2022. According to the NECP, by 2030, the government expects that coal-fired power plants will no longer be competitive based on an EU ETS price of EUR 35/tonne, along with continued cost reductions for renewables technologies and relatively low prices for natural gas. As such, the government expects all coal plants to be closed by 2030. In practice, with falling electricity demand due to COVID-19, low natural gas prices and costs for renewable generation falling rapidly, this is likely to happen much earlier. Coal-fired generation is already declining fast: its share in total generation was 14% in 2018, 5% in 2019, and in 2020 it is expected to be around 2%.

Large-scale generation facilities need approval from the government before they can be decommissioned. Currently the approval procedures are lengthy and numerous, though essential as part of the regulatory framework to ensure security of energy supply. As long as no approval is granted by the government, companies need to maintain their facilities in a state that allows them to start generation within a given time frame. This situation of readiness adds to the decommissioning costs of the power plants that were already loss-making to their companies.

Recommendation

The government of Spain should:

- ☐ Ensure a clear and efficient process for granting generators permission to decommission their coal-fired generation plants.

References

IEA (International Energy Agency) (2021), "World energy statistics", *IEA Energy Statistics and Balances* (database), www.iea.org/statistics.

10. Natural gas

Key data

(2019)

Domestic production: 0.1 bcm, +867% since 2009

Net imports: 36.1 bcm (37.2 bcm imports, 1.2 bcm exports)

Share of gas: 0% of domestic energy production, 25% of total energy supply,[1] 31% of electricity generation, 17% of total final consumption

Gas consumption by sector: Electricity and heat 41%, industry 29%, other energy 11%, services 8%, residential 10%, transport 0.8%

Overview

Natural gas places third in Spain's total final consumption (TFC), after oil and electricity. Natural gas' share has increased steadily in total energy supply over the years, reaching 25% in 2019. Heat and electricity generation has been the main gas-consuming sector over the past two decades, with a sizeable increase in the first decade, followed by a decrease in 2008, and remaining stable since 2014. The industry sector is the second-largest gas-consuming sector in Spain.

Spain has made considerable changes in the past five years to its natural gas market operations to increase the system's efficiency, in particular with the development of the MIBGAS hub to further integrate the Spanish and Portuguese gas markets. A Spanish gas exchange market was also developed in 2015 to trade natural gas and liquefied natural gas (LNG). Moreover, Spain has made notable headway in erasing its tariff deficit in the gas sector. However, there remains underutilised gas infrastructure, including on the interconnector between Spain and France. Spain is also currently working with France and Portugal to create a Solidarity Agreement on Natural Gas to further integrate its gas market with those of its neighbours.

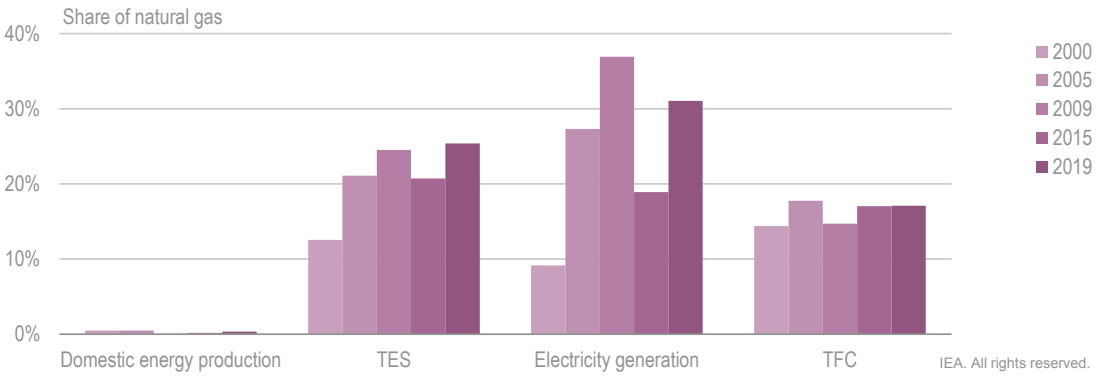
Spain has placed carbon reduction at the forefront of its energy strategy. To this end, the government will use biogas and hydrogen road maps to help clarify the main pathways to increase the share of renewable gases in its energy system.

[1] Total energy supply does not include oil used for international bunkering.

Supply and demand

The share of natural gas in total energy supply (TES) in Spain increased over the period from 2000 to 2019, as it dd in total final consumption (TFC), albeit at a more moderate rate (Figure 10.1). Natural gas was 13% of TES in 2000, 25% in 2009 and 25% in 2019, while it accounted for 14% of TFC in 2000, 15% in 2009 and 17% in 2019. Electricity generation from natural gas was relatively low in 2000 at 9%, increasing to 37% in 2009 and decreasing again to 31% in 2019; fluctuations are, in part, due to variations in the share of hydro generation.

Figure 10.1 Natural gas in energy production, total energy supply, electricity and total final consumption in Spain, 2000-19



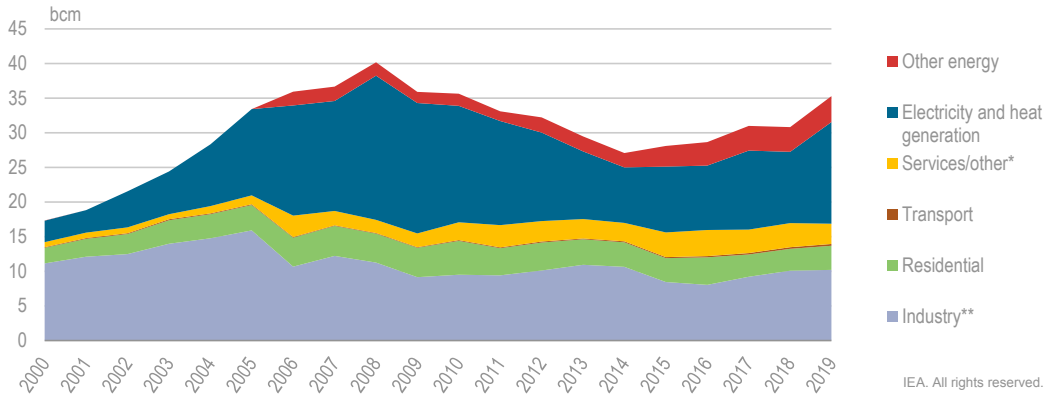
Natural gas accounts for a relatively small share of Spain's overall energy consumption and total energy production.

Notes: TES = total energy supply. TFC = total final consumption.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Spain's natural gas consumption increased significantly until 2008, largely driven by an uptick in natural gas consumption in electricity and heat generation (Figure 10.2). After 2008, consumption of natural gas gradually declined, but rose sharply in 2019. Natural gas in electricity and heat generation decreased from 2009 to 2018, but rose again in 2019 due to the substitution of coal for natural gas. Gas consumption in the industry, residential and services sectors remained relatively constant from 2008 onwards.

Figure 10.2 Natural gas consumption in Spain by sector, 2000-19



Natural gas consumption trends were heavily influenced by demand shifts in the electricity and heat generation sector.

* *Services/other* includes commercial and public services, agriculture, forestry, and fishing.

** *Industry* includes non-energy consumption, oil and gas extraction, and other energy sector use.

Note: bcm = billion cubic metres.

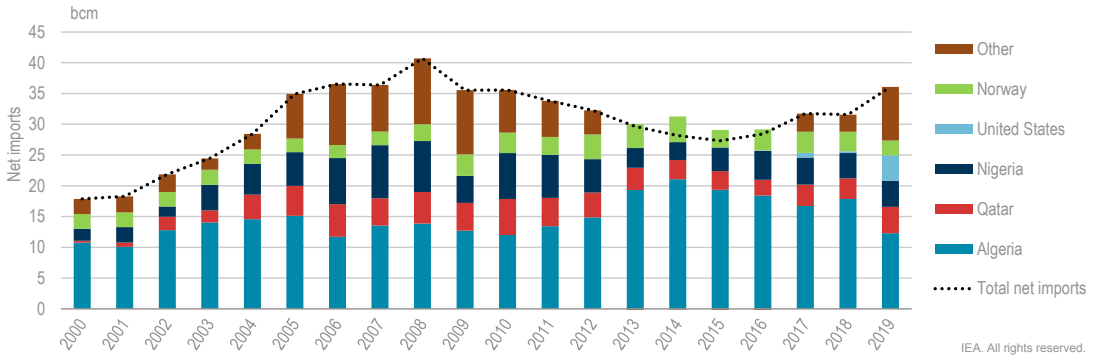
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Seasonality of natural gas demand can vary considerably in Spain. In 2019, 47% of consumption for power generation occurred between June and September. August showed the lowest demand for non-electricity sectors, while July had the highest consumption for power generation. Seasonality in the household and commercial sectors is more pronounced. The six months from May to October represented only 22% of total consumption in this segment, with the remaining consumption (78%) concentrated in the other six months.

Spain's natural gas supply is diversified, in part due to regulation on security of supply, which requires that shippers diversify their portfolios if supplies of natural gas from the same origin country are higher than 50% of national consumption (see below on regulation). Spain's total natural gas net imports in 2019 stood at 31.6 billion cubic metres (bcm). Algeria is Spain's dominant supplier (mainly pipeline), accounting for around one-third of Spain's total imports in 2019 (12.3 bcm). In 2019, Qatar was Spain's second-largest natural gas import source along with Nigeria (4.3 bcm or 12% each), followed by the United States (4.1 bcm or 11%). Imports from Algeria grew from 10.8 bcm in 2000 to 12.3 bcm in 2019 (Figure 10.3).

Looking ahead, under its National Energy and Climate Plan (NECP), Spain anticipates flat demand for natural gas from 2015 levels in a target scenario under which primary energy consumption increases by around 3% from 2015 to 2030, growing from around 27 bcm in 2015 to 30 bcm in 2020 and 27 bcm in 2025 and 2030 (EC, 2020). Under a target scenario in which final energy consumption grows by 15% to 2030, natural gas consumption is expected to grow by around 5%. As such, there remains some uncertainty surrounding future demand for gas, notably the role that gas will play in providing power system flexibility as the electricity mix shifts to one dominated by variable renewables (see Chapter 7).

Figure 10.3 Spain's natural gas net imports, 2000-19



Spain's natural gas net imports are predominantly from Algeria, Qatar, Nigeria and the United States.

Note: bcm = billion cubic metres.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Spain also exports some of its imported gas. Re-exports, by cargoes and pipeline, are a recent phenomenon in Spain and reflect the decline in domestic demand since 2008. Portugal is the main export destination, followed by France.

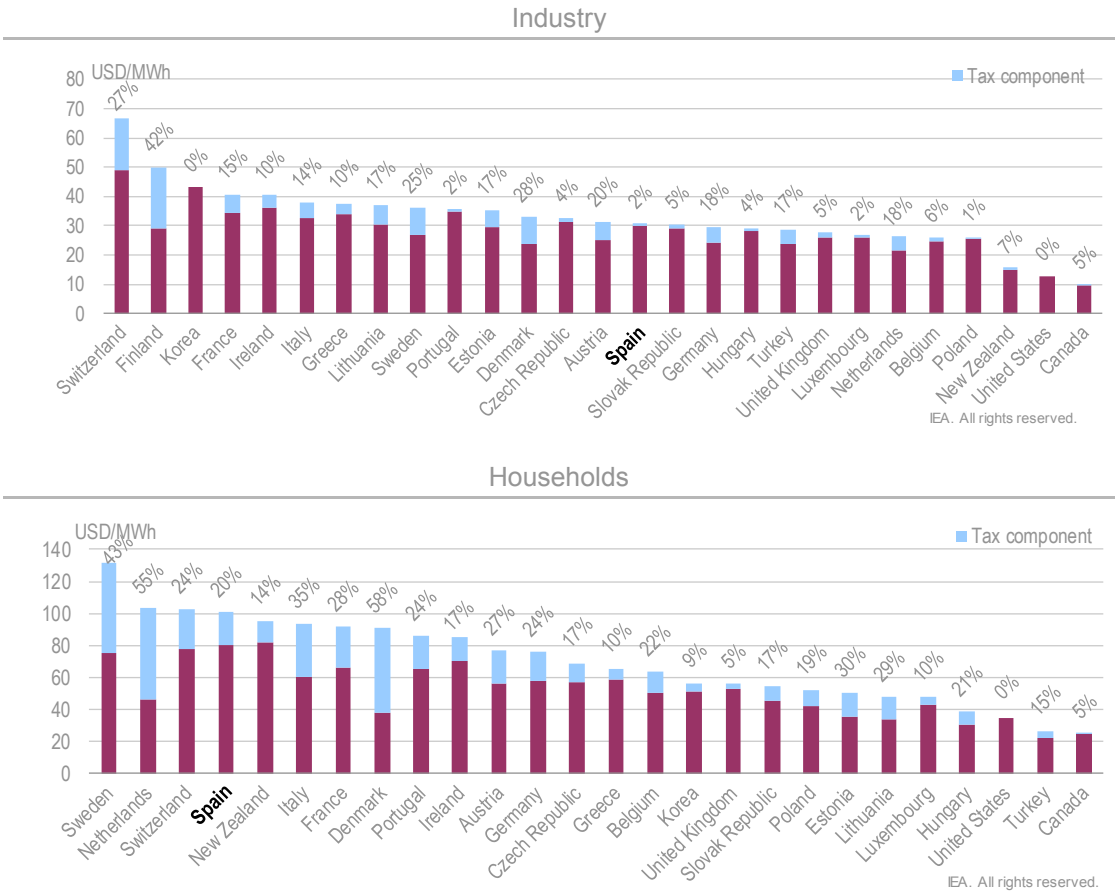
Spanish companies typically buy both LNG and pipeline gas under long-term contracts. In 2019, for the first time since 2013, LNG supplies exceeded those of piped natural gas, accounting for 57% of total supplies, driven by lower prices in the global LNG market.

Gas prices

Spain's industry gas prices are lower than the IEA average, and amounted to 30.7 USD/MWh, of which 2% comprised taxes, one of the lowest tax rates among IEA countries (Figure 10.4).

However, for household gas prices, Spain is the fourth-highest among IEA countries at 100.7 USD/MWh, with a 20% tax component.

Figure 10.4 IEA comparison of industry and household gas prices, 2019



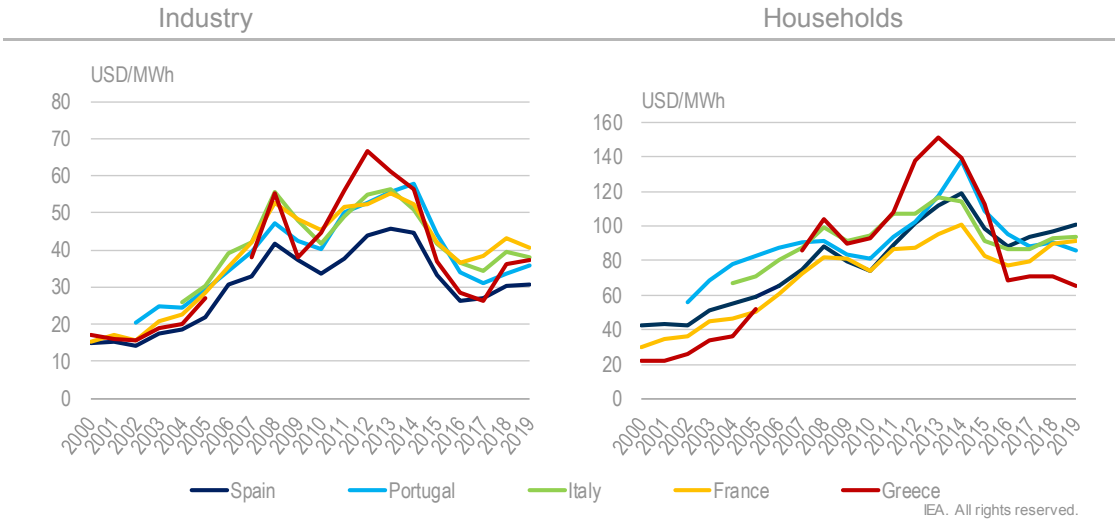
Spain's industry prices are below the IEA average, while its household prices are the fourth-highest among IEA countries.

Notes: MWh = megawatt hour. Missing industry data for Australia, Japan, Mexico and Norway. Missing tax rate industry data for the United States.

Source: IEA (2021b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Spain's natural gas prices in industry and households were both below average compared to its neighbouring IEA countries from 2000 to 2016, although they followed similar trends (Figure 10.5). In 2017, Spain's household natural gas prices surpassed all of its neighbours, and remains the most expensive to date.

Figure 10.5 Natural gas prices in industry and households in selected IEA countries, 2000-19



Spain's natural gas prices follow similar trends to its neighbours.

Notes: MWh = megawatt hour. Data missing for Portugal (2000-01) (industry and household), Italy (2000-03) (industry and household), and Greece (2006) (industry and household).

Source: IEA (2021b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Institutions

The Ministry for the Ecological Transition and the Demographic Challenge (MITERD) is the main energy policy body within the Spanish government. For the gas sector, its responsibilities include overseeing shipper registration as well as authorisation of infrastructure, including high-pressure grids, LNG terminals and subterranean storage. It also carries out safety regulations (including ensuring facilities meet requisites and undertaking periodic inspections), ensures security of supply (including strategic reserves obligations and supply diversification requirements), ensures gas quality, promotion of renewable gases (biogas, biomethane and hydrogen), and oversees revenues and third-party access tariffs for underground storage.

After the approval of Royal Decree-Law 1/2019, all competencies related to access conditions, allocation capacity, third-party access and regulated revenues were transferred to the regulator, the National Commission for Markets and Competition (CNMC), with the exception of revenues and tariffs for subterranean storage.

The CNMC was founded by Law 3/2013 and its functions related to natural gas were expanded under Royal Decree-Law 1/2019. It is an independent entity, governed by an Advisory Board composed of ten independent advisers appointed by the government based on a prior review by a parliamentary commission, which has a refusal right. Its mandate is for six years.

The CNMC is also financially independent as it receives a percentage of third-party access tariffs (currently 0.14%). Its tasks related with natural gas are:

- regulated revenues and third-party access of the transmission grid, LNG terminals and local distribution networks
- access conditions
- balancing
- assessment of investment plans of transmission companies
- access conflicts resolution
- unbundling monitoring
- sector survey.

Lastly, local distribution networks and medium pressure transport branches fall under the authority of regional governments.

Natural gas industry structure

The Spanish natural gas sector is privately owned and operated; this includes the regulated activities of transmission, distribution, LNG terminals and underground storage, as well as unregulated activities like production, trading and retail sales.

Enagás owns and operates most of Spain's high- and medium-pressure grid, as well as three of the country's six operating LNG terminals (and large stakes in two other terminals). The Hydrocarbons Act establishes the model for unbundling of the gas transmission system operator (TSO). The unbundling model adopted for the main TSO (Enagás, with more than 95% of transport pipelines) is ownership unbundling, while small TSOs can choose between an ownership unbundling and independent system operator model. The CNMC is in charge of the certification procedures for system operators and has already certified Enagás and Reganosa as TSOs.

Spanish regulation requires legal and functional unbundling of distribution companies from supplier and producer companies. There are seven distribution companies in Spain, with Nedgia Group (formerly Gas Natural Fenosa) controlling 69% of supply points. Since early 2018, only the main distribution supply operator (DSO; Nedgia Group) remains ownership unbundled as a vertically integrated company with supply activities. The other DSO groups – Nortegas, Madrileña and Redexis – were created as a result of the disinvestment in DSO grids from EDP, Gas Natural Fenosa and Endesa, respectively.

All Spanish customers (including households) have been free to choose their gas suppliers since 1 January 2003. Since July 2008, regulated tariffs for end users (last-resort tariffs) only apply to residential consumers consuming less than 50 000 kilowatt hours per year (kWh/year) and connected to a low-pressure network; they are supplied by four designated last-resort suppliers (see below for more details).

In recent years, more municipalities have been connected to the gas grid, with 33 connected in 2018 and 13 in 2019, reaching a total number of 1 805 municipalities connected. Nowadays, almost 80% of the population lives in a municipality with natural gas access, but only 30% of homes have a natural gas connection.

At the end of 2019, Spain had 7.9 million natural gas supply points, which have been steadily rising over the past decades.

The number of gas traders registered in Spain at the end of 2019 reached 198 companies, out of which 47 have stated they will operate exclusively in wholesale gas and capacity markets, without supplying final customers. The number of marketers who have signed an access contract to the balance point and/or the framework contract for access to gas facilities at the end of 2019 was 143. The number of traders registered in MIBGAS at the end of 2019 was 105 and rose to 144 at the end of 2020. The number of marketers who make sales to final consumers reached 85 in 2019.

Natural gas regulation

The basic regulations for the Spanish gas sector are set in Law 34/1998, the Hydrocarbons Act, which defines the Spanish gas sector as a single, integrated gas system comprising all regulated gas infrastructure, including local distribution grids, gas transmission networks, LNG terminals and underground storages. All of these facilities are subject to third-party access, regulated revenue, capacity allocation and balancing procedures. They are all part of a common clearing system matching regulated revenues with incomes from third-party access tariffs. In this arrangement, Enagás is the technical system manager of all of the facilities, giving instructions to different facilities to fulfil daily supply requirements in the most efficient way.

The administrative procedure for authorisation of high-pressure transmission pipelines by MITERD depends on whether the pipelines are part of the “Red Troncal” (Trunk Grid), which, according to Law 34/1998, includes all the high-pressure gas pipes that are deemed essential for security of supply. Under Law 34/1998, if a gas pipeline is categorised as “Red Troncal”, authorisation is granted directly to the main owner of the network: Enagás Transporte. Otherwise, the gas pipeline is assigned through a bidding procedure developed in Royal Decree 984/2015.

All gas infrastructure facilities under the government’s purview must be previously included in the Energy Planning Document, which lists all facilities required to match expected demand. Administrative authorisation of a project is granted by the Directorate of Energy Policy and Mines. Prior to this, the project is submitted for a general public consultation so anyone affected can appeal. An environmental assessment study is carried out if the project meets the requirements set out under Law 21/2013 on Environmental Assessment. Projects are declared to be of “public interest” if they meet the requisites. After completion, infrastructure is tested to check whether it accomplishes the capacity and stipulations included in the administrative authorisation. If the tests are positive, a commissioning document allows the facility to start operations. The revenue settlement scheme under the authorisation must elaborate on third-party access regimes and include details of terms of access, tariffs and connection provisions.

Transmission grids, local distribution networks, subterranean storages and LNG terminals are subject to third-party access requirements, which include regulated procedures for access conditions, capacity allocation, third-party access tariffs, revenues and a settlement procedure to match third-party access tariff income with regulated revenues. Congestion management procedures at interconnectors are regulated by the CNMC.

Under Royal Decree-Law 1/2019, the CNMC is the entity responsible for establishing the methodology to set tariffs for the use of the transmission grid, LNG terminals and local distribution networks, while the government sets subterranean storage tariffs. As CNMC Instruction (Circular) 6/2020 will not fully enter into force until October 2021, shippers are currently charged tariffs published by MITERD, according to Royal Decree 949/2001, which has basically remained unchanged since December 2013.

In order to participate in the Spanish gas market, a company must be registered with MITERD through a "*declaración responsable*" (responsible statement), in which it acknowledges completion of requirements to become a registered shipper published in Chapter III of Royal Decree 1434/2002. The requirements are mainly to demonstrate technical skills and sufficient financial capacity to undertake the business and to submit warranties to cover one-year payments. Afterwards, the ministry informs the CNMC, which includes the name of the company on the List of Registered Shippers.

A new legal framework was introduced in 2014 to balance system costs and revenues. After some deficits recorded in 2015-17, since 2018 the gas network has delivered a financial surplus, and the trend is expected to continue in the coming years. In October 2015, Royal Decree 984/2015 introduced a procedure to authorise regional transmission pipelines through an auction procedure with a regulated revenue scheme based on real gas flows, so no additional costs will be imposed on the gas system if demand does not meet expectations. Nonetheless, based on the demand outlook, no major new gas infrastructure is foreseen in Spain.

Since 2015, the main changes related to gas facilities management have been focused on increasing the efficiency of the system through the development of the MIBGAS gas hub (as integrated Spanish and Portuguese gas markets) and the implementation of regulation principles for all regulated infrastructure. In order to reduce entry barriers to the domestic gas market and enhance shipper flexibility, a Spanish gas exchange market was developed in 2015 to trade natural gas and LNG.

In 2019, the CNMC introduced a unique approach to managing Spain's regasification capacity by consolidating trading among the various LNG tanks into a single trading hub. The goal of the new approach was to increase utilisation of regasification capacity and facilitate booking of capacity among various market participants. CNMC Instruction (Circular) 8/2019 establishes access conditions and capacity allocation procedures for all regulated facilities of the natural gas system. It sets duties and rights of shippers and facility owners, lists the standard capacity products offered (yearly, quarterly, monthly, daily and intraday), and introduces a virtual LNG tank, which adds up all the current LNG tanks regardless of which terminal they belong to.

The Balancing Circular 2/2020 introduced two new balancing zones – in addition to the traditional one in the transmission grid (Punto Virtual de Balance, or PVB): the virtual LNG tank that combines all LNG terminal capacity and a virtual underground storage that combines all storage capacity. In these three zones, natural gas and LNG can be freely traded wherever LNG terminals or underground storage are located, a circumstance made possible thanks to Spain's extensive gas transmission network that operates with low congestion rates.

Based on these changes, in July 2020, the government started to offer capacity in Spain's LNG terminals via an auction system. For the year 2021, 90% of the capacity was offered to the market, while 50% of the capacity in the following 15 years (2022-36) was offered.

In 2021, 40% of the remaining 2022 capacity will be offered to the market, and likewise in the following years. The last 10% of available capacity will be offered on a monthly market, one month before usage, throughout 2021 until 2036.

CNMC Circular 2/2019 established the methodology to set the interest rate applied in the calculation of the regulated revenues of transmission and distribution of electricity, regasification, and transportation and distribution of natural gas. The rate is unchanged for the six years of the regulatory period (from 2021 to 2026, both included). CNMC Circular 1/2020 establishes the methodology to set the revenue applied to the system manager (Enagás) while CNMC Circular 9/2019 establishes the methodology to set the revenue applied to transmission facilities and LNG plants. It includes amortisation using a pre-defined lifespan, a financial rate applied to assets' net value and operational costs based on standard average costs. Lastly, CNMC Circular 4/2020 establishes the methodology to set the regulated revenue for local distribution networks. It is based on the number of customers and volume of gas sold, with a five-year extra-revenue provision for new local distribution networks.

Within MITERD, the Directorate General for Energy Policy and Mines each year determines the capacity to offer as interruptible service at those points in the system where congestion may occur. The capacity offered is allocated via auction annually among marketers who request it.

Natural gas market operation

In December 2015, a new Iberian Gas Market platform "MIBGAS" was launched in Spain following the principles of the European Gas Target Model.

Based on the principles informing that model, the organised gas market has a platform for trading in gas products to be delivered at the virtual balancing point and other local points in the gas system for different time horizons. All shippers, distributors, retailers and direct consumers may buy or sell gas via these products according to their commitments and needs. Likewise, and pursuant to the Code on the Balancing Network, the technical manager of the gas system is to participate in the organised gas market in order to purchase or sell the gas required to enable it to perform its balancing actions and ensure the viability of programmes.

The following core concepts define the organised gas market's operating model:

- gas trading, both at the virtual balancing point and at one or more local points
- contracting capacity independently for gas inputs and outputs on the network
- daily balancing of operations
- firmness of trades in the market, with a commitment to deliver
- involvement of the technical manager of the gas system for balancing procedures and ensuring supply.

Spain's Law 8/2015 on the Hydrocarbons Industry designates the company MIBGAS as the organised gas market operator. As such, MIBGAS is responsible for the management of the organised gas market, required to undertake the necessary and appropriate duties

for its operations and the economic management of its services, upholding the principles of efficiency, effectiveness, transparency, objectivity, non-discrimination and independence. To this end, it is charged with:

- arranging and accepting the registration of prospective agents
- defining and listing the products accepted for trading
- receiving orders for the purchase and sale of gas, and of any products involved in the gas supply chain that may at some time be traded, conducting their validation, management and matching, as well as calculating the prices arising from the matching processes
- disclosing on a daily basis the prices and volumes traded for each of the market products, as well as the reference prices and, among them, those to be used in the settlements of imbalances
- performing directly, or through a third party acting as counterparty, the settlements of market processes, invoicing and collection and payment processes, as well as managing market guarantees
- providing each technical manager, or those parties as appropriate, with information on trades made by agents in the market, per the provisions of current legislation
- send the information required in the Regulation on Wholesale Energy Market Integrity and Transparency (REMIT) that falls within its responsibility to the Agency for the Cooperation of Energy Regulators platform.

Since 2015, the product portfolio traded in MIBGAS has grown substantially, currently comprised not only of short time products delivered at the virtual balancing point, but also natural gas with longer delivery terms, LNG products and balancing services. Since January 2018, MIBGAS has also been authorised to trade natural gas products delivered outside the Spanish gas system.

To increase its liquidity, since 2017, voluntary market makers have been in operation in MIBGAS, and since 2018 incumbent shippers in the Spanish market perform as mandatory market makers, according to provisions included in Law 8/2015. Market makers serve to increase liquidity in the organised gas market by submitting orders so other exchange participants can find a counterparty at a market price.

Trading on the market is organised into trading sessions, with the possibility of trading one or more products in each session. In turn, a session may involve two types of trading: auction or continuous market. Each session's details are specified by means of a market resolution. There are currently two types of sessions: 1) a daily trading session with trading in daily, month-ahead and balance of month product; and 2) an intraday trading session with trading in intraday products.

Since 2018, there is another platform called MIBGAS Derivatives, which manages the exchange trading of future natural gas products, spot LNG products and spot underground storage products in the Iberian peninsula. Prior to this, Spain did not have a market to trade natural gas futures products. MIBGAS Derivatives offers the following futures products with physical delivery: monthly, quarterly, biannually and yearly.

The MIBGAS Derivatives products complete the current portfolio of natural gas products offered by the organised gas market, with a distinction between current regulated products

(spot and prompt market) and future products (futures market). In addition, new products of LNG in regasification plants tanks and natural gas in underground storages are also offered.

Throughout its short history, MIBGAS has been growing both in traded volume and agents, and has established itself as an emerging hub within the European gas market, while consolidating itself as a valid price reference in the Iberian peninsula. In 2019, trading volumes doubled from 2018 levels, while the number of traders grew to 105; by the end of 2020, the number of traders had increased to 144. Traded volumes reached 26.3 terawatt hours (TWh) in 2018 and 56.1 TWh in 2019. Still, overall liquidity remains relatively low. After accounting for 24.66 TWh of volume traded over-the-counter, the churn rate in the market is still below 0.5; a market is usually considered liquid when the churn rate is at least 10.

Natural gas policy

Upstream

Spain relies on natural gas imports as domestic production is negligible, accounting for less than 1% of total natural gas demand. There are very few fields, with low production, as they are in a declining phase. In 2015, the El Ruedo field stopped producing, but in 2015 trial production began at the Viura field, commissioned in 2017. Production at this field represented more than 90% of domestic gas production in 2019.

Exploitation of unconventional resources has been controversial among the public, especially hydraulic fracturing, and has therefore never been conducted in Spain.

In recent years, exploration and production (E&P) activity has been on a downtrend, without any new projects. In addition, the Bill on Climate Change and Energy Transition, currently in the process of been passed into law, forbids all E&P activity, including offshore projects. The bill also bans the authorisation of unconventional projects in which the use of high-volume hydraulic fracturing is foreseen. As such, E&P activity is expected to come to an end in Spain.

Last-resort tariff

There is a free market for natural gas pricing in Spain regardless of the distribution network to which a consumer is connected or the company with which the service is contracted. Several tariffs are available in the market to the almost 8 million natural gas consumers.

Nevertheless, consumers connected at a pressure below 4 bar with an annual consumption under 50 000 kWh qualify to subscribe to a last-resort tariff at below market rates in two ranges: 0-5 000 kWh and 5 000-50 000 kWh.

Under the first tariff (< 5 000 kWh), the fixed component of a consumer's bill (amount paid monthly regardless of consumption) is reduced, while the variable component (the gas consumed) is higher. Under the second tariff (5 000-50 000 kWh), the fixed component of the bill is higher, but the variable component is lower (Endesa, 2020).

Of all the households that qualify for the last-resort tariff, at the end of 2019, 6.3 million customers were supplied under the free market price, while 1.6 million consumers (19.92% of the total) were supplied under last-resort tariffs.

Consumers under the last-resort tariff are supplied by four retailers that have been designated as suppliers of last resort: Comercializadora Regulada Gas & Power (Gas Natural Group), Baser Comercializadora de Referencia (EDG Group), Energía XXI Comercializadora de Referencia (Endesa Group) and Curenergia Comercializacion de Ultimo Recurso (Iberdrola Group).

Last-resort tariffs are calculated by a formula established by a ministerial act that includes the price of natural gas, fees and levies, commercial costs, and security of supply costs. The natural gas cost is updated every quarter and published in the Official Journal by the Directorate of Policy Energy and Mining as long as the cost varies more than 2% (either higher or lower). This cost depends on a mix of international price indexes including the Brent oil price for long-term supply and NBP natural gas futures and options for the short term. As the price is set in calorific value (KWh), Enagás provides information on its website about the gross calorific value in every town.

Social bonus

Royal Decree-Law 15/2018 on urgent measures for the energy transition and consumer protection established the “Bono Social Térmico” (BST, or thermal social bond). It is an economic aid programme to compensate for the costs borne by the most vulnerable consumers for the use of energy for heating and hot water or cooking. It is applied as a discount on gas bills.

The BST applies to all vulnerable consumers, regardless of the fuel they use to heat their homes (natural gas, electricity, liquefied petroleum gas [LPG], etc.). All customers who qualified for the electricity social bonus as of 31 December of the previous year are eligible for the gas bonus (see Chapter 7). The budget allocated in 2019 (charged to the general state budget) for this aid was EUR 75 million. For the year 2020, the budget allocated was EUR 90 million as the number of people who can benefit from the BST increased by approximately 200 000, to 1.27 million.

The aid for each vulnerable customer ranged between EUR 25 and EUR 124 per year. The amount depends on the degree of vulnerability and climatic zone in which a residence is located (the aid is greater in cold zones). In the case of a severely vulnerable customer or one at risk of social exclusion, the aid will increase by 60% compared to that for each corresponding climatic zone.

Responses to the COVID-19 pandemic

As a result of the COVID-19 pandemic, the Spanish government, led by MITERD, enacted the following measures:

- Close monitoring of changes in gas demand and natural gas infrastructure; no risks were identified beyond the consumption reduction compared to previous years’ levels.
- Exceptionally, as long as the state of emergency was in effect, the supply of electricity, petroleum products, natural gas and water must not be suspended in any home considered a main residence (even if such a possibility is stated in supply contracts signed by consumers).
- More flexibility granted to small and medium-sized enterprises in terms of energy (electricity and gas) contracts to alleviate their burden during the state of emergency.

- A possibility to suspend electricity and gas bills for freelancers and small and medium-sized enterprises.
- Suspension of the methodology to determine the last-resort tariff for natural gas for six months from March 2020 to protect vulnerable customers (an exception was included to modify the maximum prices if the modification implies a reduction from the prevailing level).

Renewable gases

Spain has more recently embarked on a plan to increase the use of renewable gases in its energy sector as a pathway to decarbonisation. To this end, the government has plans to promote the use of biogas, biomethane and hydrogen from renewable sources (see Chapter 5 for more details).

In 2019, 100 gigawatt hours (GWh) of biomethane was injected into the gas grid from one plant in Valdemingómez, Madrid. Power generation from biogas stands at 234 megawatts (MW), and 55 tonnes of oil equivalent [toe] of biogas is employed in thermal uses.

The government plans to significantly expand these levels based on a Biogas Roadmap that is currently under development. An initial public consultation ended in June 2020 and several working groups are currently putting together a draft road map, which will then be released for public comment before being finalised. The issue of injecting biomethane into existing grids was a particular focus area on which the government requested stakeholder inputs.

The government has also issued a Hydrogen Roadmap for the development of renewable hydrogen in Spain in October 2020, in line with the European Hydrogen Strategy.

In the short and medium term, the government's focus will be on boosting the production and consumption of biogas and biomethane, while it sees renewables-based hydrogen as an important longer term opportunity.

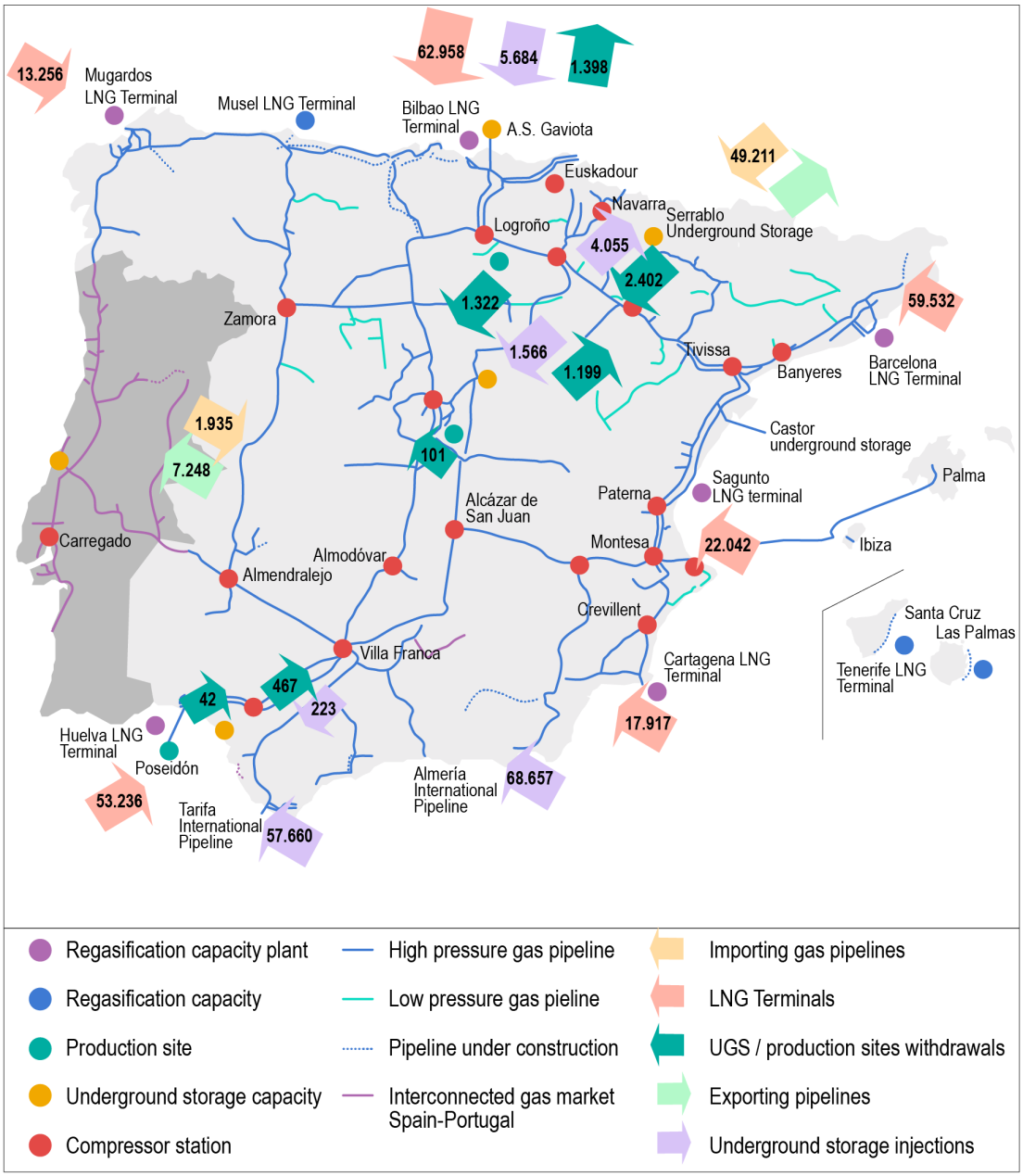
Natural gas infrastructure

Transmission and distribution network

The Spanish gas grid reached a total length of 11 369 km in 2019, with seven LNG terminals (six operating) and four underground storage facilities, providing natural gas to 1 805 municipalities and 7.9 million supply points. Moreover, the gas pipeline network has 19 compression stations, 45 transmission centres, and 416 measurement and regulation stations. Notably, the circular structure of the gas grid allows nearly every region of the country to be supplied from two directions. All this allows smooth distribution of gas throughout the national territory, ensuring security of natural gas supply even in peak demand situations.

The natural gas transmission network has eight main lines: the Central Axis, Eastern Axis, Western Axis, Spanish-Portuguese Western Axis, Axis of the Ebro, Cross Axis, Connection to Medgaz, and the Gas Pipeline to the Balearic Islands.

Figure 10.6 Map of Spain's natural gas infrastructure



Source: Spanish administration's response to the IEA questionnaire.

Interconnections

Spain's international gas pipelines include: the Magreb pipeline (Tarifa-Morocco), the Medgaz pipeline (Almería-Algeria), the International Connection with France (VIP Pirineos: Irún and Biriatou) and the International Connection with Portugal (VIP Ibérico: Tuy and Badajoz).

Table 10.1 Technical capacity (firm and interruptible) of international interconnections (GWh/day)

	Import	Export
Tarifa (Morocco)	444	–
Almería (Algeria)	306	–
VIP Pirineos (France)	225	225
VIP Ibérico (Portugal)	80	144

Note: GWh = gigawatt hour.

Source: Spanish administration's response to the IEA questionnaire.

Two main interconnection projects have been planned for several years: STEP with France and the Third Interconnection with Portugal. STEP was also designated as an EU Project of Common Interest in 2013. Nevertheless, after the TSOs of France and Spain issued an investment request in July 2018, the national regulatory authorities in both countries rejected it in January 2019. No gas projects from Spain, Portugal and France were included in the 4th List of Projects of Common Interest approved by the European Commission.

Liquefied natural gas

Spain maintains Europe's largest fleet of LNG terminals, with seven facilities – six in operation. The Spanish gas system has a total of 25 fuel tanks storages, 8 berths and capacity to receive methane vessels of up to 270 000 cubic metres (m^3). In 2019, gas receipts from LNG terminals to the transmission grid saw a significant rebound of almost 57% compared to 2018. However, the utilisation rate of Spain's LNG regasification capacity is relatively low, at only 21% on average between 2012 and 2018 (GIE, 2021).

Table 10.2 Spanish liquefied natural gas import terminals (operating facilities)

LNG terminal	LNG storage capacity (m^3)	Send out capacity (m^3/hour)	LNG tanks	LNG trucks loading (GWh/day)	Docks	Maximum docking capacity (m^3)
Barcelona (Enagás)	760 000	1 950 000	6	15	2	266 000
Huelva (Enagás)	619 500	1 350 000	5	15	1	175 000
Cartagena (Enagás)	587 000	1 350 000	5	15	2	266 000
Bilbao (BBG)	450 000	800 000	3	5	1	270 000
Sagunto (Saggas)	600 000	1 000 000	4	10.5	1	266 000
Mugardos (Reganosa)	300 000	412 800	2	10.5	1	266 000

Note: GWh = gigawatt hour.

Source: Spanish administration's response to the IEA questionnaire.

In 2019, LNG storage capacity of regasification plants in Spain was unchanged, as was average send out capacity, though production increased to 659 GWh/day from 430 GWh/day in 2018. On the other hand, the loading of LNG trucks increased by 7%, doubling the increase in 2018 and reaching 12 597 GWh. As for stocks in tanks, the annual average was 60%, reaching as high as 94% on certain days. As of 31 December 2019, the accumulated storage in regasification plants reached 71% of total capacity.

Storage

In order to adjust supply to meet changing demand, including consumption peaks brought on by seasonal variations, it is beneficial to store large quantities of gas in strategic locations for use under such circumstances (see below).

Spain currently has four underground storages in operation: Gaviota (offshore), Serrablo, Yela and Marismas. Enagás manages the first three while Naturgy Almacenamientos Andalucia manages the Marismas gas storage. The capacity in the four storage facilities for the period from 1 April 2019 to 31 March 2020 was 33 253 GWh (around 3 bcm)[2].

Gas injected into storage in 2019 reached 12 869 GWh (1.16 bcm), with an 87% increase compared to 2018. On the other hand, extraction was 5 489 GWh (0.49 bcm). The high utilisation of storage was reflected in its high contracted capacity; the maximum annual contracting of 31 011 GWh (2.79 bcm) took place in November 2019.

Natural gas security of supply

Institutional responsibilities

The Specialized Energy Security Committee is a support body of the National Security Council, created in 2017 as Spain's National Emergency Strategy Organisation. The committee, presided over by the Secretary of State for Energy, is supposed to meet at least every two months, or as many times as it deems appropriate. With respect to energy security, the committee's functions include:

- Propose to the National Security Council the guidelines for planning and co-ordinating national security policy related to energy security.
- Contribute to reinforcing the proper functioning of the National Security System in the field of energy security, whose supervision and co-ordination is the remit of the National Security Council.
- Support the National Security Council in its function of verifying the degree of compliance with the National Security Strategy and propose, where appropriate, its revision, in relation to energy security.
- Contribute to the elaboration of regulatory proposals to strengthen the National Security System in the field of energy security.

[2] For the purpose of this document, we assume that to arrive at standard (GCV=40 MJ/m^3) bcm units, values expressed in TWh should be divided by 11.1 (or multiplied by 0.09). Consequently, 1 bcm of natural gas = 11.1 TWh.

- Support the National Security Council's decision making in matters pertaining to the field of energy security, through the analysis, study and proposal of initiatives both nationally and internationally.
- In support of the Specialised Situation Committee, carry out an assessment of risks and threats, analyse possible crisis scenarios, especially those likely to lead to a situation of interest to national security, in the field of energy security, and evaluate the results of its execution, all in co-ordination with the directly competent bodies and authorities and with the Specialised Situation Committee.

The Corporación de Reservas Estrategicas de Productos Petrolíferos (CORES) is responsible for ensuring security of supply for oil products, liquefied petroleum gas and natural gas in Spain. In 2013, CORES was designated Spain's central stockholding entity as defined in EU Directive 2009/119. In this capacity, it is responsible for controlling the minimum stockholding obligations as well as for verifying operators' obligations to diversify their natural gas supplies.

Regulatory framework

The gas security framework in Spain is based on national and European legislation. At the national level, the Hydrocarbon Law of 1998 and Royal Decree 1714/2004 established the basis for natural gas security of supply. The main measures to safeguard the security of gas supply are:

- The obligation to diversify the supply of natural gas: When the supplies of natural gas for national consumption from the same origin country are higher than 50% of national consumption, then shippers or self-consumers that have a share of imports higher than 7% must diversify their portfolios in order to have gas supplies lower than 50% from that origin country.
- Stockholding obligations on natural gas operator: The shippers and self-supplied consumers must maintain at all times natural gas stocks equalling 20 days of firm sales or consumption during the preceding calendar year (firm sales are supplies that cannot be interrupted, for either commercial or technical reasons). The stocks must be kept in underground storage. The government assumes control of the strategic stocks in emergency situations.

As an additional measure, the Spanish administration enforces a Winter Action Plan, which lays out additional requirements for shippers from 1 November to 31 March in accordance with the Gas System Technical Management Rules. The Winter Action Plan is approved on a yearly basis by the Directorate General for Energy Policy and Mining at MITERD and includes additional minimum stocks levels (3.5 days of contracted LNG capacity between 1 November and 31 March), a method to predict the increase of demand in case of a cold spell and a cold spell definition.

Furthermore, the Spanish natural gas system is based on the System Technical Management Rules, with a procedure to cope with exceptional situations that may affect the operation of the system. The system operator (Enagás) is responsible for putting this procedure into practice, declaring the level of emergency and co-ordinating the actions of system users.

LNG also plays an important role in bolstering Spain's supply of gas security as it provides a high degree of flexibility and source diversification. Moreover, the geographic location of Spain, with access to both the Atlantic and Mediterranean basins, increases the scope of

available LNG sources, allowing gas suppliers to import gas from virtually any LNG producing country. Moreover, LNG also serves as a competition driver, enabling newcomers to access the wholesale market and introduce gas in the Spanish network via spot sales.

At the European level, EU Regulation 2017/1938 establishes provisions to safeguard the security of gas supply in the European Union by ensuring the proper and continuous functioning of the internal market in natural gas. It allows for exceptional measures to be implemented when the market can no longer deliver the gas supplies required, including solidarity measures of last resort with neighbouring countries. It also provides a clear definition and attribution of responsibilities among natural gas undertakings, member states and the European Union regarding both preventive action and reaction to concrete disruptions of gas supply. Spain is currently working with France and Portugal to create a Solidarity Agreement on Natural Gas.

To ensure maximum preparedness, avoid a disruption of gas supply and mitigate its effects should it nevertheless occur, EU Regulation 2017/1938 also establishes that member states have to elaborate national risk assessments, preventive action plans and emergency plans at least every four years.

In addition, the regulation created risk groups, based on the main gas supply sources and routes. These risk groups serve as the basis for strengthening regional co-operation in order to increase the security of gas supply and make it possible to conclude agreements on appropriate and effective cross-border measures of all interested member states within risk groups or outside of them along the emergency supply corridors.

Risk assessments

Spain has co-ordinated the elaboration of the Algeria Risk Assessment and has participated in the Norway Risk Assessment. The conclusions from the Algerian risk group indicate strong resilience, even in the event of a complete interruption of Algeria's gas supply (including LNG), an unlikely event.

Spain submitted the National Risk Assessment and the Preventive Action Plan and the Emergency Plan for the period 2019-2023 to the European Commission as required under EU Regulation 2017/1938.

In the Spanish system, the infrastructure with the greatest send out capacity to the network is the regasification plant in Barcelona, with a send out capacity, regasification and cistern load of 559 GWh/day (48.1 mcm/day). Under the N-1 formula, applied to the Spanish gas system, the risk assessment obtained results of over 123%, in accordance with the demand and infrastructure scenarios forecast for four winters.

A number of other risks were analysed, including disruption to other LNG terminals and main interconnectors, though none presented problems to gas supply to protected customers. The greatest potential risk identified for the Spanish gas system is the total failure of the main supplier (Algeria), whose gas deliveries into the Spanish gas system accounted for 48% of the total in 2017, 9% less than in 2016 (even though such a failure has never occurred, even during the period of instability in Algeria during the 1990s). Risks are further minimised by the growing liquidity and flexibility of the global gas market, the capacity for LNG supplies into the Spanish gas system, supply diversification available to

marketers, and the renewal or renegotiation of contracts to make their clauses more flexible and to contemplate spot contracts.

Preventive measures outlined in the Preventive Action Plan, in addition to the obligation to diversify natural gas imports, stockholding obligations and the Winter Outlook Plan, include investments in gas infrastructure, flexibility of entry points, interruptible contracts, fuel switching at power plants and greater use of renewable sources, among others.

Emergency response

The emergency response measures of the Spanish gas system are described in detail in the Emergency Plan. In accordance with EU Regulation 2017/1938, there are at least three crisis levels: early warning, alert and emergency. Each one adopts different emergency response measures. Early warning measures include modifications of shipping schedules and optimising logistics at LNG terminals. Alert level measures include application of interruptible contracts and fuel switching at power plants, notably greater use of renewable energy sources. Emergency level measures include temporary interventions in the gas market, use of emergency natural gas stocks, suspension of rights to access facilities and government authorisation of natural gas sales abroad.

Additionally, other measures included in the Emergency Plan are interruption of natural gas supply to certain consumers and the use of strategic stocks. The priority of gas supply follows this order: 1) protected customers, including households; 2) consumers who are not industrial or protected customers; and 3) industrial consumers with firm supply, including power plants.

Assessment

The Spanish gas system went through major changes from the beginning of the 2000s, with rapidly increasing demand and the construction of new infrastructure, followed by a substantial decline in demand due to the economic crisis starting in 2008. In 2012, construction of new infrastructure was stopped. Gas demand reached a low point in 2014, with consumption of 300 TWh (27.2 bcm), but since then demand has gradually grown to 400 TWh (35.4 bcm) in 2019. Gas demand has, however, not rebounded to the levels seen before the economic crisis, or to the levels that were expected when the expansion of the system was planned. Thus, the system has abundant capacity both in terms of supply options and transmission capacity across the country.

Spain has very little indigenous production; 99% of gas supply is imported. The Spanish gas system has numerous supply options through both pipelines and especially through LNG terminals, which enhance its security of supply. Utilisation of the country's LNG terminals in 2019 ranged between 15% and 77%. The capacities of the interconnectors with France and Algeria have been contracted close to their nameplate capacity (84% and 82%, respectively), while the capacity with Morocco has been contracted at 56% of nominal capacity. In 2019, the average actual utilisation level of the firm entry capacity with Algeria was around 66%, while that with France was just below 60% (peak utilisation levels have been considerably higher than those levels, at close to 100%). As such, the Spanish gas system currently has plenty of supply options.

In spite of the high utilisation rate on the interconnectors between France and Spain, there is remaining capacity that is not contracted or utilised to its full potential. The current

capacity between Spain and France is partly firm and partly interruptible. The uncontracted capacity is interruptible, which makes it less attractive to shippers.

There are 7.9 million gas consumers in Spain, with stable growth of about 1% per year in the number of consumers over the last few years. Since 2014, there has been a reduction in the number of consumers who are under the "last-resort price"; their share has fallen, from 25% in 2014 to 19.9% in 2019, which is still relatively high. The last-resort price is set in line with the market price and does not entail subsidies to the consumer. In 2018, a thermal social bond was established, which is an economic aid to vulnerable consumers. In 2019, 1 million customers were eligible for the BST, and this number increased to 1.27 million in 2020.

According to the NECP, gas demand is targeted to decrease by about 8-9% in the coming ten years (flat from 2015 levels). There is, therefore, no need for further expansion of gas infrastructure. While annual gas consumption is not expected to change much, electricity security in Spain will rely on gas emergency stocks and a flexible gas system. Electricity security will especially rely on the flexibility of gas-fired combined cycle power plants, as they can balance the variability of future renewable electricity production, supported by demand response and interconnections to neighbouring countries. Therefore, the security of supply of the gas system and the electricity system are closely interlinked, and will become more so in the coming years.

During the last five years, the emphasis has been on ensuring sustainable financing of the gas system, following reforms in 2014. The overall balance between income and costs in the Spanish gas system has gone from a substantial deficit of over EUR 1 billion in 2014 to surpluses in both 2018 and 2019. The remuneration methodologies for gas transport and access to the system have been modified to ensure that deficits are reduced.

There have been positive developments in the liberalisation of the Spanish gas market over the last years. The number of registered traders has increased, from 150 in 2016 to 198 in 2019. A similar and even more positive development occurred in the MIBGAS market, where the number of active traders has more than doubled since 2016 and surpassed 100 in 2019. Trade on the MIBGAS platform has been enhanced by the use of voluntary market makers in 2017, and from 2018 onwards the incumbent shippers have been acting as mandatory market makers. From 2018 to 2019, traded volumes doubled, and now comprise 12.5% of annual consumption. This development is very positive, but there is still room for improvement. To this end, the decision to extend the organised gas market to include Portugal is a good one, and should be implemented as soon as possible.

The recent establishment of a single virtual LNG point and a single virtual storage point in the Spanish market system are also welcome improvements to the setup of the market. However, market concentration is still high in the Spanish market, with the four largest companies covering more than 60% of the market.

In July 2020, the government started to offer capacity in Spain's LNG terminals via an auction system. For the year 2021, 90% of the capacity was offered to the market, while 50% of the capacity in the following 15 years (2022-36) was offered. In 2021, 40% of the remaining 2022 capacity will be offered to the market, and likewise in the following years. The last 10% of available capacity will be offered on a monthly market, one month before usage, throughout 2021 and until 2036. There are some restrictions on reselling the auction capacity bought at a premium, but if the capacity cannot be resold, it can be returned to the seller. In the coming years, it will be important to ensure that there is

maximum flexibility when it comes to utilising capacity. Reviewing the system in order to ensure this could therefore be beneficial.

There is very little renewable gas in the Spanish gas system. Currently only one large landfill gas plant produces biomethane that is injected into the system, accounting for 92 GWh/year. Besides that, biogas is directly used for electricity production, with a total installed capacity of 234 MW, and 55 ktoe/year is used for thermal uses. The government is developing a Biogas Roadmap, which will include an assessment of the potential for biogas in Spain, and for biogas to be upgraded to biomethane and injected into the gas system.

Likewise, a draft road map for hydrogen was released in October 2020. It includes provisions to review what is necessary for the injection and use of hydrogen in the natural gas networks – looking at both storage and adaptation needs in gas transport and usage equipment.

Given Spain's ambitious carbon reduction targets, timely issuance and execution of the road maps will help clarify the role that these renewable gases will play in the Spanish system.

Recommendations

The government of Spain should:

- ☐ Closely monitor developments in the gas sector to ensure that the sector continues to deliver the flexibility needed to support security of electricity supply in the coming years.
- ☐ Further develop the MIBGAS market, including the integration of Portugal into the market as soon as possible.
- ☐ Quickly finish and execute the envisaged road maps for biogas and hydrogen to develop the potential for sustainable green gases (biomethane and hydrogen), and their injection, transportation and storage in the gas system, where technically feasible.
- ☐ Work on maintaining firm capacity in both directions on the border with France.
- ☐ Develop new measures to deter speculative hoarding of LNG capacity and other gas infrastructure without hindering resale of capacity to ensure maximum utilisation.

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11. Oil

Key data

(2019)

Domestic crude oil production: 49 thousand barrels per day (kb/d), +101% since 2009

Net imports of crude oil:* 1 336 kb/d, +18% since 2009

Domestic oil products production: 1 353 kb/d, +14% since 2009

Net exports of oil products: 56 kb/d (net importer at 286 kb/d in 2009)

Share of oil: 48% total supply (total energy supply and international bunker fuels),** 51% total final consumption, 5% in electricity generation

Oil consumption by sector: 1 295 kb/d (domestic transport 51%, international bunkering 18%, industry including non-energy consumption 13%, services and agriculture 5%, residential 4%, energy sector including power generation 4%)

* Imports of crude oil include crude oil, natural gas liquids and feedstock.

** Total energy supply does not include oil used for international bunkering.

Overview

Spain is almost entirely dependent on crude oil imports as domestic oil production is marginal; however, security of supply in the country is high thanks to robust infrastructure, including multiple oil terminals, an impressive pipeline network and a refining industry with capacity exceeding domestic demand.

Oil remains the largest energy source in Spain's total final consumption (TFC), at 51%, and the largest in total supply,[1] at 48% in 2019. These high shares have slowly diminished over the past few years; oil constituted 54% of total supply in 2000 and 52% in 2009, while TFC for oil was 61% in 2000 and 56% in 2009.

Domestic transport is the most important energy-consuming sector in Spain and has been the main cause of fluctuations in oil consumption. Transport contributes heavily to greenhouse gas emissions (27% of the total in 2016) (EC, 2020). The transport sector decreased its oil consumption from 2007 to 2013, but it increased again thereafter. However, the transport sector is expected to be the second-largest contributor (just after

[1] Total supply includes total energy supply and international bunker fuels.

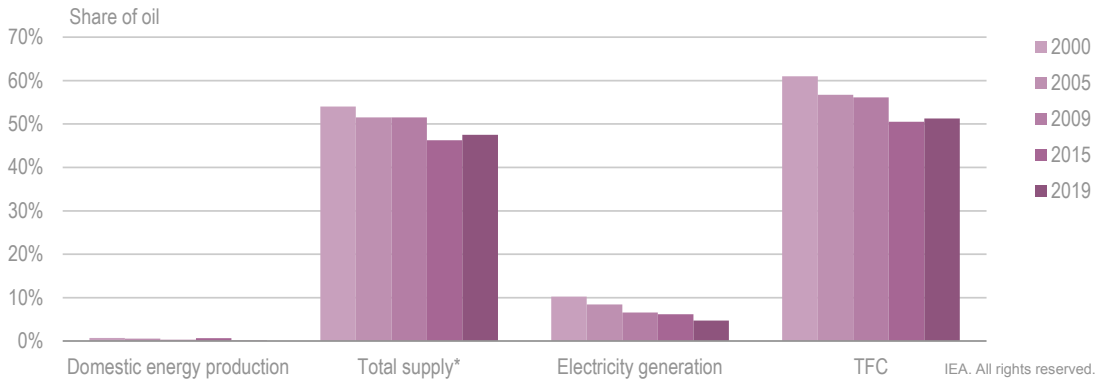
electricity and heat generation) for Spain to reach its climate goals. According to the National Energy and Climate Plan (NECP), by 2030, total oil consumption in the country will see a 23% drop, which will support expected emissions cuts from the transport sector of 31% over the next decade. The transport sector is also the most important consumer of diesel fuel. Spain expects to deploy up to 5 million electric vehicles by 2030, which would have a significant impact on the oil sector as a whole.

Spain has eight refineries producing fuels, with a processing capacity of 1.59 mb/d (79 million tonnes per year), with seven installations located close to seaports, thus benefiting from easy access to seaborne crude. Spain has been a net exporter of oil products since 2012, reflecting output from its refineries that exceeds its oil products demand, particularly in jet and kerosene and gasoline. However, demand for diesel oil is greater than refinery output.

Supply and demand

Oil accounted for almost half of Spain's energy supply at 48% (including international bunker fuels) in 2019 (Figure 11.1). Its share in electricity generation was quite low, however, with a steady decline from 10% in 2000 to 5% in 2019. Oil accounted for 61% of Spain's TFC in 2000, but fell to 51% in 2019. Oil in domestic total energy production has been negligible, at close to 1% in 2019.

Figure 11.1 Share of oil in energy production, total energy supply, electricity and total final consumption in Spain, 2000-19



The share of oil in Spain's total supply, electricity generation and TFC decreased over the 2000-19 period.

* *Total supply*: share of oil in total energy supply + international bunker fuels.

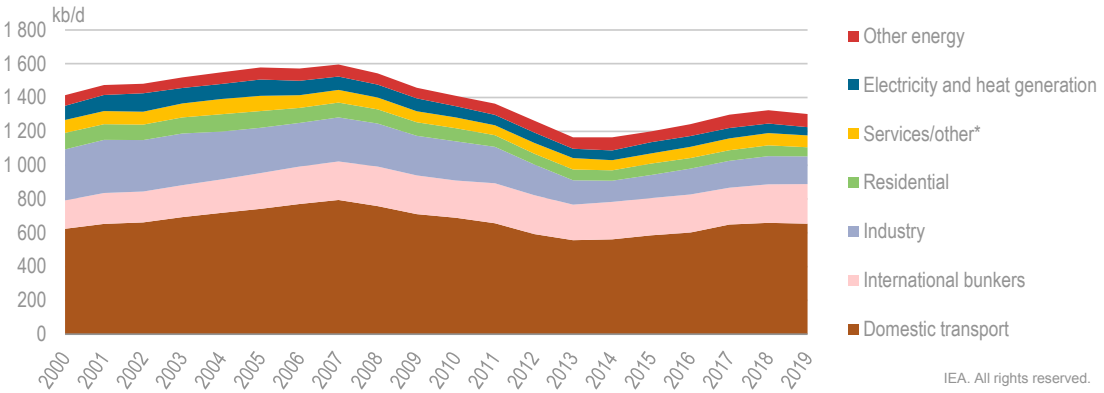
Note: TFC = total final consumption.

Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Since 2007, oil consumption has decreased gradually in absolute terms, although it has grown slightly again since 2013 (Figure 11.2). Domestic transport remains the most important consumer of oil, accounting for 654.5 thousand barrels per day (kb/d) in 2019, or 51% of total oil consumption. International bunkers are the second-largest consumers of oil (18% in 2019) at 233.8 kb/d, followed by industry (163.5 kb/d, 13% in 2019), other energy (77.7 kb/d, 6%), services (70.2 kb/d, 5%), residential (54.3 kb/d, 4%), and power

and heat generation (48.8 kb/d, 4%). In the past decade, oil consumption has decreased the most significantly in power and heat generation (-35%), the residential sector (-31%), and the industry sector (-30%).

Figure 11.2 Oil consumption in Spain by sector, 2000-19



Domestic transport followed by international bunkers account for the largest shares of oil consumption.

* *Services/other* includes commercial and public services, agriculture and forestry, fishing, and non-energy use.

Note: kb/d = thousand barrels per day.

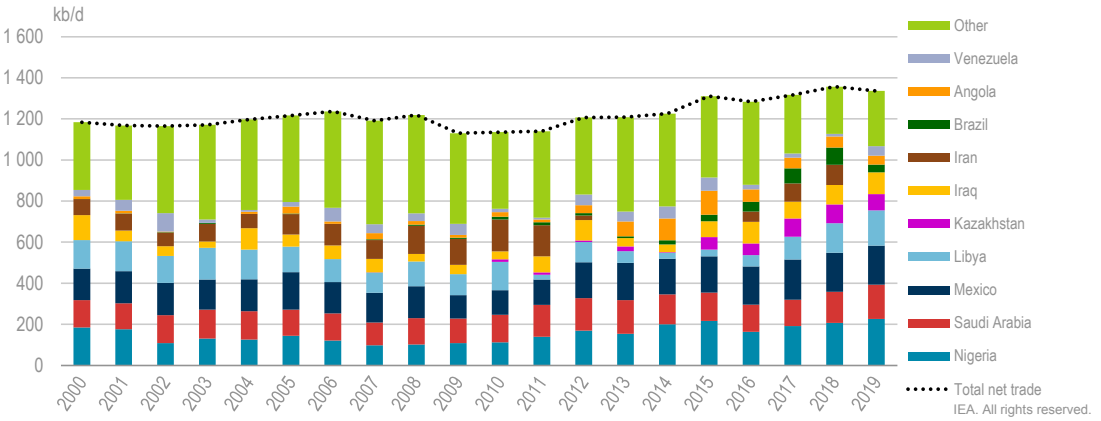
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Spain is almost entirely reliant on crude oil imports and has increased its total imports progressively since 2011, reaching 1 394.5 kb/d in 2019, with a small but notable reduction of 3% from 2018. However, the country has also increased its crude oil exports since 2012, to 58.2 kb/d in 2019 (Figure 11.3) and, as a result, net imports of oil stood at 1 336.4 kb/d in 2019.

Spain imports from a variety of countries and regions (Figure 11.3). Nigeria was the largest net exporter of crude oil to Spain at 226 kb/d in 2019, a consistent increase from 154 kb/d in 2000. In 2019, Spain also registered net imports of crude oil of 191 kb/d from Mexico and 166 kb/d from Saudi Arabia. Additionally, Spain started importing crude oil from Kazakhstan in 2010 at 12.9 kb/d, with fluctuating quantities over the past decade, rising to 79 kb/d in 2019.

Spain also registered small amounts of net exports of crude oil, natural gas liquids and feedstock in 2019, totalling 58 kb/d, of which 11 kb/d went to Brazil, 9 kb/d to the United States, 8 kb/d to Belgium, 6 kb/d to the Netherlands, and 1 kb/d to Japan and the People's Republic of China each.

Figure 11.3 Spain's crude oil net imports, 2000-19

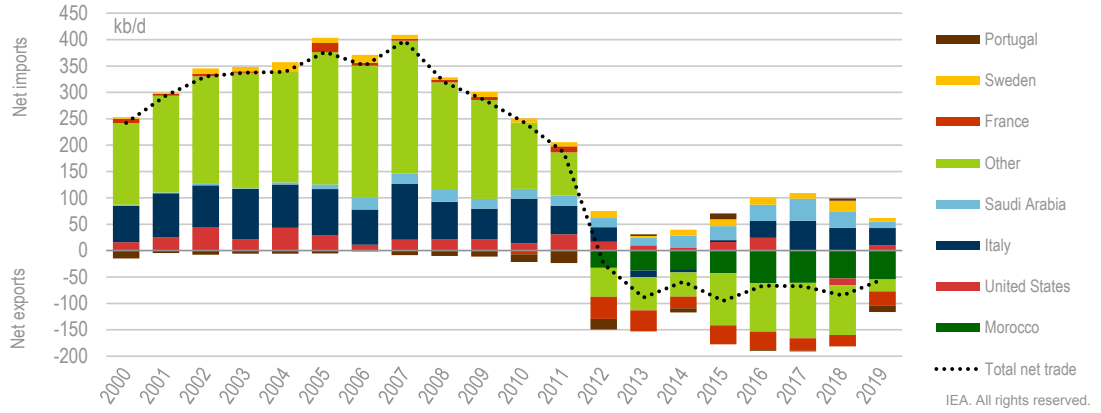


Spain's crude oil imports are well diversified, with Nigeria, Mexico and Saudi Arabia being the main import sources in 2019.

Notes: kb/d = thousand barrels per day. Crude oil data include crude oil, natural gas liquids and feedstock.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In terms of oil products, Spain has ramped up its exports over the past decade, turning to a net exporter since 2012 (Figure 11.4). Total net trade in Spain was 26 kb/d in 2012 and 55 kb/d in 2019, an increase of over 200%. In 2019, its largest total export markets for oil products were Morocco (55 kb/d), the United States (45 kb/d), France (44 kb/d), Portugal (34 kb/d) and Italy (28 kb/d). Spain also imported oil products in 2019 from Italy (60 kb/d), the United States (55 kb/d), Portugal (21 kb/d), France (17 kb/d) and Saudi Arabia (12 kb/d).

Figure 11.4 Spain's oil products imports and exports by country, 2000-19

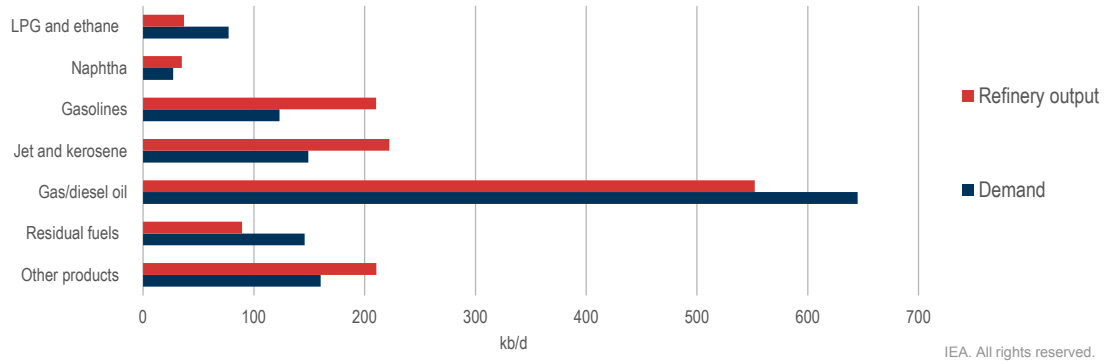


After its shift from being a net importer of oil products to a net exporter in 2012, Spain's largest net exporting markets for oil products were Morocco and France in 2019.

Note: kb/d = thousand barrels per day.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2019, refinery output in Spain equalled 1 357 kb/d, above its overall oil products demand of 1 328 kb/d the same year (Figure 11.5). Spain's oil products demand surpassed its production in gas/diesel oil, where demand was at 645 kb/d and output at 552 kb/d. However, refinery output exceeded demand for the following products: gasoline, jet and kerosene, and other products.

Figure 11.5 Spain's oil refinery output and demand, 2019

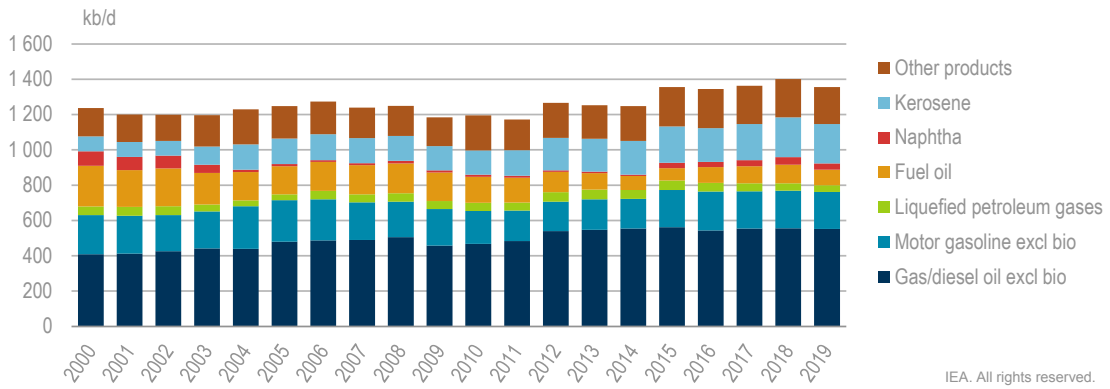


Spain is self-sufficient in gasoline, jet and kerosene, and other oil products but remains reliant on imports for its diesel oil consumption.

Notes: LPG = liquid petroleum gas. kb/d = thousand barrels per day.
Source: IEA (2021b), *Monthly Oil Data Service*, www.iea.org/statistics.

Spain's refinery output is predominantly composed of gas/diesel oil, motor gasoline and kerosene. In 2019, annual output was 552 kb/d, 210 kb/d and 223 kb/d, respectively, for a total of 1 357 kb/d of oil products produced (Figure 11.6). Fuel oil production fell from 231 kb/d in 2000 to 89 kb/d in 2019. Kerosene production was as low as 85 kb/d in 2000 and increased continuously over the period.

Figure 11.6 Spain's oil refinery output, 2000-19



Diesel oil and motor gasoline have consistently been the main products from Spain's oil refineries.

Note: kb/d = thousand barrels per day.
Source: IEA (2021a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

As a result of the COVID-19 pandemic, demand for oil products shrunk during the confinement period. In April 2020, oil products demand fell by 51% on average compared to April 2019. The most significant decrease in sales was observed in kerosene (-93%), followed by gasoline (-78%) and diesel oil (-42%). One refinery (Tarragona) also stopped operations for 21 days in April and May 2020 to reduce market oversupply.

Oil market structure

The Spanish oil wholesale market is fully open to competition. Imports, exports, trade and prices are set on the free market. The government intervenes only to protect competition and to avoid abuse of a dominant position. The wholesale market is carried out by agents who supply retailers, who in turn supply final consumers. It also includes the direct sale of fuels to commercial or industrial customers. The companies that operate in wholesale markets are either the oil companies that own the refineries (producer operators) or wholesale fuel operators who import products or buy them from another operator (non-producer operators), and sell them for retail distribution. However, due to the market structure and the traditionally dominant role of the largest operators, the wholesale market is highly concentrated. At the end of 2020, there were more than 90 wholesale operators, out of which the 3 biggest companies controlled over 50% of the market (Repsol, Cepsa and BP).

Similarly, the Spanish retail market is also fully open to competition, and trade and prices are set freely. At the end of 2020, Spain had close to 11 700 filling stations, an increase of 10% from the end of 2013. The retail network has been rather concentrated in the hands of integrated oil companies, such as Repsol, Cepsa, BP and GALP, but their market share has decreased from 55% in 2013 to 47% in 2020. In March 2020, 31% of the stations were dealer owned and dealer operated, a significant reduction from 39% in 2013. Competition in the retail market was reinforced by Law 11/2013, which strengthened the role of Spain's National Authority for Markets and Competition (CNMC) in the oil retail market. It also regulated clauses in exclusive contracts between retailers and major operators, simplified administrative procedures to set up new filling stations, and capped the market share of operators at 30% of sales in any province or island.

Oil market policies

The NECP specifies measures to support achieving its objective of reducing oil consumption by 2030 by 23% compared to 2015 levels and a 31% emissions reduction target for the transportation sector. They include promoting advanced biofuels in transport, moving road freight and passenger transport to railways, boosting the deployment of electric vehicles, as well as promoting modal and alternative transport means.

From an upstream perspective, Spain’s domestic crude oil production has been in a steady decline in recent years, making the country almost entirely dependent on imports. Commensurate with the decline, exploration and production activity (E&P) has also slowed considerably, with no new projects announced in many years. Moreover, the draft Bill on Climate Change and Energy Transition forbids new E&P projects across Spain, including offshore projects (Magnus Commodities, 2020).

Mobility

Given the complexity of the challenges that mobility and transport will face in fulfilling Spain's oil reduction target as set in the NECP, the Spanish Ministry of Transport, Mobility and the Urban Agenda considers it imperative to establish a robust dialogue with different stakeholders to guarantee the success of its regulatory project. It considers the following areas as priorities for structuring future regulations, mainly via the Bill of Climate Change and Energy Transition (Pechin, 2020):

- transport taxation
- financing of urban transport
- subsidies and aid to transport
- planning and financing of transport infrastructures
- regulation to promote sustainable mobility
- regulation on raising awareness and training in sustainable mobility
- research and innovation in transport and mobility
- regulation of logistics and urban distribution of goods
- digitisation and automation of transport, including open data
- improving the competitiveness of transport and other sectoral measures
- instruments for governance and public participation.

In 2019, the total vehicle fleet reached 35.16 million, dominated by diesel vehicles, which account for 51.6% (18.14 million vehicles) of the total, followed by gasoline at 47.9% (16.86 million). Electric vehicles (EVs) accounted for a miniscule share at 0.2% (81 316 vehicles), having grown by 57.1% from 2018. Within the electric fleet, 57% was made up of passenger cars and light-duty cargo vehicles, and 43% by motorcycles and mopeds.

The Plan MOVES I, established by Royal Decree 132/2019, and the more recent Plan MOVES II, established by Royal Decree 569/2020, have incentivise efficient and sustainable mobility. The measures provide economic incentives for buying electric and fuel cell vehicles and for the installation of EV charging stations, among other measures. According to the government's plans, the deployment of EVs in Spain is set to surge to 5 million EVs on the roads in 2030. To develop adequate public charging infrastructure, the Bill on Climate Change and Energy Transition makes it obligatory to install high-voltage chargers at each petrol station with yearly sales exceeding 5 million litres of fuels.

Furthermore, the bill envisages a binding target to create low-emissions zones in all cities of 50 000 inhabitants or more. It also assumes a 35% reduction of passenger traffic in urban areas by 2030 and foresees a considerable shift of passenger and cargo transport to railways. Rail transport accounted for just 4% of total passenger and cargo transport in 2020 in Spain, while in Germany it surpassed 17%.

Among the measures of the planned regulation, the following stand out: apply green taxation in transport; establish a financing system for public transport based on stable, predictable and proportionate criteria; develop a governance model that allows for the coherent design of mobility policies; steer innovation and digitisation in transport and

logistics; and move towards a sustainable transport and mobility model. All of these efforts combined with effective taxation of fossil fuels use (vehicle circulation tax, excise duty, value-added tax and regional taxes), aim at disincentivising the use of fossil fuels, especially diesel oil, and the creation of more advanced modal shifts in transport. The government's ambition is that in 2040, all new cars will be emissions-free vehicles, which will entail a complete overhaul of the fleet and supporting infrastructure (EV charging, hydrogen). The average age of a passenger car in Spain in 2020 was 12 years.

Biofuels

Spain has made efforts to increase the share of renewables in the transport sector. Royal Decree 1085/2015 established targets for the proportion of biofuels consumption for the years 2016-20 at 4.3%, 5%, 6%, 7% and 8.5%, respectively, in order to reach the objectives of EU Directive 20098/CE. The target for 2021 was set at 9.5% and increases to 10% for 2022. The regulation also introduced an indicative objective of 0.1% energy content for advanced biofuels in 2020.

Obligated entities (wholesalers and retailers or consumers) in Spain may choose to fulfil blending requirements up to 30% with certificates transferred from the previous year, or up to 50% of the obligation can be covered with compensatory payments amounting to EUR 763 for one certificate (1 toe of biofuels equals 1 certificate). In 2019, consumption of biofuels in Spain amounted to 2.8 million cubic metres (m^3).

The Ministry for the Ecological Transition and the Demographic Challenge (MITERD) is working to transpose the second EU Renewables Directive into Spanish legislation, which establishes a final objective for the penetration of renewables in transport of 14% in 2030.

The NECP envisages achieving a 28% share of renewables (including electricity) in the transport sector by 2030 (double the EU's ambition). It foresees a greater role for biofuels resulting from much higher blending targets, but for that to happen, the government needs to address the issue of security of supply of biofuels. Domestic production of biofuels currently stands at 52% of demand for bio-esters and 96% for bioethanol. Nevertheless, only 5% of raw material for bio-esters and 21% for bioethanol production comes from indigenous sources, while the remaining shares are imported, mostly from Indonesia.

Spain may choose to reduce import dependency of biofuels by increasing domestic production of hydrotreated vegetable oil and advanced biojet fuel from wastes and used cooking oil at refineries, which will anyway have to gradually reduce throughputs of crude in the years to come in line with falling demand.

Prices and taxation

Fuel prices in Spain are below the IEA average in general. Automotive diesel was priced at 1.23 USD/L (tax share of 53%) during the third quarter of 2020, and is the 14th lowest among IEA countries (Figure 11.7).

Unleaded gasoline was priced at 1.36 USD/L during the same period, and was the 11th lowest among IEA countries, with the share of taxes at 58% (Figure 11.8).

Light fuel oil was at 0.63 USD/L with a relatively high tax share at 35%, and ranked eighth lowest among IEA member countries (Figure 11.9).

Article 38 of Law 34/1998 on the Hydrocarbons Sector (Government of Spain, 2020a) establishes that oil products prices in Spain are freely established by retailers and operators. However, there are some exceptions included in the law that apply to prices of specific formats of liquefied petroleum gases (LPG). These are: LPG in bottles of 8-20 kg, excluding LPG for motor vehicles; LPG in individual tanks for end users; and LPG in bulk purchases for LPG distributors.

Due to low taxes on LPG, Spain has seen rather significant development of personal cars and light-duty vehicle conversions to LPG in recent years, leading to the opening of 700 new LPG filling stations in 2019.

The Spanish administration has also launched a website on which customers can verify fuel prices across the country in real time[2]. There are plans to include hydrogen and EV charging prices to this system, adding to market transparency and the promotion of green mobility.

The subsidies and incentives for consumption of oil products in Spain are described in Law 38/1992 on Special Taxes (Government of Spain, 2020b). Aside from the LPG pricing exceptions described above, subsidies are divided into three categories:

- tax exemptions for gasoil used in electricity production and other uses such as navigation and rail transport, kerosene for air transport, and fuel oil for electricity production
- tax reductions for gasoil for some engine types (including farm tractors)
- partial tax refunds for road transport activities including freight transport, taxis and some regular passenger transport as well as for agriculture and farmers.

[2] https://geoportalgasolineras.es/#/Inicio

Figure 11.7 Price comparison for automotive diesel in the IEA, Q3 2020

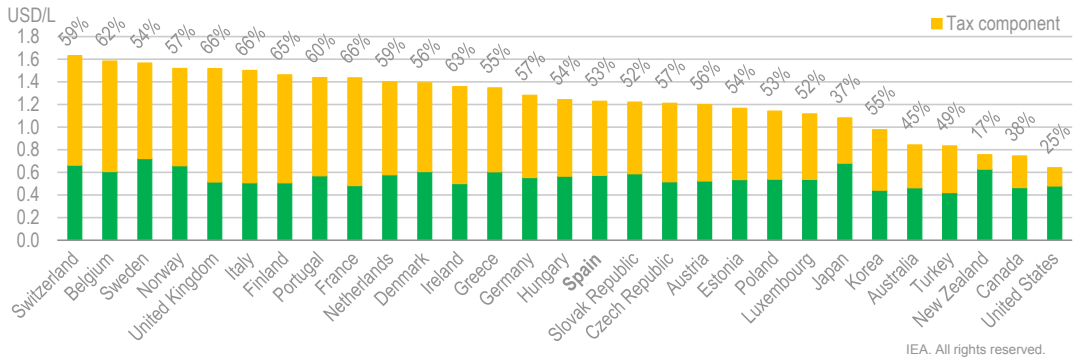


Figure 11.8 Price comparison for unleaded gasoline in the IEA, Q3 2020

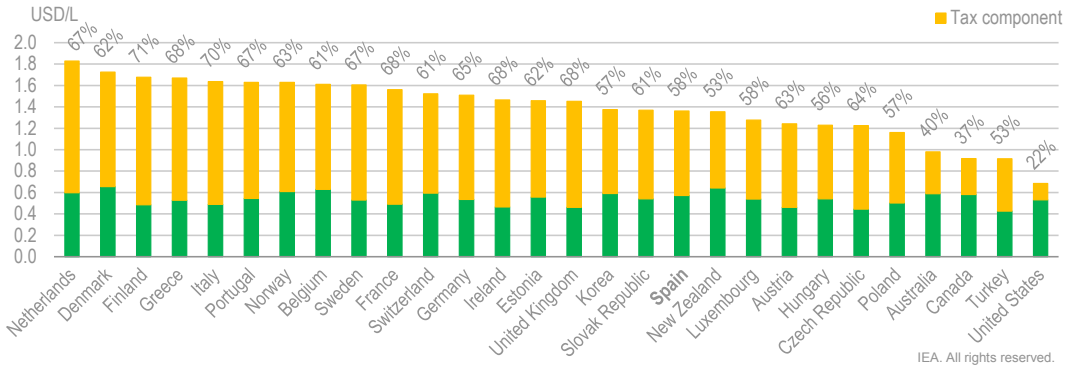
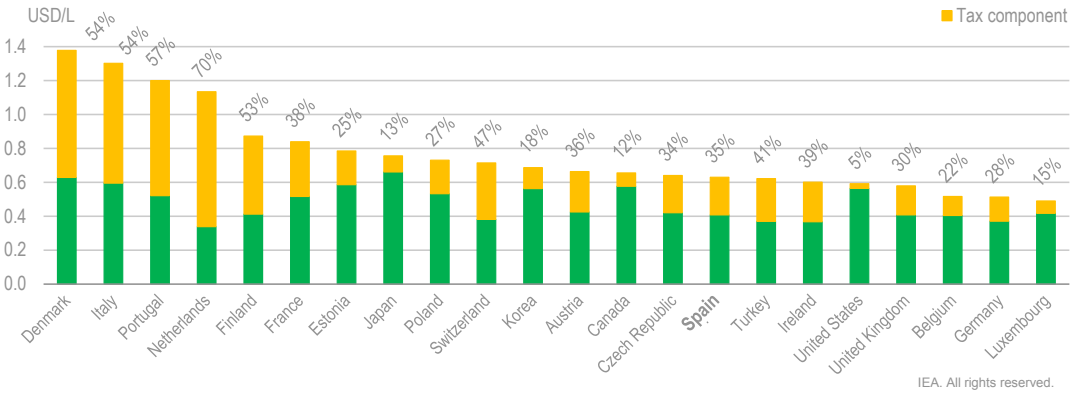


Figure 11.9 Price comparison for light fuel oil in the IEA, Q3 2020



Automotive diesel, unleaded gasoline and light fuel oil prices in Spain are below most IEA countries.

Notes: Automotive diesel data are not available for Mexico. Unleaded gasoline data are unavailable for Japan and Mexico. Light fuel oil data are unavailable for Australia, Greece, Hungary, Mexico, New Zealand, Norway, the Slovak Republic and Sweden.

Source: IEA (2020c), *Energy Prices and Taxes Third Quarter 2020* (database), www.iea.org/statistics.

The subsidies for oil products in 2019 amounted to an estimated EUR 1 087 billion, close to 50% of which went to the farming sector in the form of subsidies for fuel used for

agricultural production (agriculture fuel is available at separate filling stations, which are not evenly accessible throughout the country); an additional one-fourth were tax exemptions for kerosene used in air transport (Congress of Deputies, 2020).

Oil infrastructure

Pipelines and storage

Spain enjoys a unique oil infrastructure system with wide geographic and interconnecting coverage, including 11 oil port terminals, an extensive network of pipelines and storage capacity connected to refineries. The system is owned and operated by the CLH Group (Compañía Logística de Hidrocarburos). CLH's liquid hydrocarbons transport and storage network has 4 006 km of product pipelines (the biggest civil pipeline network in western Europe) and 39 storage facilities, with a total capacity of 7.9 million m^3, in addition to storage facilities at 37 Spanish airports. It links the 8 peninsular refineries and the main import ports with 39 storage plants of the companies that serve the mainland. Even though the system is owned by CLH, third-party access is guaranteed to both logistics and storage facilities by means of a negotiated procedure; in addition, the prices charged must be made public. Spain has the highest rate of inland oil transportation via pipelines, with 90% of primary transport using the network (compared to 11% in Germany that has a similar pipeline system length).

The Spanish storage system is a competitive market with growing capacity and many players. There are 41 companies offering storage services in Spain in over 138 sites (including airports), some of which are subsidiary companies of oil operators. Most of the storage sites, including the largest ones, are connected to the CLH pipeline network. Total storage capacity in 2019 was around 29.2 million m^3 (or 184 million barrels [mb]). Coastal refineries are the main sites for crude imports and storage. These refineries also import a substantial share of refined products through nearby ports. Total on-site storage capacity at the country's refineries amounts to 8.1 million m^3 (above 54 mb). The remaining volumes of refined products are imported directly to inland storage facilities.

Refining

Spain has a large and relatively complex refining industry, with eight refineries to produce oil products and another one (ASESA, owned by Repsol and Cepsa) for the treatment of heavy crudes to produce asphaltic or paving bitumen. Additionally, the Cepsa refinery in Tenerife stopped distillation activities in 2018, but has served as a storage site to secure undisrupted supplies for the Balearic Islands. Repsol has five refineries (Bilbao-Petronor, Cartagena, La Coruña, Puertollano and Tarragona), Cepsa has two (Algeciras and Huelva) and BP has one (in Castellon). The total nameplate capacity is 1.59 mb/d (79 million tonnes per year) and the average utilisation rate reached 84.2% in 2019, slightly lower than in the previous year (88.0%). Eight of the nine refineries are located on the coast and easily supplied by ship. Only Repsol's Puertollano refinery is located inland and supplied with crude oil by a 358 km pipeline linked to the port and refinery in Cartagena.

In view of the NECP's plans, refineries will have to face a major transformation of their business activities due to a foreseen sharp reduction of oil consumption in the country.

Figure 11.10 Map of the Spanish oil infrastructure

Source: Spanish administration's response to the IEA questionnaire.

Oil emergency policies and organisation

Spain has a robust and proven system of oil emergency preparedness based on a stockholding obligation for public and private entities (see next section), high-quality data and accuracy of market data reporting, regularly conducted emergency response exercises, and strong institutions. Maintaining this system is key to ensuring the emergency response capabilities of the country, especially in anticipation of profound changes to oil consumption over the next decade.

Law 34/1998 on the Hydrocarbons Sector, along with Royal Decree 1716/2004 regulating the obligation to maintain minimum security stocks, the diversification of natural gas supplies and the Corporation of Strategic Reserves of Oil Products (CORES), as amended by Royal Decree 984/2015, constitute the two most important pieces of legislation. They provide the Spanish government with powers to guarantee that oil stocks in the country are sufficient to meet the IEA's and EU's requirements and that it can draw stocks in case of a domestic or international emergency.

Within MITERD, the Directorate General for Energy Policy and Mines is ultimately responsible for managing the oil security of the country.

The Spanish National Emergency Strategy Organisation is part of the country's general emergency structure: the National Security System. According to the National Energy Security Strategy of 2015, the National Emergency Strategy Organisation reports to the National Security Council of Spain, which is the highest decision-making body of the National Security System and the principal advisory body used by the Prime Minister for considerations of national security and foreign policy issues. Oil emergencies fall into the category of national security matters according to these provisions.

In December 2013, CORES was appointed central stockholding entity as defined in EU Directive 2009/119/EC. The agency's foremost activity is to set, maintain and manage strategic stocks of crude oil and oil products. CORES is a non-profit public corporation under the aegis of MITERD. It is a separate legal entity, operating under private law. CORES finances its activities by collecting a periodic fee from operators, distributors and consumers obliged to keep security stocks (collected monthly).

CORES is also responsible for data collection of the hydrocarbons sector in Spain, providing comprehensive data and analysis to the government, market stakeholders and international institutions, including the IEA and Eurostat. The agency's digital data platform, InfoCores, is accessible by all market participants and allows gathering and processing market data without delays.

In case of an oil supply disruption, the Directorate General for Energy Policy and Mines, together with CORES, plays a major role by providing technical support between the administration and industry to smoothly co-ordinate emergency stocks releases. In case of a disruption, CORES' Contingency Plan, a document of more than 200 pages, serves as a manual to help guide the decision-making process. It comprises procedures, draft decisions, contact details and specificities of the stockholding system. It was developed in 2018 through co-operation with all companies and the ministry. The document is classified.

In 2018, Spain also concluded a first draft of the updated Handbook for Stocks Release in case of an emergency, with the objective of making it suitable for new market conditions as well as to review procedures and protocols and include new useful content (the previous update was in 2015 with minor changes and the preceding one was in 2011). The new draft distinguishes primarily between national and international crises.

Spain has also approved a confidential document entitled "Demand Restriction Measures Plan against Oil Market Crisis", in co-ordination with other relevant ministries. The plan defines several scenarios based on previous security of supply crises, such as Hurricanes Katrina and Rita, the Iraq war and the Gulf Crisis in 1991, as well as local supply disruption scenarios. It constitutes an additional set of measures to react to oil supply distortions.

CORES, in collaboration with MITERD, has to date carried out four national emergency exercises: in October 2013, October 2015, January 2018 and November 2019. Following previous recommendations from the IEA, the objective of these exercises was to assess the Spanish oil market resilience in case of a supply disruption.

Emergency oil stocks

The Law on Hydrocarbons sets a maximum level of emergency stocks of 120 days of annual imports or consumption of crude oil and/or oil products. It also specifies that the minimum level of oil stocks should correspond to at least 92 days of sales or consumption in the previous year. In addition, companies active in the LPG sector are obliged to store 20 days of stocks of this fuel.

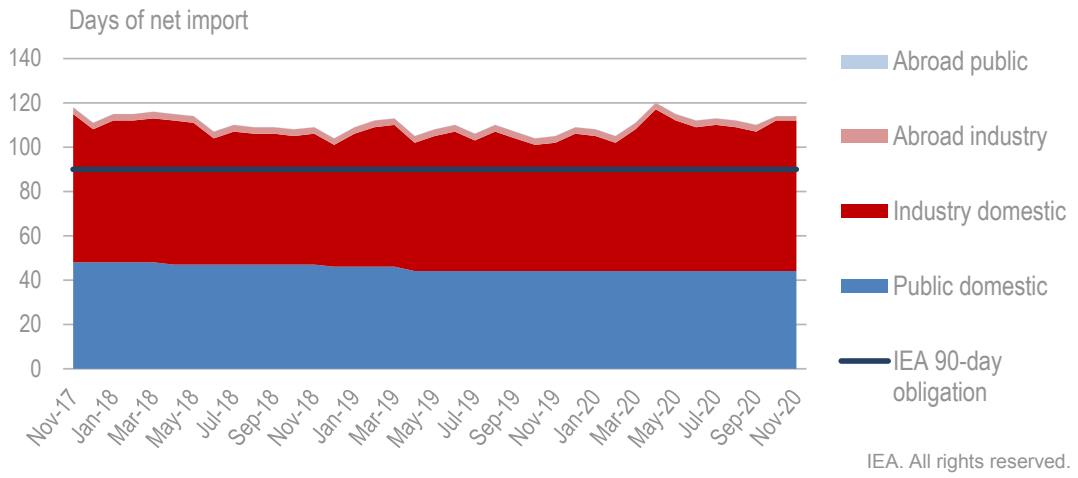
The minimum obligation of 92 days is split between CORES, which is responsible for maintaining strategic stocks to the tune of 42 days, and industry, which has an obligation of 50 days. Industry maintains the so-called minimum security stocks and CORES oversees the strategic (public) stocks. The industry can request CORES to maintain additional days up to 100% of a given company's obligation in exchange for a fee and according to storage availability. CORES does not maintain stocks of LPG; the full obligation in this regard lies with the industry. CORES is also responsible for monitoring compliance with the minimum stock levels of industry for oil, LPG and natural gas.

CORES owns 7.3 million m^3 of oil strategic stocks, which are held in the form of diesel oil (54%), crude oil (31%), gasoline (8%), and the remainder in kerosene and fuel oil, reflecting the country's consumption. Strategic stocks are distributed in five areas based on the consumption needs of each region: 50% of stocks are held in the eastern region, 17% in central region, 15% in the northern and 14% in southern regions of the country. Almost 95% of CORES' stocks are held mostly within the oil and logistic operators' facilities, whether separated or commingled, according to storage agreements, as well as in its own facilities at the Puertollano and Cartagena refineries.

The industry-obligated stocks are composed of middle distillates (42%), crude oil (25%), gasoline (10%), fuel oil (9%) and other legally permitted oil products. Industry's stocks may be held outside of Spanish territory up to a level of 40% of a given company's obligation, but not exceeding 15% of the country's total stocks. Holding stocks abroad is allowed only in those countries with which the government has concluded intergovernmental agreements. In 2019, 96% of industry stocks were held within the national territory.

As of end October 2020, Spain had a stock level equivalent to 115 days of the country's net imports, exceeding the IEA's 90-day requirements (Figure 11.11). Industry stocks accounted for 71 days, while public stocks totalled 44 days. Stocks held abroad amounted to two days. Spain's emergency stocks have consistently been above the IEA 90-day requirement in past years.

Figure 11.11 Spanish oil stocks, as of end November 2020



Spain's emergency stocks have consistently been above the IEA requirements in recent years.

Source: IEA (2021b), *Monthly Oil Data Service*, www.iea.org/statistics.

Assessment

The Spanish oil sector is entering a period of profound transformation due to the implementation of the country's NECP. The transport sector, which accounts for over 50% of the country's total oil consumption and 80% of diesel oil use, is expected to be the second-largest contributor for reaching the climate objectives as set in the NECP, just after power generation. The NECP envisages achieving a 28% share of renewables (including electricity) in the transport sector by 2030 (double the EU's ambition in this regard), increasing from today's 7%; and a 23% reduction in total oil consumption, which will support expected emissions cuts from the transport sector by 31% over the next decade. Although the NECP's objectives have not yet been transposed into binding domestic legislation, all market stakeholders are advanced in preparing for the swift transformation. In fact, refiners see new business opportunities in pursuing energy efficiency, producing green hydrogen and eco fuels. As efforts that companies will have to make could jeopardise market stability, the Spanish government can be commended for providing very clear communication on its climate objectives thus far.

Consumption of oil in Spain has been on a slow but steady rise since 2013 and amounted to 1 295.1 kb/d in 2019. In 2019, oil accounted for 48% of Spain's total energy supply and 51% of total final energy consumption. With very insignificant domestic oil production, the country is over 99% reliant on oil imports, which stood at 1 336.4 kb/d in 2019.

Spain's refining sector is large and relatively complex. Out of nine functioning refineries with nameplate processing capacity of 1.59 mb/d (an increase of 9% since 2014), five are operated by the country's largest oil company, Repsol, while two belong to Cepsa and one to BP. With the exception of one refinery in Puertollano, all installations are located close to seaports, thus benefiting from easy access to seaborne crude. In 2019, close to 42% of the country's 1 357 kb/d of oil of refinery output was diesel oil.

The Spanish wholesale and retail oil markets are fully open to competition. Imports, exports, trade and prices are set on the free market. However, due to the market's structure and the traditionally important role of the biggest operators, both the wholesale and retail markets are highly concentrated. Out of the 90 wholesale operators, the 3 biggest companies control 50% of the market. Similarly, the first four operators in the retail market control around 60% of petrol stations. The IEA commends the government of Spain for reducing market concentration since the last in-depth review thanks to actions led by the CNMC. The CNMC has strictly observed provisions abolishing pricing agreements of dealer owned and dealer operated service stations and prevented market dominance by restricting retail concentration to a maximum of 30% of sales by one operator in a given administrative region. Access to the market for new entrants is also simplified with third-party access rights to the infrastructure and publicly known pricing for their services.

Fuel prices in Spain are below the IEA average due to relatively low taxation. There are also regulated prices that apply only to specific formats of LPG, which is treated in the country as an alternative to natural gas for heating and cooking, notably in areas where the natural gas network is unavailable, such as islands and rural areas. Tax exemptions are granted for some types of diesel oil consumption, including for agriculture, road freight and taxi services, and the government will have to review these provisions to promote alternative fuels.

Mandatory blending targets for biofuels were introduced into Spanish law in 2015 with an initial goal of 4.3% for 2016. Since then, the government has made significant progress by steadily expanding the target, which stands at 10% for the year 2022. As of January 2021, MITERD has assumed the role of biofuel certification body (previously exercised by the CNMC) to ensure both timely implementation of blending targets and the development of a certificates scheme. Although the NECP envisages a greater role for biofuels to achieve the NECP's target of 28% of renewables in the transport sector by 2030, only 5% of raw material for bio-esters and 21% for bioethanol production comes from indigenous sources; the remaining shares are imported.

According to the government's plans, the deployment of electric vehicles in Spain is set to surge to 5 million EVs on the roads in 2030. In 2019, the total vehicle fleet in Spain passed 35 million and was dominated by diesel vehicles, accounting for 51.6% of the total. EVs accounted for a small share at 0.2%. Tools to support purchases of EVs are being implemented, but will require further enhancement, mainly as they relate to charging and related infrastructure throughout the country to support attainment of the targets.

Spain has a robust and proven system of oil emergency preparedness, based on a stockholding obligation, high-quality data and accuracy of market data reporting, regularly conducted emergency response exercises, and strong institutions. Maintaining this system is key to ensuring Spain's emergency response capabilities.

The minimum obligation of 92 days of oil stocks as set by the national legislation is split between the national stockholding agency, CORES, which is responsible for maintaining strategic stocks to the tune of 42 days, and industry, which has an obligation of 50 days. CORES does not maintain stocks of LPG and the full obligation in this regard lies with the industry. CORES is also responsible for monitoring compliance with the minimum stock levels of industry for oil, LPG and natural gas.

CORES is not financed by the state budget, but instead collects revenues from market participants to finance its stockholding, monitoring and data collection activities.

The revenues are collected via a fee on the monthly sales of the market participants and therefore vary month by month. As CORES hardly has any financial buffers, the fees for oil and gas suppliers had to be substantially increased when monthly sales considerably dropped during the COVID-19 pandemic.

Spain has a unique logistical system of pipelines and storages for crude oil and petroleum products, owned and operated by the company CLH. Thanks to Europe's second-longest pipeline system (over 4 000 km of pipelines), 90% of oil is transported via the network, which is the highest share among IEA countries. Pipelines connect all 8 refineries with 39 storage depots and another 37 storage sites serving main airports. The central dispatching unit at Torrejón supports, manages and supervises the automatic systems in all installations. According to the latest IEA data, Spain has a rather low utilisation rate of its storage system (60% for crude oil and 68% for products).

The Spanish National Emergency Strategy Organisation is part of the country's general emergency structure: the National Security System. According to the National Energy Security Strategy, the National Emergency Strategy Organisation reports to the National Security Council, which is the highest decision-making body of the National Security System. In case of an oil supply disruption, the Directorate General for Energy Policy and Mines within MITERD and CORES play a major role by providing technical support to smoothly co-ordinate emergency stock releases.

Since the last in-depth review, Spain has also updated its emergency operational handbook (in December 2018), which together with the ministry's Demand Restraint Measures Plan and CORES's Contingency Plan (all classified documents) comprise the guidelines for acting during any kind of oil market emergency.

All of these changes will have profound effects on the level of oil stockholding, utilisation of related infrastructure, including refineries, and may trigger a fundamental market rearrangement. It is critically important that changes to the oil emergency system are discussed with all stakeholders before implementation. Security of supply during the energy transition needs to be maintained and is key for achieving its goals in an orderly manner.

Recommendations

The government of Spain should:

- Conduct timely dialogue with oil industry stakeholders to support their endeavours in adapting to the changing business environment in view of implementation of the NECP's objectives.
- Ensure effective co-ordination of implementation of the NECP with all 17 autonomous communities to develop the infrastructure for clean alternatives for the transport sector throughout the country.
- Strengthen sustainability criteria for biofuels used in Spain and ensure sufficient measures to increase advanced biofuels penetration.
- Enhance public campaigns that promote acceptance of electric vehicles and new commuting models in public transport.

- Ensure the continuous operational stability of CORES, thereby providing for the stable functioning of CORES both in normal and emergency situations.
- Provide the conditions for a stable development of sustainable biofuels, with a particular emphasis on reducing dependency on imports and promoting domestic production.

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ANNEX A: Organisations visited

Review criteria

The Shared Goals, which were adopted by the IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews (IDRs) conducted by the International Energy Agency (IEA). The Shared Goals are presented in Annex C.

Review team and preparation of the report

The IEA's in-depth review team conducted a virtual review of Spain from 28 September to 9 October 2020. The team met with government officials, energy companies, interest groups, research institutions, and other organisations and stakeholders. This report was drafted on the basis of the review team's preliminary assessment of the country's energy policy and information on subsequent policy developments from the government and private sector sources. The members of the team were:

IEA member countries

Ms. Angelina Avgeropoulou, United Kingdom (team leader)

Mr. Ignacio Perez Caldentey, European Commission

Mr. Cristina Cardoso, Portugal

Ms. Malene Hein Nybroe, Denmark

Mr. Kathrin Renz, Austria

Mr. Wieger Wiersema, Netherlands

OECD Nuclear Energy Agency

Mr. Hiroyuki Goto

IEA Secretariat

Mr. Simon Bennett

Mr. Aad van Bohemen

Mr. Milosz Karpinski

Mr. Luis Munuera

Ms. Divya Reddy

The team is grateful for the co-operation and assistance of the many people it met throughout the visit. Thanks to their kind hospitality, openness and willingness to share information, the virtual visit was highly informative, productive and enjoyable. The team expresses particular gratitude to the Ministry for the Ecological Transition and the Demographic Challenge for organising the visit and for all its support throughout the review process, especially Carlos Jose Ortiz Bermuda and Jose Luis Cabo Sánchez.

The team is also sincerely grateful to Mr. Hugo Lucas Porta, Director of Cabinet, Secretary of State for Energy, for meeting with the review team.

Divya Reddy managed the review visit process and drafted the report, with the exception of Chapter 6, which was prepared by Simon Bennett and Luis Munuera of the IEA; Chapter 8, drafted by Hiroyuki Goto of the Nuclear Energy Agency; and Chapter 11, which was prepared by Milosz Karpinski of the IEA.

The report was prepared under the guidance of Aad van Bohemen, Head of the IEA's Energy Policy and Security Division. Helpful comments and updates were provided by the review team members and IEA staff, including Yasmina Abdeliliah, Carlos Fernández Alvarez, Heymi Bahar, Alyssa Fischer, Randi Kristiansen, Luca Lo Re, Jinsun Lim, Sara Moarif and Gergely Molnar.

Bomi Kim, Clémence Lizé, Alessio Scanziani and Dahyeon (Lisa) Yu managed the data and prepared the figures. Roberta Quadrelli, Erica Robin, Stève Gervais, Jungyu Park and Pouya Taghavi-Moharamli provided support on statistics. Therese Walsh managed the editing process, Jennifer Allain copy edited the report, Tanya Dyhin managed the design process,Astrid Dumond managed the production process, Isabelle Nonain-Semelin and Clara Vallois finalised the production. Jad Mouawad and Jethro Mullen supported the press launch.

Organisations visited

During its virtual meetings with Spain, the review team met with the following organisations:

A3e, Spanish Association of Energy Efficiency Companies

ACOGEN, Spanish Association of Co-generation

AEDIVE, Iberian Association for Electromobility

AEE, Spanish Wind Association

AEH2, Spanish Hydrogen Association

AELEC, Spanish Association of Electric Power Companies

ALINNE, Alliance for Energy Research and Innovation

ANESE, National Association of Energy Service Companies

ANFAC, Spanish Association of Auto and Truck Makers

AOP, Spanish Association of Petroleum Products Operator

APPA, Spanish Renewables Association

Atecyr, Spanish Technical Association for Air Conditioning and Refrigeration

CDTI, Centre for Industrial Technological Development

CIEMAT, Centre for Energy, Environment and Technology

CNMC, National Commission on Markets and Competition

CORES, central stockholding entity

Ecologistas en Acción

EDP

Enagás

Endesa

Enresa

Greenpeace Spain

Grupo Hunosa

Iberdrola

Ministry for the Ecological Transition and the Demographic Challenge

Ministry of Finance

Ministry of Science and Innovation

Ministry of Transport, Mobility and Urban Agenda

OMIE, electricity market operator

Protermosola

Red Eléctrica

Sedigas

Spanish State Research Agency

UNEF, Spanish Solar Association

ANNEX B: Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2017	2018	2019
TOTAL PRODUCTION		**11.3**	**34.6**	**31.5**	**34.4**	**33.6**	**34.0**	**34.1**
Coal		6.5	11.7	8.0	3.3	1.1	0.9	-
Peat		-	-	-	-	-	-	-
Oil		0.7	1.2	0.2	0.1	0.1	0.1	0.0
Natural gas		0.0	1.3	0.1	0.0	0.0	0.1	0.1
Biofuels and waste[1]		0.0	4.1	4.1	6.3	8.1	8.1	8.4
Nuclear		1.7	14.1	16.2	16.2	15.1	14.5	15.2
Hydro		2.5	2.2	2.4	3.6	1.6	3.0	2.1
Wind		-	0.0	0.4	3.8	4.2	4.4	4.8
Geothermal		-	0.0	0.0	0.0	0.0	0.0	0.0
Solar/other[2]		-	0.0	0.0	1.0	3.4	2.9	3.4
TOTAL NET IMPORTS[3]		**41.7**	**55.6**	**91.0**	**95.0**	**90.2**	**89.5**	**88.7**
Coal	Exports	0.0	0.0	0.5	1.1	0.2	0.3	1.0
	Imports	2.1	7.1	13.3	7.8	11.2	9.5	5.5
	Net imports	2.1	7.1	12.8	6.7	10.9	9.2	4.5
Oil	Exports	4.3	12.1	7.5	11.5	27.1	25.1	23.6
	Imports	45.3	61.7	78.5	80.5	89.7	88.9	88.1
	Int'l marine and aviation bunkers	-2.2	-4.7	-8.7	-11.4	-11.1	-11.6	-11.8
	Net imports	38.8	44.9	62.3	57.6	51.5	52.3	52.6
Natural gas	Exports	-	-	-	1.0	2.5	2.8	1.0
	Imports	0.9	3.7	15.5	32.0	30.1	30.3	32.4
	Net imports	0.9	3.7	15.5	31.0	27.6	27.5	31.4
Electricity	Exports	0.2	0.3	0.7	1.2	1.3	1.1	1.0
	Imports	0.0	0.3	1.1	0.4	2.0	2.1	1.6
	Net imports	-0.2	-0.0	0.4	-0.7	0.8	1.0	0.6
TOTAL STOCK CHANGES		**-1.5**	**-0.2**	**-1.1**	**-2.2**	**1.7**	**1.6**	**-1.4**
TOTAL SUPPLY (TES)[4]		**51.6**	**90.1**	**121.4**	**127.3**	**125.6**	**125.0**	**121.4**
Coal		9.0	19.3	20.9	7.8	12.8	11.3	4.9
Peat		-	-	-	-	-	-	-
Oil		37.6	45.5	61.6	57.7	52.9	52.9	51.5
Natural gas		0.9	5.0	15.2	31.1	27.3	27.1	30.9
Biofuels and waste[1]		0.0	4.1	4.1	6.7	7.6	8.0	8.0
Nuclear		1.7	14.1	16.2	16.2	15.1	14.5	15.2
Hydro		2.5	2.2	2.4	3.6	1.6	3.0	2.1
Wind		-	0.0	0.4	3.8	4.2	4.4	4.8
Geothermal		-	0.0	0.0	0.0	0.0	0.0	0.0
Solar/other[2]		-	0.0	0.0	1.0	3.4	2.9	3.4
Electricity trade[5]		-0.2	-0.0	0.4	-0.7	0.8	1.0	0.6
Shares in TES (%)								
Coal		*17.4*	*21.4*	*17.3*	*6.1*	*10.2*	*9.0*	*4.0*
Peat		-	-	-	-	-	-	-
Oil		*72.9*	*50.5*	*50.8*	*45.3*	*42.1*	*42.3*	*42.4*
Natural gas		*1.8*	*5.5*	*12.5*	*24.5*	*21.7*	*21.7*	*25.4*
Biofuels and waste[1]		-	*4.5*	*3.4*	*5.3*	*6.0*	*6.4*	*6.6*
Nuclear		*3.3*	*15.7*	*13.4*	*12.7*	*12.0*	*11.6*	*12.5*
Hydro		*4.8*	*2.4*	*2.0*	*2.9*	*1.3*	*2.4*	*1.7*
Wind		-	-	*0.3*	*3.0*	*3.4*	*3.5*	*3.9*
Geothermal		-	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Solar/other[2]		-	*0.0*	*0.0*	*0.8*	*2.7*	*2.3*	*2.8*
Electricity trade[5]		*-0.3*	-	*0.3*	*-0.6*	*0.6*	*0.8*	*0.5*

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2017**	**2018**	**2019**
TFC	**38.5**	**60.8**	**85.5**	**92.1**	**84.0**	**86.0**	**85.5**
Coal	4.2	3.4	1.4	0.9	0.9	0.7	0.5
Peat	-	-	-	-	-	-	-
Oil	28.9	38.3	52.2	50.0	42.8	43.8	43.9
Natural gas	0.4	4.3	12.3	14.8	13.9	14.7	14.7
Biofuels and waste[1]	-	3.9	3.4	5.2	5.5	5.9	6.0
Geothermal	-	0.0	0.0	0.0	0.0	0.0	0.0
Solar/other[2]	-	0.0	0.0	0.2	0.3	0.3	0.3
Electricity	5.1	10.8	16.2	21.0	20.6	20.5	20.2
Heat	-	-	-	-	-	-	-
Shares in TFC (%)							
Coal	*10.8*	*5.6*	*1.6*	*1.0*	*1.0*	*0.9*	*0.6*
Peat	-	-	-	-	-	-	-
Oil	*74.9*	*63.0*	*61.0*	*54.3*	*51.0*	*50.9*	*51.3*
Natural gas	*1.2*	*7.1*	*14.4*	*16.1*	*16.6*	*17.1*	*17.2*
Biofuels and waste[1]	-	*6.5*	*4.0*	*5.6*	*6.5*	*6.9*	*7.0*
Geothermal	-	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Solar/other[2]	-	*0.0*	*0.0*	*0.2*	*0.4*	*0.4*	*0.4*
Electricity	*13.2*	*17.8*	*19.0*	*22.9*	*24.5*	*23.8*	*23.6*
Heat	-	-	-	-	-	-	-
TOTAL INDUSTRY[6]	**20.6**	**25.2**	**34.0**	**27.8**	**24.3**	**25.1**	**25.0**
Coal	3.6	2.8	1.1	0.6	0.7	0.5	0.3
Peat	-	-	-	-	-	-	-
Oil	13.3	11.4	14.6	11.5	7.2	7.6	7.7
Natural gas	0.4	3.8	9.6	8.2	8.0	8.8	8.9
Biofuels and waste[1]	-	1.8	1.3	1.1	1.4	1.5	1.6
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	0.0	0.0	0.0	0.0
Electricity	3.3	5.4	7.4	6.3	7.0	6.8	6.5
Heat	-	-	-	-	-	-	-
Shares in total industry (%)							
Coal	*17.5*	*11.1*	*3.3*	*2.2*	*2.8*	*2.1*	*1.4*
Peat	-	-	-	-	-	-	-
Oil	*64.8*	*45.0*	*43.0*	*41.3*	*29.8*	*30.2*	*30.7*
Natural gas	*1.9*	*14.9*	*28.3*	*29.6*	*32.9*	*34.9*	*35.5*
Biofuels and waste[1]	-	*7.3*	*3.8*	*4.1*	*5.9*	*5.8*	*6.3*
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	-	-	-	-
Electricity	*15.9*	*21.6*	*21.6*	*22.7*	*28.6*	*26.9*	*26.1*
Heat	-	-	-	-	-	-	-
TRANSPORT[4]	**10.9**	**21.3**	**30.2**	**33.9**	**31.4**	**32.2**	**32.6**
OTHER[7]	**7.1**	**14.2**	**21.2**	**30.4**	**28.2**	**28.6**	**27.9**
Coal	0.6	0.6	0.3	0.3	0.2	0.2	0.1
Peat	-	-	-	-	-	-	-
Oil	4.8	6.0	7.8	6.4	5.9	6.2	5.8
Natural gas	0.1	0.5	2.6	6.5	5.8	5.8	5.6
Biofuels and waste[1]	-	2.1	2.1	2.6	2.8	2.8	2.8
Geothermal	-	0.0	0.0	0.0	0.0	0.0	0.0
Solar/other[2]	-	0.0	0.0	0.2	0.3	0.3	0.3
Electricity	1.7	5.1	8.5	14.5	13.3	13.4	13.3
Heat	-	-	-	-	-	-	-
Shares in other (%)							
Coal	*7.7*	*4.1*	*1.2*	*0.8*	*0.7*	*0.8*	*0.5*
Peat	-	-	-	-	-	-	-
Oil	*67.8*	*41.8*	*36.6*	*21.2*	*21.0*	*21.6*	*20.7*
Natural gas	*0.8*	*3.8*	*12.3*	*21.3*	*20.4*	*20.1*	*19.9*
Biofuels and waste[1]	-	*14.6*	*9.7*	*8.5*	*9.8*	*9.6*	*9.9*
Geothermal	-	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*
Solar/other[2]	-	*0.1*	*0.1*	*0.6*	*1.1*	*1.1*	*1.2*
Electricity	*23.7*	*35.5*	*40.0*	*47.6*	*47.0*	*46.8*	*47.7*
Heat	-	-	-	-	-	-	-

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2017**	**2018**	**2019**
ELECTRICITY GENERATION[8]							
Input (Mtoe)	12.6	33.1	45.6	49.0	46.7	44.6	42.6
Output (Mtoe)	6.5	13.0	19.0	25.7	23.5	23.4	23.3
Output (TWh)	75.7	151.2	220.9	298.3	273.0	272.0	271.0
Output shares (%)							
Coal	*18.9*	*40.1*	*36.6*	*8.8*	*17.0*	*14.2*	*5.2*
Peat	-	-	-	-	-	-	-
Oil	*33.2*	*5.7*	*10.2*	*5.6*	*5.8*	*5.3*	*4.8*
Natural gas	*1.0*	*1.0*	*9.1*	*31.8*	*23.5*	*21.3*	*30.9*
Biofuels and waste[1]	*0.1*	*0.4*	*1.0*	*1.6*	*2.5*	*2.5*	*2.4*
Nuclear	*8.7*	*35.9*	*28.2*	*20.8*	*21.3*	*20.5*	*21.5*
Hydro	*38.2*	*16.8*	*12.8*	*14.2*	*6.7*	*12.6*	*9.1*
Wind	-	-	*2.1*	*14.8*	*18.0*	*18.7*	*20.5*
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	*2.5*	*5.3*	*4.7*	*5.6*
TOTAL LOSSES	**13.9**	**29.4**	**36.4**	**36.1**	**40.5**	**38.0**	**36.2**
of which:							
Electricity and heat generation[9]	6.1	20.1	26.6	24.2	26.3	23.8	22.4
Other transformation	4.1	3.1	1.8	1.3	2.0	1.9	1.7
Own use and transmission/distribution losses	3.7	6.2	8.0	10.7	12.2	12.3	12.1
Statistical differences	**-0.9**	**-0.1**	**-0.5**	**-1.0**	**1.2**	**1.0**	**-0.3**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2017**	**2018**	**2019**
GDP (billion 2015 USD)	471.76	737.32	971.13	1197.15	1267.46	1297.26	1322.94
Population (millions)	35.25	39.34	40.55	46.56	46.53	46.73	47.10
TES/GDP (toe/1000 USD)[10]	0.11	0.12	0.13	0.11	0.10	0.10	0.09
Energy production/TES	0.22	0.38	0.26	0.27	0.27	0.27	0.28
Per capita TES (toe/capita)	1.46	2.29	2.99	2.73	2.70	2.68	2.58
Oil supply/GDP (toe/1000 USD)[10]	0.08	0.06	0.06	0.05	0.04	0.04	0.04
TFC/GDP (toe/1000 USD)[10]	0.08	0.08	0.09	0.08	0.07	0.07	0.06
Per capita TFC (toe/capita)	1.09	1.54	2.11	1.98	1.80	1.84	1.82
CO_2 emissions from fuel combustion ($MtCO_2$)[11]	139.4	202.6	278.6	262.1	254.0	248.9	230.9
CO_2 emissions from bunkers ($MtCO_2$)[11]	6.9	14.9	27.3	35.9	34.6	36.2	37.1
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-16**	**16-17**	**17-18**	**18-19**
TES	3.3	3.0	0.5	-1.1	5.2	-0.5	-2.9
Coal	4.6	0.8	-9.4	5.2	21.5	-12.1	-56.7
Peat	-	-	-	-	-	-	-
Oil	1.1	3.1	-0.7	-2.3	5.4	0.1	-2.7
Natural gas	10.3	11.8	7.4	-3.6	8.9	-0.7	14.1
Biofuels and waste[1]	40.2	0.2	5.0	1.1	5.5	5.7	0.3
Nuclear	13.3	1.4	-0.0	-0.9	-1.0	-3.9	4.6
Hydro	-0.7	1.0	4.1	-2.5	-49.7	87.4	-28.2
Wind	-	82.3	25.1	1.7	0.5	3.6	9.3
Geothermal	-	2.3	12.3	2.9	-	-	-
Solar/other[2]	-	4.6	41.1	20.6	5.4	-13.1	16.2
TFC	2.7	3.5	0.7	-1.9	2.4	2.5	-0.6
Electricity consumption	4.6	4.1	2.6	-0.9	2.8	-0.3	-1.6
Energy production	6.8	-0.9	0.9	-0.1	-1.6	0.9	0.5
Net oil imports	0.9	3.3	-0.8	-2.4	3.7	1.5	0.7
GDP	2.7	2.8	2.1	0.5	2.9	2.4	2.0
TES/GDP	0.7	0.2	-1.6	-1.5	2.3	-2.7	-4.8
TFC/GDP	0.1	0.7	-1.3	-2.4	-0.5	0.2	-2.6

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Footnotes to energy balances and key statistical data

1. Biofuels and waste comprise solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.

2. Other includes tide, wave and ambient heat used in heat pumps.

3. In addition to coal, oil, natural gas and electricity, total net imports also include peat, biofuels and waste, and trade of heat.

4. Excludes international marine bunkers and international aviation bunkers.

5. Total supply of electricity represents net trade. A negative number in the share of total primary energy supply indicates that exports are greater than imports.

6. Industry includes non-energy use.

7. Other includes residential, commercial and public services, agriculture/forestry, fishing, and other non-specified.

8. Inputs to electricity generation include inputs to electricity, co-generation and heat plants. Output refers only to electricity generation.

9. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and solar thermal; 10% for geothermal; and 100% for hydro, wind and solar photovoltaic.

10. Toe per thousand US dollars at 2010 prices and exchange rates.

11. "CO_2 emissions from fuel combustion" have been estimated using the Intergovernmental Panel on Climate Change (IPCC) Tier I Sectoral Approach methodology from the 2006 IPCC Guidelines. Emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: International Energy Agency's "Shared Goals"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases, this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the polluter-pays principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 in Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, the Netherlands ,Turkey, the United Kingdom and the United States.

ANNEX D: Glossary and list of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

AC	alternating current
AI	artifical intelligence
ALINNE	Alliance for Energy Research and Innovation
BST	thermal social bond
BWR	boiling water reactor
CDTI	Centre for Industrial Technological Development
CEIDEN	Nuclear Fission Energy Technology Platform
CIEMAT	Centre for Energy, Environment and Technology Research
CNMC	Commission of Markets and Competition
CO_2	carbon dioxide
CORES	Corporation of Strategic Reserves of Oil Products
CSF	centralised storage facility
CSN	Nuclear Safety Council
DC	direct current
DGR	deep geological repository
DSO	district system operator
E&P	exploration and production
EPB	Energy Performance of Buildings (Directive)
ERDF	European Regional Development Fund
ESD	Effort Sharing Decision
ESR	Effort Sharing Regulation
ETS	Emissions Trading System
EU	European Union
EV	electric vehicle
FNEE	National Energy Efficiency Fund
GDP	gross domestic product
GDP PPP	gross domestic product with purchasing power parity
GHG	greenhouse gas
GRWP	General Radioactive Waste Plan
HLW	high-level waste
IDEA	Institute for Diversification and Energy
IDR	in-depth review

IEA	International Energy Agency
IGCC	Integrated gasification combined cycle
IPCC	Intergovernmental Panel on Climate Change
LILW	low- and intermediate-level waste
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LTS	Long-Term Strategy
LULUCF	land use, land-use change, and forestry
MIBEL	Iberian power market (Mercado Ibérico de Electricidad)
MITERD	Ministry for the Ecological Transition and the Demographic Challenge
NECP	National Energy and Climate Plan
NPP	nuclear power plant
OMI	Iberian Market Operator (Operador del Mercado Ibérico)
PAREER	Energy Rehabilitation of Existing Buildings Programme
PPA	power purchase agreement
PPP	purchasing power parity
PV	photovoltaics
PVPC	voluntary price for the small consumer
PWR	pressurised water reactor
R&D	research and development
RD&D	research, development and deployment [or demonstration]
REMIT	Regulation on Wholesale Energy Market Integrity and Transparency
SME	small and medium-sized enterprise
SNF	spent nuclear fuel
SW	special waste
TES	total energy supply
TFC	total final consumption
TFeC	total final energy consumption
TPES	total primary energy supply
TSO	transmission system operator
USD	United States dollar
VLLW	very low-level waste

Units of measure

bcm	billion cubic metres
CO_2-eq	carbon dioxide equivalent
GW	gigawatt
GWh	gigawatt hour
kb/d	thousand barrels per day

km	kilometre
km^2	square kilometre
kote	kilotonne of oil equivalent
kW	kilowatt
kWh	kilowatt hour
m	metre
m^3	cubic metre
mb	million barrels
mcm	million cubic metres
Mt CO_2	million tonnes of carbon dioxide
Mt CO_2-eq	million tonnes of carbon dioxide equivalent
Mtoe	million tonnes of oil equivalent
MW	megawatt
MW_e	megawatt electrical
MWh	megawatt hour
t CO_2	tonne of carbon dioxide
toe	tonne of oil equivalent
Twh	terawatt hour

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Energy Policy Review

The International Energy Agency (IEA) regularly conducts in-depth peer reviews of the energy policies of its member countries. This process supports energy policy development and encourages the exchange of international best practices and experiences.

Since the last IEA review in 2015, Spain has solved a long-standing issue of tariff deficits in its electricity and gas sectors and closed all of its coal mines, which has allowed it to place the energy transition at the forefront of its energy and climate change policies.

The current Spanish framework for energy and climate is based on the 2050 objectives of national climate neutrality, 100% renewable energy in the electricity mix, and 97% renewable energy in the total energy mix. As such, it is centred on the massive development of renewable energy, energy efficiency, electrification and renewable hydrogen.

Notwithstanding its considerable progress to date on decarbonising and increasing the share of renewables in the electricity sector, Spain's total energy mix is still heavily dominated by fossil fuels. Notably, the transport, industry and buildings sectors all have considerable work ahead of them to meet the country's targets for decarbonisation and higher shares of renewables.

When all of Spain's plans and strategies are implemented, a completely different energy sector will emerge in which fossil fuels are no longer dominant and end-user sectors are mostly electrified. Such a transformed energy landscape will come with new challenges and will provide new opportunities.

In this report, the IEA provides energy policy recommendations to help Spain effectively manage this transformation of its energy sector.