Portugal 2021

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Foreword

The International Energy Agency (IEA) has conducted energy policy reviews of its member countries since 1976. This peer review process supports energy policy development and encourages the exchange of international best practices. By seeing what has worked – or not – in the "real world", these reviews help to identify policies that deliver concrete results.

Throughout its 40 years as a member of the IEA, Portugal has been an active contributor to efforts to improve global energy security and sustainability. I particularly appreciate the leadership that João Pedro Matos Fernandes, Minister of Environment and Climate Action, is now bringing in these areas, including through partnership with the IEA. Portugal is an active participant in the IEA Technology Collaboration Programme, specifically, the collaborations on industry-based biorefineries, energy-flexible buildings, renewable energy and hydrogen.

Portugal was notably impacted by the Covid-19 pandemic, with GDP dropping by over 8% in 2020, the largest decline since 1936. Portugal's economic recovery plan places a strong emphasis on accelerating energy transitions with funding for sustainable mobility, energy efficiency, renewables, decarbonisation and the bio-economy.

Portugal has demonstrated important leadership in the transition to clean energy, especially in integrating electricity from renewable sources. The combined share of wind and solar PV in electricity generation reached almost 30% in 2019 and will continue to grow. Portugal will also phase out coal-fired generation in 2021.

Portugal was among the first countries in the world to set 2050 carbon neutrality goals. Portugal's energy and climate policies seek to achieve carbon neutrality primarily through broad electrification of energy demand and a rapid expansion of renewable electricity generation, along with increased energy efficiency. There is a strong focus on reducing energy import dependency and maintaining affordable access to energy. In the longer term, Portugal is aiming for hydrogen to play a major role in achieving carbon neutrality.

Yet despite this notable progress on decarbonising power generation and electrifying building energy demand, Portugal's energy mix is still dominated by fossil fuels. The transport, industry and buildings sectors all have considerable work ahead of them to meet Portugal's targets for increasing the share of renewables, lowering energy demand and reducing emissions. I sincerely hope the recommendations proposed in this report will help Portugal navigate the transformation of its energy systems as it seeks to build momentum towards achieving climate neutrality while maintaining secure supplies of energy.

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1. Executive summary

Overview

Since the International Energy Agency's (IEA) last energy policy review in 2016, Portugal has recovered from the extended economic downturn it experienced following the 2008 financial crisis. In 2019, gross domestic product (GDP) reached USD 340 billion, higher than the 2008 pre-crisis level of USD 325 billion. The unemployment rate fell from a high of 16.2% in 2013 to 6.5% in 2019 (compared to 7.6% in 2008). The economic recovery accelerated ongoing structural changes away from energy-intensive activities and Portugal is showing signs of decoupling economic growth from energy demand, with total final consumption per GDP dropping by 8% between 2014 and 2019.

Portugal was notably impacted by the Covid-19 pandemic, with GDP dropping by 8.4% in 2020, the largest annual decline since 1936. Both Portugal and the European Union (EU) have taken major steps to address the impacts of the pandemic and support a return to economic growth. In March 2020, Portugal announced a EUR 9.2 billion stimulus package consisting mainly of broad fiscal measures, state-backed credit guarantees and increased social payments. Portugal also took actions specific to the energy sector, including fast-tracking the permitting and grid connection of 220 solar photovoltaic (PV) projects, providing funding to public transportation operators, and introducing a financial support programme for building energy efficiency measures, which was highly successful and will be continued in the coming years.

The EU has approved EUR 750 billion in funding to support recovery and resilience plans being developed by each EU member state. Portugal's plan was submitted to the EU in April 2021, requesting EUR 13.9 billion in grants and EUR 2.7 billion in loans. Portugal's plan dedicates notable funding to the energy sector, with funding for sustainable mobility, energy efficiency, renewables, decarbonisation and bio-economy. The plan includes EUR 610 million for energy efficiency and renewable energy in buildings and EUR 185 million to support 264 megawatts (MW) of renewable gas production (hydrogen and biomethane). The EU has estimated that Portugal's recovery and resilience plan, along with other measures taken by the government, should result in strong recovery from the pandemic, with GDP increasing by 4.1% in 2021 and 4.3% in 2022.

Portugal remains reliant on imported fossil fuels, which accounted for 76% of primary energy supply in 2019 (43% oil, 24% natural gas and 6% coal). All oil, natural gas and coal are imported. As a result of increased economic activity and the high share of fossil fuels in its energy supply, Portugal's greenhouse gas (GHG) emissions increased by 13% from 2014 to 2018, with notable annual variations driven by the seasonal availability of generation from Portugal's large fleet of hydropower dams. Since 2005, land use, land-use change and forestry has, on average, reduced Portugal's annual GHG emissions.

However, in 2017, extreme wildfires caused notable GHG emissions, and in fact, Portugal is facing an increasing risk of wildfires.

Portugal has also achieved a high level of electrification. In 2019, electricity covered 25% of total final energy demand, 56% of building energy demand and 25% of industry energy demand. Portugal has also achieved high shares of renewable energy, which covered 30.6% of gross final energy demand in 2019. Thanks mainly to hydropower and wind generation, renewables covered 54% of electricity generation and there is high use of bioenergy in industry and buildings. However, there has been limited growth in renewables in recent years, but Portugal is taking steps to accelerate renewables deployment, especially for solar PV, and is completing a new 1.2 gigawatt (GW) hydropower project. From 2014 to 2019, the share or renewables in gross final energy demand increased by 3.8%. Sustained deployment of renewables is needed in all areas to meet Portugal's 2030 targets.

In response to policy and market pressures, the private operators of Portugal's two coal-fired power plants announced in 2020 that both plants will permanently close in 2021. The 1.3 GW Sines coal-fired power plant closed in January 2021 and the 0.6 GW Pego coal power plant will close in November 2021.The government indicates that natural gas electricity generation will be maintained until at least 2040.

Energy research, development and demonstration (RD&D) expenditure in the country reached 0.07% of GDP in 2019 (against 0.06% in 2016). The share of energy RD&D in total R&D expenditure evolved from 4% to 5% between 2016 and 2019.

Energy and climate policy

Portugal was among the first countries in the world to set 2050 carbon neutrality goals. Portugal's energy and climate policies push for carbon neutrality primarily through broad electrification of energy demand and a rapid expansion of renewable electricity generation, along with increased energy efficiency. There is a strong focus on reducing energy import dependency and maintaining affordable access to energy. These policy goals are supported through clear targets, detailed national strategies and a wide range of regulations, economy-wide programmes and sector-specific measures.

The European Union (EU) Emission Trading System (ETS) encourages GHG emissions reductions from Portugal's energy-intensive industries and electricity generation. Portugal's National Energy and Climate Plan (NECP) sets 2030 targets for a 17% reduction of non-ETS GHG emissions and a 45-55% reduction in total GHG emissions (both compared to 2005 levels), energy efficiency (primary energy demand less than 21.5 million tonnes of oil equivalent (Mtoe), compared to 22.1 Mtoe in 2019, and final energy demand less than 14.9 Mtoe, compared to 17.1 Mtoe in 2019), renewable energy (47% of gross final energy demand, 80% of electricity generation, 49% of heating and cooling demand, and 20% of transport demand), 15% cross-border electricity interconnection (compared to 10% in 2019), and 65% external energy dependency (compared to 74% in 2019).

Portugal sees a key role for hydrogen produced from renewable energy in hard-to-decarbonise sectors and for achieving carbon neutrality. The National Hydrogen Strategy (EN-H2) sets a goal for hydrogen produced from renewable energy to cover 1.5-2.0% of

Portugal's energy demand by 2030, with use in industry, domestic maritime shipping, road transport and for injection into the natural gas network. The EN-H2 indicates that achieving these goals requires deployment of 2.0-2.5 GW of electrolysis capacity along with enabling legislation, regulations and standards.

Both the NECP and the EN-H2 call for RD&D. The NECP sets 2030 targets for combined public and private spending on overall RD&D to increase to 3% of GDP and for combined public and private spending on energy RD&D and on climate and water RD&D to both increase to 0.2% of GDP. In 2019, total public and private spending on energy RD&D was 0.07% of GDP. Portugal's energy RD&D measures and programmes support commercial deployment of products and services, pilot projects and industrial clusters focused on new technologies, and business models based on low-carbon products and services.

The NECP and EN-H2 are intended to put Portugal on a path to achieving the goals set in the Roadmap for Carbon Neutrality 2050 (RNC2050), which calls for GHG emissions reductions of 85-90% by 2050 versus 2005 levels, complete decarbonisation of electricity generation and transport, and carbon sequestration to reach carbon neutrality. The RNC2050 envisions achieving the 2050 goals through the deployment of renewables to cover 86-88% of final energy demand, electrification (with electricity covering 66-68% of final energy demand) and major demand reductions achieved mainly through energy efficiency measures that aim to reduce primary energy demand to less than 12.5 Mtoe, compared to 22.1 Mtoe in 2019 and final energy demand to less than 11.4 Mtoe, compared to 17.1 Mtoe in 2019.

The Azores and Madeira autonomous regions set their own energy and climate policies and strategies. These islands still heavily rely on oil products, even for electricity generation. With the increasing introduction of renewable energy, oil demand is decreasing and some islands have already reached high shares of renewable electricity generation by leveraging a wide range of technologies (geothermal, wind, hydro, solar PV and energy storage). The Azores and Madeira are testing different approaches to increase the share of renewables, boost the use of electric vehicles (EVs), and improve the energy efficiency of residential and service sector buildings. The Azores' and Madeira's programmes to support the energy transition appear to be more ambitious than those for mainland Portugal, and these island regions can pioneer living labs to test innovative solutions, like storage, smart grids, electric mobility and integration of very high shares of renewables.

Key measures

A central aspect of Portugal's energy and climate policy is the Green Taxation Law, passed in 2014 to better align energy sector taxation with decarbonisation goals. As part of the Green Taxation Law, Portugal established a carbon tax in 2015 that covers fossil fuel demand in all non-ETS sectors. The carbon tax is charged as an additional amount on top of the energy products tax (ISP), which covers most energy demand including fossil fuels, electricity and heat. The carbon tax rate is based on historic price trends of ETS allowances and conversion factors that assign higher tax rates to fuels with higher emissions and environmental impacts. Revenue from the carbon tax and ETS allowance auctions are allocated to Portugal's Environmental Fund, which supports a wide range of government programmes, including some decarbonisation measures.

The government has made adjustments to the carbon tax to drive decarbonisation. In 2018, a progressive elimination of the ISP and carbon tax exemptions for coal used in electricity generation was introduced. As a result of the reduced exemption and market factors, Portugal's largest coal-fired electricity plant closed in January 2021 and the last coal-fired electricity plant will close in November 2021. Since April 2020, natural gas used for electricity generation (excluding co-generation) is subject to a progressive reduction of the ISP and carbon tax exemptions. This is intended to favour the deployment of renewable generation, although the NECP indicates that natural gas electricity generation will be maintained until at least 2040.

Portugal has several measures to drive the deployment of renewable electricity generation, including feed-in tariffs and a new system for allocating grid connection capacity that includes solar PV auctions. Since this new system was established in 2019, network capacity reserve titles have been granted to over 1.95 GW of renewable energy projects (primarily solar PV, along with some wind and battery storage). The government approved 1.16 GW of new hydropower capacity and major expansions of electricity infrastructure to support the integration of renewables and better interconnection with Spain. The government is also taking steps to increase the flexibility of the electricity system, including the deployment of smart grids and pilot projects for dynamic tariffs and demand response market participation.

In 2020, only 33% of the average household retail electricity price was energy costs, with the remaining 67% coming from tariffs and taxes. For industrial users, only 42% of the average retail price was composed of energy costs, with the remaining 58% coming from tariffs and taxes. The high level of taxes and tariffs hampers electricity from competing with other fuels and is a barrier to achieving Portugal's goals for electrification. The government should continue its efforts to adjust energy taxation to ensure that energy prices drive consumer behaviour and investment decisions that support Portugal's decarbonisation goals.

Strong action is needed to support Portugal's goals for transport decarbonisation. In 2019, 94% of transport energy demand was covered by oil, and transport GHG emissions increased by 10% from 2014 to 2019. Portugal has several measures to drive transport decarbonisation. Road vehicle taxation encourages the purchase of lower emission vehicles and there is a strong focus on transitioning to EVs. The RNC2050 indicates that electricity should cover 36% of passenger vehicle demand by 2030 and 100% by 2050. To drive EV uptake, Portugal introduced monetary incentives for battery electric vehicles (BEVs) in 2015. There is also favourable tax treatment for BEVs and support for EV charging infrastructure.

Portugal is also pushing for transport decarbonisation, with over EUR 10 billion of investments in electrified passenger and freight rail, and electrified public transportation. The government has developed a National Strategy for Bicycling and Active Mobility, which aims to increase bike lanes in Portugal from 2 000 km in 2018 to 10 000 km in 2030. There are also financial incentives for purchasing electric and regular bicycles (including cargo bikes).

The System for Management of Intensive Energy Demand (SGCIE) is Portugal's main programme to promote energy efficiency in industry. Under SGCIE, energy-intensive industrial facilities must complete an energy audit every eight years and develop plans to implement energy efficiency measures achieving a 4-6% reduction in energy demand. Progress on the implementation of these plans is monitored by the government. Industrial facilities regulated by the SGCIE receive exemptions from the carbon tax and the ISP. The government is considering a progressive reduction of the carbon tax exemption for facilities regulated by the SGCIE, which would result in higher taxes on fossil fuels. More aggressive SGCIE efficiency targets and policy clarity on industrial decarbonisation pathways are needed to help industry achieve cost-effective decarbonisation.

Portugal has a wide range of measures to support the decarbonisation of buildings, including codes, certifications and financial support mechanisms for renovations. As of January 2019, all new buildings owned or occupied by a public entity need to satisfy nearly zero-energy buildings (NZEB) requirements. Starting in January 2021, all newly constructed or majorly renovated private buildings with an area greater than 1 000 square metres need to satisfy NZEB requirements. Under the National Buildings Energy Performance Certification System (SCE), all residential, service sector and public buildings must go through an audit to receive an energy certificate when they are constructed or deeply renovated, each time the building changes ownership or is leased, and under other conditions for service sector or public buildings. The SCE has improved insulation and heating and cooling in both new buildings and resulted in deep renovations of existing buildings.

However, around two-thirds of Portugal's building stock was constructed before any energy performance requirements were put in place, and around two-thirds of buildings still lack SCE certificates and 75% of certified buildings do not meet requirements for thermal comfort. Major efforts are needed to accelerate building renovation to reduce building energy demand and emissions and improve thermal comfort. In February 2021, Portugal approved a Long-term Renovation Strategy that aims to rapidly increase the pace of renovations through specific public and private investments to be made in buildings until 2050.

Energy poverty

Portugal faces challenges relating to energy poverty, with relatively high energy prices and a building stock that often lacks adequate insulation. In 2018, the EU Energy Poverty Observatory noted that 19.4% of Portugal's population reported that they were unable to keep their homes adequately warm (the EU average was 7.3%) and also noted challenges related to cooling. The government places a strong priority on energy affordability and has established social tariffs for electricity and natural gas that provide discounts on parts of the distribution tariffs to reduce the electricity and gas bills of households that meet certain socio-economic criteria. In December 2020, 752 965 households (14% of all households) received the electricity social tariff, while 34 709 households (2.4% of all households connected to the gas network) received the natural gas social tariff.

In 2020, the electricity social tariff reduced the bills of qualifying households by a total of around EUR 109 million, an average reduction of EUR 114 per household. The gas social tariff led to a total reduction of around EUR 1.6 million, an average reduction of EUR 45 per household. The electricity social tariff is financed by the owners of fossil fuel generation assets and large-scale hydropower plants, both in proportion to installed capacity. The gas social tariff is financed by gas network operators and gas suppliers in proportion to the amount of gas delivered or sold in the previous year. While the need to protect vulnerable households is understood, the IEA notes that the social tariffs unduly add responsibilities and costs for energy suppliers.

Portugal is developing a National Long-Term Strategy to Tackle Energy Poverty to improve vulnerable consumer protection instruments and propose measures to reduce energy poverty. Portugal is also preparing a National Strategy to Combat Poverty that is intended to address all issues that contribute to poverty, including energy poverty. The IEA recommends that the government use the development of these two strategies to examine a full range of options to address energy poverty. Especially critical are deep renovations that reduce energy demand (and consumer bills) while improving the comfort of residences, and supporting electrification and distributed renewable energy. The recently launched long-term renovation strategy gives priority to renovating the worst performing buildings to address energy poverty.

Energy security

As a result of the high demand for fossil fuels (primarily oil and natural gas) and the lack of domestic fossil resources, Portugal has a high energy import dependency. In 2019, Portugal's energy import dependency was 74%, one of the highest levels among IEA member countries. Portugal has made progress on reducing energy import dependency by increasing the share of renewables in the energy supply, especially for electricity. The NECP sets ambitious targets to reduce energy import dependency below 65% by 2030 and the RNC2050 sets ambitious targets to reduce energy import dependency below 19% by 2050. Achieving these goals will require strong and sustained measures to reduce fossil fuel demand, especially in transport, where 94% of energy demand was covered by oil in 2019, as well as in industry, where oil and natural gas together covered 51% of energy demand in 2019.

Portugal's energy system delivers a high level of security of supply. However, susceptibility to climate impacts is emerging as a significant risk. Portugal's transmission and distribution infrastructure face a growing threat from extreme weather events and wildfires, both of which are likely to increase in frequency and severity because of climate change. Climate impacts on rainfall pose a threat to Portugal's hydropower generation, which is critical for secure grid operations and for meeting goals for decarbonisation, electrification and reducing energy import dependency. It is recommended that Portugal include potential climate impacts on the electricity system in the Security of Supply Monitoring Report and in the planning for climate adaptation. The government is working internationally to increase electricity interconnections with Spain and the rest of Europe, which will help to increase the security of electricity supply.

Many of Portugal's energy sector goals rely on increasing the flexibility of the energy system, especially electricity supply and demand. This presents excellent opportunities to leverage hydropower (especially pumped storage), battery storage, smart grids, distributed generation and demand response, but will also increase cybersecurity risks. The government should ensure that all energy sector planning processes incorporate assessments of cybersecurity risks and take appropriate measures to plan for and reduce risks, and mitigate potential impacts.

Key recommendations

The government of Portugal should:

- Establish a broad stakeholder alliance to drive rapid implementation of the measures in the Roadmap for Carbon Neutrality, the National Energy and Climate Plan and the National Hydrogen Strategy, and to provide investor certainty on policy direction.
- Accelerate the reform to align energy taxes with decarbonisation goals and ensure that the carbon tax drives emissions reductions in all sectors.
- Enhance electricity retail market competition by removing barriers to entry for new players and facilitate market innovation to incentivise demand response, distributed renewables and increased electrification while ensuring market integrity and security.
- Prioritise deep renovation of public buildings and residences owned or rented by vulnerable consumers in order to reduce energy poverty, increase thermal comfort and support the achievement of decarbonisation goals.
- Develop a clear strategy for rapid electrification and the use of sustainable biofuels and hydrogen in the transport sector. Reduce the use of private cars and promote the use of railway to transport people between major cities and for international freight.
- Continue to work with Spain on increasing electricity interconnection capacity between Portugal and Spain and between the Iberian peninsula and the rest of Europe.
- Develop a dedicated strategy for energy research, development and demonstration that aligns policy design, implementation and funding with the achievement of Portugal's 2030 energy sector targets and 2050 decarbonisation goals, including support for commercial deployment of new energy technologies, products and services.

2. General energy policy

Key data (2019)

Total energy supply (TES): 21.8 Mtoe (oil 43.1%, natural gas 24.3%, bioenergy and waste 14.8%, coal 5.7%, wind 5.4%, hydro 3.5%, solar 1.0%, geothermal 0.9%, electricity imports 1.3%), -10.6% since 2009

TES per capita: 2.1 toe/cap (IEA average:* 4.1 toe/cap)

TES per unit of GDP: 64 toe/USD million (IEA average:* 92 toe/USD million)

Energy production: 5.9 Mtoe (biofuels and waste 60.2%, wind 20.0%, hydro 12.9%, solar 3.6%, geothermal 3.3%), +19.4% since 2009

Total final consumption (TFC): 16.8 Mtoe (oil 49.4%, electricity 24.5%, bioenergy and waste 13.2%, natural gas 10.8%, heat 1.5%, solar 0.6%, coal 0.1%, geothermal 0.01%), -11.3% since 2009

* Weighted average among the 30 IEA member countries.

Note: GDP is expressed in 2015 prices and purchasing power parity (PPP) unless otherwise noted. TES excludes heat pumps.

Country overview

Portugal (officially the Portuguese Republic) is located on the Iberian peninsula bordering Spain and has a total land area of just over 92 000 square kilometres (Figure 2.1). In 2019, the population was 10.3 million, with around 44% residing in the metropolitan areas of Lisbon (the capital) and Porto. Portugal has two autonomous island regions located in the Atlantic Ocean (the Azores and Madeira), which have notable independence in setting local policy, including for energy.

Portugal is a parliamentary republic with a Constitution from 1976, most recently amended in 2005. The national parliament is the unicameral National Assembly of 230 members, who are elected to four-year terms. The Portuguese President is the head of state and nominates the Prime Minister, who presides over the Cabinet. The Socialist Party (PS) and the Social Democratic Party (PSD) have dominated the political system since 1976. The most recent election was held in October 2019, in which the PS won with 36% of the votes and 108 seats, followed by the PSD, with 24% of the votes and 79 seats. António Costa, the current Prime Minister (PS) has led a minority government since 2015.

Portugal has been a member of the European Union (EU) since 1986, holding 21 seats in the European Parliament. The country has been a member of the Organisation for Economic Co-operation and Development (OECD) since 1961, and of the International Energy Agency (IEA) since 1981.

Figure 2.1 Map of Portugal

Portugal was severely hit by the 2008 financial crisis, but since 2014 the economy has been recovering. During the crisis, Portugal received substantial economic assistance from the EU with the three-year EU economic adjustment programme ending in June 2014. Portugal is now under post-programme surveillance until it has repaid at least 75% of the financial assistance received, which is expected to take until 2035 (EC, 2021).

The economy recovered markedly between 2014 and 2018. In 2018, gross domestic product (GDP) reached USD 340 billion, higher than the 2008 pre-crisis GDP of USD 325 billion. The unemployment rate fell from a peak of 16.2% in 2013 to 6.5% in 2019 (compared to 7.6% in 2008). Nevertheless, the poverty rate of 10.4% is still in the high range compared to other OECD countries. The public debt to GDP ratio has fallen, from 131% in 2014 to 117.2% in 2019, but is still one of the highest among OECD countries and well above the pre-crisis level of 70% in 2008 and the EU target of 60%.

Similar to other developed countries, Portugal's economy relies mainly on services, which accounted for 65.3% of GDP in 2018, followed by industry (19%) and agriculture (2.1%).

Tourism is a key driver, accounting 15.4% of GDP in 2019 (Statistics Portugal, 2020). Portugal's exports grew to USD 67.1 billion in 2019, with the largest share coming from automobiles. The Covid-19 pandemic has strongly affected the Portuguese economy, with GDP falling by 8.4% in 2020. The EU has estimated that Portugal's recovery and resilience plan, along with other measures taken by the government, should result in strong recovery from the pandemic, with GDP increasing by 4.1% in 2021 and 4.3% in 2022.

Energy sector overview

In 2019, fossil fuels accounted for 76% of Portugal's total energy supply (TES).[1] Portugal has no production of crude oil, natural gas or coal and relies entirely on imports for these energy sources. Domestic energy production comes primarily from bioenergy (direct use and electricity generation) and generation from wind and hydro (Figure 2.2). Oil products were the largest energy source in 2019, accounting for 43% of TES. Road transport accounted for most oil products demand (51%), followed by industry (16%) and oil-based building heating (5%). Natural gas is the second-largest energy source, accounting for 24% of TES, and is used mainly for electricity generation (60%) and industrial processes (24%). In comparison to many IEA countries, only a small share of gas demand (10%) comes from buildings.

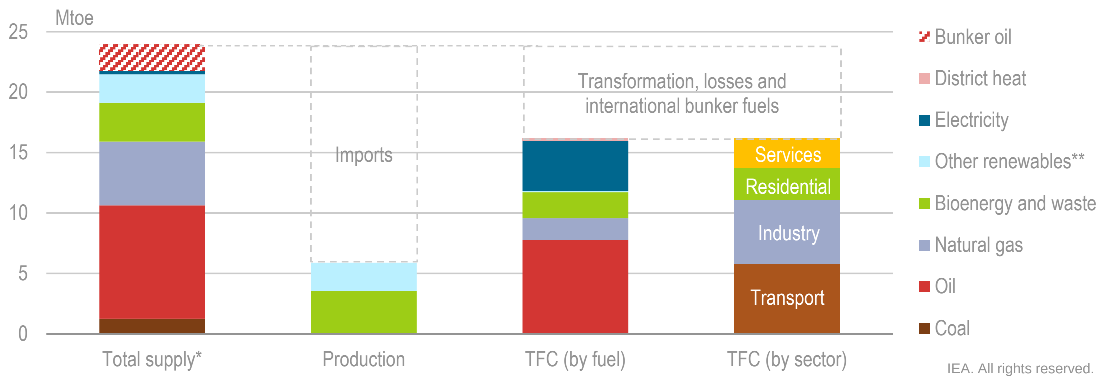
Bioenergy and waste covered 15% of TES, mainly solid biomass used in industry (52%) and buildings (36% of bioenergy demand) and biofuels in transports (12%). Bioenergy and waste provides 7% of total electricity generation. Coal accounted for 6% of TES and is almost exclusively used for electricity generation (99%), with very low use in industry. Wind and hydro generation accounted respectively for 5.5% and 3.5% of TES in 2019.

Supply

From 2008 to 2012, Portugal's TES decreased from 24.7 million tonnes of oil equivalent (Mtoe) to 21.4 Mtoe, in line with reduced economic activity resulting from the 2008 financial crisis. Since 2012, improving economic conditions have driven growth in TES, which reached 22.8 Mtoe in 2017. TES declined in 2018 and 2019 to reach 21.7 Mtoe (Figure 2.3). From 2008 to 2014, the share of fossil fuels in TES decreased from 79% to 73%, driven mainly by a decrease in oil supply. Since 2014, the share of fossil fuels in TES has been stable at just above 75%, with an increasing supply of natural gas offsetting reductions in oil and coal supplies. In 2017, low hydropower production resulted in an increased demand for natural gas generation, which pushed the share of fossil fuels in TES to 78.9%.

[1] TES comprises: production + imports – exports – international marine and aviation bunkers ± stock changes. TES is the total supply of energy that is consumed domestically, either in transformation (e.g. electricity generation and refining) or in direct use.

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



Most of Portugal's energy supply is provided by imported fossil fuels. In 2019, oil was the main energy source, while demand was concentrated in the transport and industry sectors.

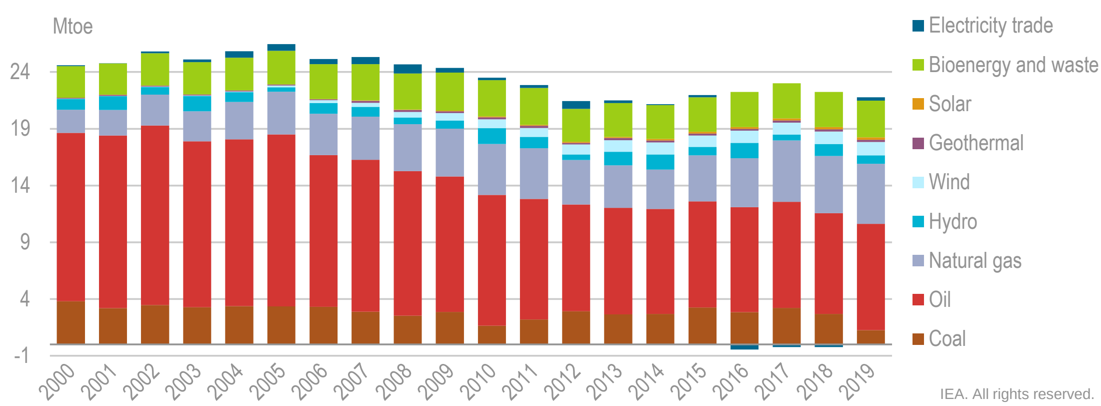
* *Total supply* includes total energy supply (which includes electricity imports) + international bunker fuels.

** *Other renewables* includes wind, hydro, solar and geothermal.

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

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 2.3 Total energy supply in Portugal by source, 2000-19



TES dropped from 2007 to 2012, increased until 2017 then decreased in 2018 and 2019. The share of fossil fuels dropped from 2008 to 2014 and has since been around 75% of TES.

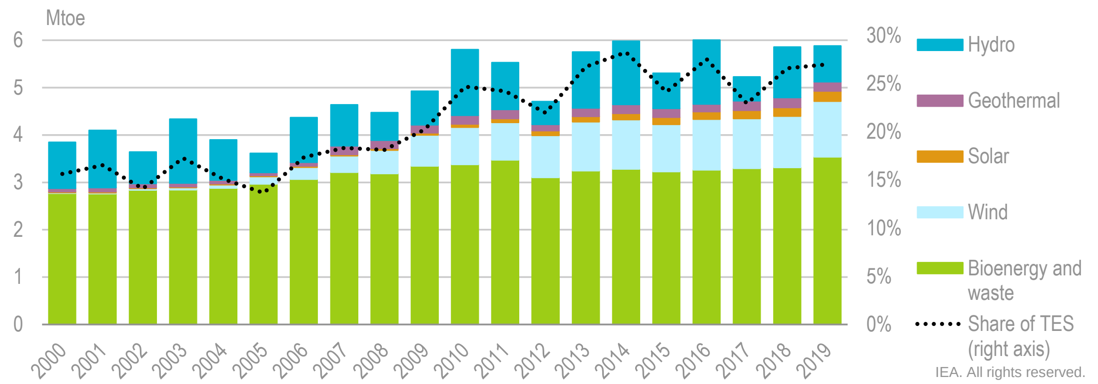
Note: Mtoe = million tonne of oil equivalent.

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Domestic production and import dependency

Portugal's domestic energy production comes from renewable energy (mainly bioenergy, wind and hydro) and a small share of non-renewable waste. From 2008 to 2019, Portugal's domestic energy production increased from 18% to 27% of TES, driven largely by growth in wind generation from 2005 to 2012 (Figure 2.4). Annual variations in hydro generation have a notable impact on Portugal's domestic energy production, which has reached 28% during years with strong hydro output (2014 and 2016). In 2019, Portugal had the seventh-lowest share of domestic production in TES among IEA member countries (the IEA median was 54% of TES), reflecting the high dependency on imported fossil fuels.

Figure 2.4 Energy production in Portugal by source, 2000-19

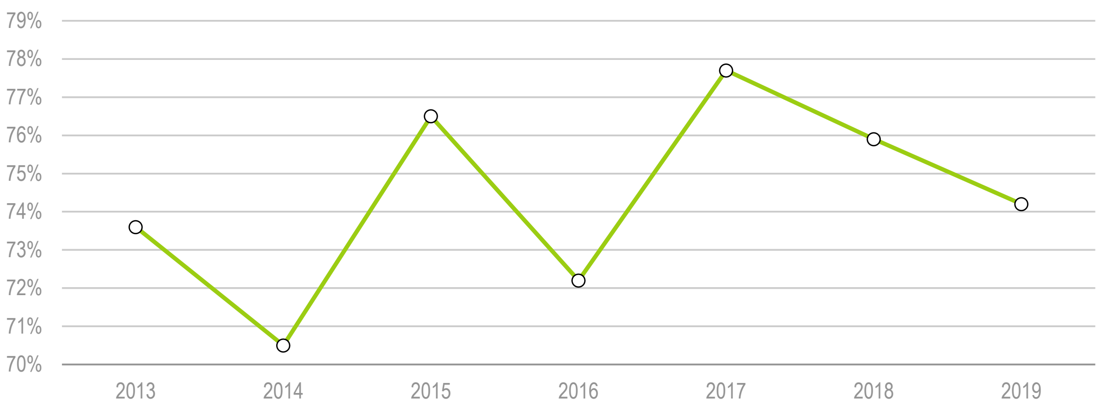


Domestic energy production comes primarily from bioenergy, with notable shares from wind and hydropower. Variations in hydro output have a notable impact on total production.

Notes: Mtoe = million tonne of oil equivalent. TES = total energy supply.
Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Portugal has no domestic production of oil, coal or natural gas and 100% of the supply of all these fuels is imported. Portugal's lack of fossil fuel resources and its relatively small domestic energy production result in a high energy import dependency (Figure 2.5). In 2019, external energy dependency was 74.2% (DGEG, 2020), one of the highest shares among IEA countries.

Figure 2.5 Portugal's energy import dependency (external energy dependency), 2013-19



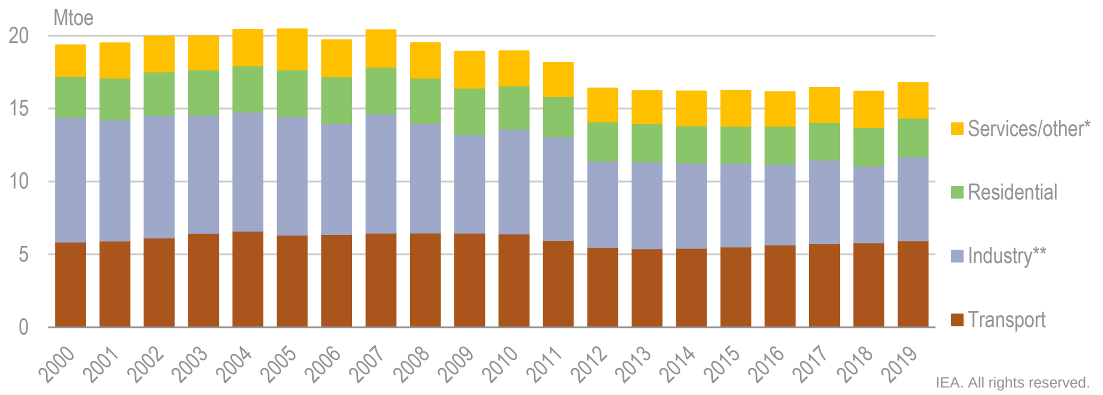
Portugal's energy import dependency remains high, experiences notable fluctuations, linked mainly to large changes in hydropower output, and has increased since 2013.

Source: DGEG (2020), *Energy Balances 2019*, www.dgeg.gov.pt/media/fpnkfdva/dgeg-ben-2019.pdf.

Demand

Energy demand in Portugal was notably reduced by the 2008 financial crisis (Figure 2.6). Pre-crisis total final consumption (TFC)[2] averaged around 20 Mtoe per year, but dropped by 20% from 2007 to 2012 to reach 16.4 Mtoe. Over this period, energy demand fell in every sector, with industry seeing the largest drop (down by 28%). Since 2012, energy demand has been stable at around 16.2 Mtoe, with demand in the transport and services/other sectors slightly increasing, residential demand remaining constant, and industrial demand continuing to decline. In 2019, the transport sector had the largest share of TFC (35%), followed by industry (34%), residential (16%) and services/other (14%).

Figure 2.6 Total final consumption in Portugal by sector, 2000-19



From 2007 to 2012, Portugal's energy demand dropped 20%. Since 2012, demand has been stable at around 16.2 Mtoe. Transport and industry together accounted for 70% of TFC in 2019.

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

** *Industry* includes non-energy demand, i.e. fuels used as raw materials and not used as a fuel or transformed into another fuel.

Note: Mtoe = million tonne of oil equivalent.

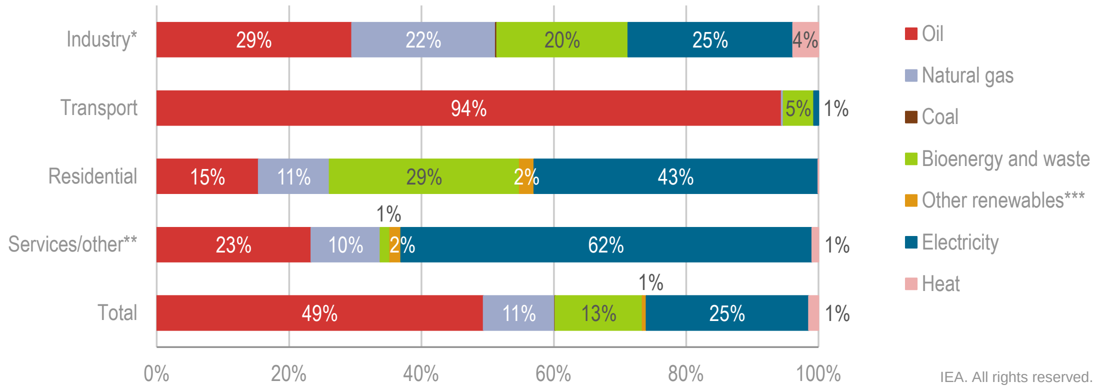
Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2019, the largest shares of Portugal's TFC were covered by oil (49%) and electricity (25%); smaller contributions came from bioenergy and waste (13%) and natural gas (11%), while direct use of heat covered only 1% of TFC (Figure 2.7). Most oil demand comes from road transportation, but there is also significant oil demand for heating in buildings and from Portugal's refining industry. Electricity covered a quarter of total demand and the largest share of demand in both the services/other (62%) and residential (43%) sectors. Natural gas was only introduced into Portugal's energy system in 1997 and despite a rapid adoption in all sectors except transport, covered just 11% of TFC in 2019. Among IEA member countries, the median share of natural gas in TFC was 21% in 2019. Heat demand is covered mostly by co-generation[3] plants in industry, with a very small share of district heating in the services/other sector (EHP, 2019).

[2] TFC is the final demand of energy (electricity, heat and fuels such as natural gas and oil products) by end users, excluding transformations (e.g. electricity generation and refining).

[3] Co-generation refers to the combined production of heat and power.

Figure 2.7 Total final consumption in Portugal by source and sector, 2019



Oil is by far the major source for TFC, particularly in the transport sector. The residential and services sectors consume the most electricity, while the share of natural gas in TFC is low.

* *Industry* includes non-energy demand.

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

*** *Other renewables* include direct use of solar thermal and geothermal.

Source: IEA (2020), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Key institutions

The Directorate-General for Energy and Geology (DGEG), housed within the Ministry for the Environment and Climate Action, has the main responsibility for developing and implementing Portugal's energy policy, including transposing relevant EU directives and regulations (e.g. for renewable energy, energy efficiency, security of supply, etc.). The DGEG also grants licences and concessions for the operation of electricity and gas infrastructure, public transportation, the public electric vehicle (EV) charging network, and for energy suppliers. The DGEG is responsible for monitoring the obligations of concessionaires and licensees under concession contracts and licences that it issues. It also promotes actions to ensure access to the networks, the guarantee of public service, the quality of service and security of supply.

The Energy Services Regulatory Authority (ERSE) is the independent regulator for the energy sector with responsibility over the markets for electricity, natural gas, oil, biofuels and electric mobility. The National Entity for the Energy Sector (ENSE) is a public organisation that has numerous responsibilities over the energy sector, including serving as the Portuguese central stockholding entity with responsibility for oil reserves. The ENSE also supervises the generation, transmission, distribution and sale of electricity; conducts inspections of energy sector facilities and infrastructures; investigates energy sector accidents; monitors compliance with licensing obligations; and supervises third-party access to storage, transport and distribution infrastructure in the fuels sector.

A small number of private companies have dominant positions in Portugal's energy sector in terms of energy supply (including oil and gas imports, and electricity generation and wholesale supply); operation of the gas and electricity networks; and the retail markets for oil products, natural gas and electricity. Redes Energéticas Nacionais (REN) is a 100% privately owned corporation that plays a major role in Portugal's gas and electricity sectors. It holds concessions from the government as the natural gas transmission system operator

(TSO) and the electricity TSO, the second-largest gas distribution system operator (DSO), and for operation of the Sines liquefied natural gas (LNG) terminal and Portugal's only large-scale underground natural gas storage facility at Carriço.

The Galp Group plays a major role in Portugal's energy sector, especially in relation to natural gas and oil. Galp is 92.52% privately owned and 7.48% owned by the Portuguese state. Galp owns Portugal's two oil refineries, most of Portugal's oil storage capacity and has a dominant position in the retail market for oil products. Galp is the main natural gas supplier in Portugal at both the wholesale and retail levels and owns or holds controlling shares in 9 of Portugal's 11 gas DSOs, which together operate the majority of Portugal's gas distribution network. Portugal's only large-scale oil pipeline is owned by the private company CLC, which is 65% owned by Galp, 15% by BP Portugal S.A., 15% by the Repsol YPF Group and 5% by Rubis Energia Portugal, S.A.

Energias de Portugal (EDP) is a private utility that plays a major role in Portugal's electricity and natural gas sectors. It owns a large share of Portugal's electricity generation capacity and the electricity DSO (now named E-Redes) that operates most of Portugal's electricity distribution network. EDP is a major importer of natural gas and one of the largest retail suppliers of natural gas, especially in the residential and small business market segment.

The National Energy Agency in Portugal (ADENE) is a private non-profit public benefit association with the mission to develop public interest activities in the areas of energy efficiency (including in buildings, industry and mobility) and water efficiency. ADENE is responsible for the management of the National Building Energy Certification System (a key programme for building efficiency) and the Intensive Energy Consumption Management System. These actions are naturally and by force of the institutional legal framework monitored, supervised and inspected by the DGEG.

The National Laboratory of Energy and Geology is the national state laboratory conducting RD&D with a focus on energy. It runs two main research centres: the Laboratory of Energy and the Laboratory of Geology and Mines. The Laboratory of Energy's work is organised under three units (bioenergy and biorefineries, renewables and energy efficiency, and materials for energy). The Laboratory of Geology and Mines' work on energy RD&D includes geothermal energy, geological CO_2 storage and hydrogeology. The National Laboratory of Energy and Geology also includes a network of accredited labs supporting research in biofuels and biomass, materials and coatings, and solar energy.

Energy sector targets

Under EU directives and national laws, Portugal has 2020 and 2030 targets for greenhouse gas (GHG) emissions, renewable energy, energy efficiency, electricity interconnection and energy dependency, with 2030 targets set in Portugal's National Energy and Climate Plan (NECP) (Table 2.1). Portugal has achieved, or is on track to meet, most of its 2020 energy sector targets.

Table 2.1 Portugal's 2020 and 2030 energy sector targets and 2019 status

		2019	2020	2030
Renewable energy share	Gross final energy consumption	30.6%	31%	47%
	– Electricity	54%	60%	80%
	– Heating and cooling	42%	41 %	49 %
	– Transport	9%	10%	20%
Energy efficiency	Maximum primary energy consumption	22.1 Mtoe (925 PJ)	22.5 Mtoe (942 PJ)	21.5 Mtoe (900 PJ)
	Maximum final energy consumption	17.1 Mtoe (716 PJ)	17.4 Mtoe (728 PJ)	14.9 Mtoe (624 PJ)
Energy import dependency	External energy dependency	74.2%	No target	65%
Cross-border electrical interconnection capacity*		10.4 %	10%	15%
Total GHG emissions	CO_2-eq reduction versus 2005 (excluding LULUCF)	(2018) -21%	-18% to -23%	-45% to -55%
Total non-ETS GHG emissions (with respect to 2005)		-14.5%	+1%	-17%

* Target based on the ratio of the annual average of commercial interconnection import capacity and generation capacity.

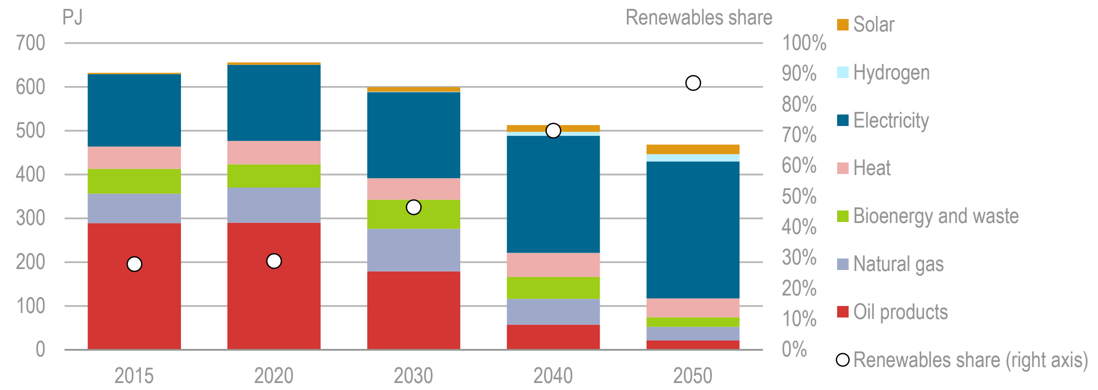
Notes: GHG = greenhouse gas. ETS = Emissions Trading System. CO_2-eq = carbon dioxide equivalent. LULUCF = land use, land-use change and forestry. Mtoe = million tonne of oil equivalent. PJ = petajoule.

Sources: Eurostat (2021a), *Energy from Renewable Sources*, https://ec.europa.eu/eurostat/web/energy/data/shares; Eurostat (2021b), *Complete Energy Balances*, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_bal_c; Eurostat (2021c), "Greenhouse gas emissions in ESD sectors", https://ec.europa.eu/eurostat/databrowser/view/T2020_35__custom_822590/default/table?lang=en; UNFCCC (2020), *GHG Total Without LULUCF* (database),https://di.unfccc.int/time_series.

Roadmap for Carbon Neutrality 2050

The targets in the NECP are intended to put Portugal on a path to achieving the economy-wide carbon-neutral goals set in the Roadmap for Carbon Neutrality 2050 (RNC2050). The RNC2050 defined indicative trajectories covering all sectors of the economy, with a focus on increasing the use of domestic renewable energy while reducing and electrifying final energy demand (Figure 2.8). The RNC2050 calls for complete decarbonisation of electricity generation and transport by 2050 and sets goals for renewables to cover 71-72% of final energy consumption by 2040 and 86-88% by 2050. The RNC2050 also sets goals for electricity to cover 32-33% of total energy demand in 2030 and 66-68% in 2050, and to reduce energy import dependency to below 19% by 2050, while the NECP set a target to reduce energy import dependency to 65% by 2030.

Figure 2.8 Evolution of Portugal's final energy demand under the Roadmap for Carbon Neutrality 2050



The RNC2050 sets goals to reduce energy demand while increasing electrification and the share of demand covered by renewable energy.

Note: PJ = petajoule.

Source: Ministry for the Environment and Energy Transition (2019), *Roadmap for Carbon Neutrality 2050 (RNC2050)*, https://unfccc.int/sites/default/files/resource/RNC2050_EN_PT%20Long%20Term%20Strategy.pdf.

National Hydrogen Strategy

Portugal sees a key role for hydrogen produced with renewable energy to support clean energy transitions in hard-to-decarbonise sectors and end uses and to achieve carbon neutrality by 2050. The National Hydrogen Strategy (EN-H2) indicates that by 2030, hydrogen should cover 1.5-2% of Portugal's energy demand, 2-5% of industry energy demand, 3-5% of domestic maritime shipping energy demand, 1-5% of road transport energy demand and 10-15% of the volume of gas delivered by the natural gas network. This would require the deployment of an estimated 2-2.5 gigawatts (GW) of electrolysis capacity powered by renewable electricity by 2030, along with enabling legislation, regulations and standards. The EN-H2 also indicates that in the long term, renewable hydrogen could be used directly for electricity generation and energy storage.

Policies and support measures

Portugal's energy sector policy aims to decarbonise the energy supply and reduce energy import dependency primarily through broad electrification and a rapid expansion of renewable electricity generation, along with increased energy efficiency. There is also a strong focus and maintaining affordable access to energy. The NECP describes the key support measures and actions to achieve the 2030 energy sector targets. Additional measures are defined in a wide range of laws, government decrees, regulations and standards. Funding for support measures comes from the state budget and several national funds targeting energy and climate priorities. The government has established numerous taxes and fees that direct revenues to energy transition programmes and measures. Portugal also receives notable support for energy transitions and climate measures from EU funds.

Energy taxation

Taxation of energy is relatively high in Portugal and household consumers pay notably higher taxes than industrial consumers. In 2020, around 38% of the average retail gas price for household consumers was composed of energy costs, with the remaining 62% coming from tariffs and taxes. For industrial gas consumers, around 76% of the average retail price was composed of energy costs, with the remaining 24% coming from tariffs and taxes. In 2020, only around 33% of the average retail electricity price for household consumers was composed of energy costs, with the remaining 67% coming from tariffs and taxes. For industrial electricity consumers, around 49% of the average retail price was composed of energy costs, with the remaining 51% coming from tariffs and taxes.

A central aspect of Portugal's energy policy is the Green Taxation Law (Law No. 82-D/2014), passed in 2014 to better align energy taxation with decarbonisation goals. As part of the Green Taxation Law, Portugal established a carbon tax in 2015 that covers fossil fuel demand of consumers in all non-ETS (EU Emissions Trading System) sectors. The level of the carbon tax is based on ETS prices with adjustment factors for each type of fossil fuel based on relative emissions and environmental impacts. The base rate of the carbon tax is adjusted annually to drive emissions reductions. The carbon tax is charged in addition to the energy products tax (ISP), which covers most energy demand in Portugal, including fossil fuels, electricity and heat. A share of the revenues from the carbon tax and ETS allowance auctions are allocated to Portugal's Environmental Fund, which supports a wide range of government programmes, including some decarbonisation measures (ECCP, 2021).

In 2018, the government created a working group to analyse Portugal's taxation system and ensure its alignment with the transition to carbon neutrality. The group had a particular focus on identifying environmentally harmful incentives and proposing reforms for phasing out any such incentives. It identified EUR 441 million of tax exemptions associated with fossil fuels. Based on these findings, the government indicated it will continue to eliminate environmentally harmful subsidies and promote higher taxation on fossil fuels. Since 2018, the government has passed laws that progressively reduce tax exemptions for coal, natural gas and oil.

The ISP and carbon tax rates for all energy products are the same for all consumers. There are not different rates for households or industrial consumers and rates do not vary with the level of demand. However, industrial consumers have a 100% exemption from the ISP and the carbon tax for fuels and electricity if they are covered by the EU-ETS regime or Portugal's main programme for industry energy efficiency, the System for Management of Intensive Energy Demand (SGCIE). As a result, the level of energy taxation is significantly lower for industrial consumers compared to residential and commercial consumers. In the State Budget for 2021, the government proposed to progressively eliminate the carbon tax exemption on energy products used by industrial installations participating in the SGCIE.

In 2019 and 2020, Portugal made changes to the value-added tax (VAT) charged on electricity and gas demand that reduced taxation of electricity in comparison to gas for many consumers and created VAT rates for electricity that increase with higher levels of demand to encourage efficiency. For consumers connected to the low-voltage electricity network with a contract not exceeding 3.45 kilovolt-amperes (kVA) and for natural gas consumers connected to the low-pressure gas network with a contract not exceeding 10 000 cubic metres per year, the VAT charged on the fixed component of network access tariffs was lowered from 23% to a “reduced rate” of 6% in mainland Portugal, 4% in the Azores and 5% in Madeira. For electricity consumers with a contract lower than or equal to 6.9 kVA (and those receiving the social tariff), the VAT charged on the entire electricity bill (but not the gas bill) was reduced from 23% to an “intermediate rate” of 13% in mainland Portugal, 9% in the Azores and 12% in Madeira. The intermediate rate only applies to the first 100 kilowatt hours (kWh) per 30 days (150 kWh per 30 days for households of more than 5 persons); above this demand, the 23% rate is applied (ERSE, 2020a).

In January 2021, Portugal experienced record-breaking low temperatures resulting in large increases in electricity. In response, the government provided a temporary discount on the electricity bills of household consumers with a contracted power lower than or equal to 6.9 kVA and on the bills of consumers receiving the electricity social tariff. This exceptional reduction in electricity bills was financed by the Environmental Fund.

Electricity measures

A central element of Portugal’s emissions reduction strategy is decarbonising the electricity supply, with policies and measures pushing for reduced fossil fuel generation and increased renewable generation.

In 2018, Portugal introduced a progressive elimination of the ISP and carbon tax exemptions of coal used for electricity generation. Since then, the competitive position of coal-fired generation in Portugal has been significantly eroded by reduced tax exemptions, higher ETS prices, low natural gas prices and increasing generation from low-cost renewables. As a result, Portugal’s two coal-fired power plants will permanently close in 2021 (Simon, 2021). The NECP indicates that natural gas electricity generation will be maintained until at least 2040, with the level in 2030 depending on the development of other flexibility assets such as pumped hydro, battery storage and hydrogen. Starting in April 2020, natural gas used for electricity generation (excluding co-generation) is subject to a progressive reduction of the exemption from the ISP or the carbon tax.

The NECP indicates that to meet the 2030 targets, renewable electricity generation capacity should grow from 14 GW in 2019 to 27.4 GW by 2030. Most of this growth is expected to come from a near tenfold increase in solar photovoltaic (PV) capacity, followed by a near doubling of wind capacity and expansion of hydropower capacity. Several measures support the deployment of renewable generation in Portugal. Large-scale renewable energy projects commissioned before 2012, primarily onshore wind projects, receive a feed-in tariff (FIT) for 15 years from the start of operations. In 2014, a new FIT was introduced supporting renewable generation from small-scale and self-consumption projects. In 2018, the government approved the construction of 1.16 GW of new hydropower capacity, of which 0.88 GW will be pumped hydro (commissioning of this hydropower capacity in 2023). In 2019, annual auctions for large-scale solar PV projects were established. The first two PV auctions awarded network capacity to 1.85 GW of PV projects, including 0.5 GW of projects that will deploy at least 100 megawatts (MW) of battery storage. A legal framework approved in 2019 promotes energy communities and self-consumption of renewable generation.

Several major transmission system projects completed since 2016 support the integration of increased hydropower, while major transmission projects to integrate solar PV and hydropower generation are ongoing or will begin construction in 2021. Portugal is also working with France and Spain to increase cross-border electricity interconnection capacity between both the Iberian peninsula and the rest of Europe and between Portugal and Spain.

In addition, there are numerous programmes and measures that aim to support efficient use of electricity. A key programme is this area is the Portuguese Electricity Demand-Side Efficiency Promotion Plan under which electricity suppliers; network operators; government agencies; research centres; higher education institutions; and consumer, business and municipal associations can propose energy efficiency measures, which are reviewed and selected for support by the ERSE through a competitive process based on a cost-benefit analysis. The DGEG also plays a role in approving the funding by examining if proposed projects align with Portugal's overall energy policy goals.

Transport measures

Portugal's transport policy is primarily focused on the decarbonisation of road vehicles, which account for almost all transport GHG emissions and most oil demand. Portugal's system for road vehicle taxation encourages purchasing lower emission/higher efficiency vehicles. The motor vehicle tax (ISV), paid when registering a vehicle, and the single road tax (IUC), which is paid annually, are both proportional to CO_2 emissions. There is a strong focus on transitioning to electric vehicles (EVs). The RNC2050 indicates that electricity should cover more than 30% of passenger vehicle mobility demand by 2030 and 100% by 2050. To drive increased EV uptake, Portugal introduced monetary incentives for battery electric vehicles (BEVs) in 2015. There is also favourable tax treatment for BEVs, which are exempt from the ISV and the IUC. Portugal also supports the deployment of EV charging infrastructure.

Portugal has a biofuel blending obligation that requires fuel suppliers to blend a certain share of biofuels into automotive diesel and gasoline, with the share increasing progressively from 6% in 2009 to 10% in 2020. In December 2017, Portugal passed a law transposing EU Directive 2015/1513, which promotes the production and use of advanced biofuels and seeks to limit the use of first-generation biofuels (those produced from crops that can be used as food or animal feed). The National Plan for the Promotion of Biorefineries, approved in October 2017, promotes the production of advanced biofuels. Decree-Law 8/2021 sets biofuels blending targets for 2021 (11%) and the government is working to transpose the EU requirements for biofuels. The NECP shows a slight reduction in overall biofuels consumption in transport by 2030, but with notable growth in the share of advanced biofuels and a focus on EVs.

The government is also working on many fronts to encourage a shift from private vehicles to public transport, and active and shared mobility. The National Investment Plan 2030 (NIP 2030) sets infrastructure investment priorities in the transport, environment and energy sectors from 2020 to 2030. The NIP 2030 directs the majority of transportation funding to projects that support rail, public transport and decarbonisation. The government has also developed a National Strategy for Active Mobility covering cycling, which aims to increase bike lanes in Portugal from 2 000 km in 2018 to 6 500 km in 2023 and 10 000 km in 2030. In 2019, the government introduced subsidies of EUR 250 for purchasing new electric bicycles. Portugal is developing a National Strategy for Active Mobility supporting walking (Boost, 2020).

Industry measures

The main programme supporting industrial energy efficiency is the SGCIE, which requires energy audits and energy demand reduction strategies from energy-intensive facilities (those with energy demand greater than 500 toe per year). Under the SGCIE, such facilities must develop an energy consumption rationalisation agreement (ARCE), which defines efficiency measures that must be implemented. Industrial facilities with an ARCE have a 100% exemption from the ISP and the carbon tax. In the State Budget for 2021, the government proposed to progressively eliminate the carbon tax exemption on energy products used by industrial facilities with an ARCE. If passed, the law would result in those installations paying 5% of the carbon tax in 2021, 10% in 2022, 30% in 2023, 65% in 2024 and 100% from 2025 onwards.

Buildings measures

Buildings decarbonisation is supported through a range of programmes and measures pushing for improved energy efficiency, higher electrification and use of renewable energy. Under the National Buildings Energy Performance Certification System (SCE), all residential and commercial buildings must be audited to receive an energy certificate when they are built or deeply renovated and each time the building changes ownership or is leased. The SCE has contributed to better insulated buildings, resulting in lower energy demand and emissions. Portugal also has several programmes offering low-cost loans for energy efficiency renovations and measures to reduce building emissions through the deployment of distributed renewable energy.

As of January 2019, all new buildings owned or occupied by a public entity need to satisfy nearly zero-energy buildings (NZEB) requirements. Starting in January 2021, all newly constructed or majorly renovated private buildings with an area greater than 1 000 square metres (m^2) need to satisfy NZEB requirements. Portugal's national building code requires the installation of solar thermal heating systems with a minimum size of 1.0 m^2 per building occupant (or other renewable energy systems providing a similar energy savings). In February 2021, the government published the Portuguese Long-Term Renovation Strategy, which promotes building renovation through indicative objectives of rennovations, primary energy savings and a reduction of hours of discomfort for 2030, 2040 and 2050. The strategy also defines measures to support the achievement of these objectives.

Social tariffs

Portugal has social tariffs for electricity and natural gas that provide discounts on parts of distribution tariffs to reduce the electricity and gas bills of households that meet certain socio-economic criteria. In 2016, the process to apply for social tariffs was amended so that qualifying households are automatically assigned the social tariff. This resulted in an increase in the number of consumers receiving the electricity social tariff from 140 545 in the first quarter of 2016 to 691 860 in June 2016. Since then, the number households receiving the electricity social tariff has continued to grow. In December 2020, 752 965 households received the electricity social tariff (14% of all households). The switch to automatic assignment also led to an increase in the number of consumers receiving the natural gas social tariff, which grew from 14 103 in the first quarter of 2016 to 34 935 in June 2016. From 2016 until 2020, the number of households on the social tariff has been relatively stable, with 34 709 households (2.4% of all households connected to the gas network) receiving the tariff in December 2020.

In November 2020, eligibility requirements for the electricity and gas social tariffs were amended to cover all situations of unemployment. This was to address concerns related to the economic impacts of Covid-19 and to ensure that the tariffs were available to the most economically vulnerable consumers (ERSE, 2020b).

The government and the ERSE evaluate and if necessary update the level of discount given by the electricity and gas social tariffs on an annual basis. In 2020, the electricity social tariff supported a cost reduction of around EUR 109 million. The gas social tariff supported a cost reduction of around EUR 1.6 million in the 2020-21 gas year. The cost of the electricity social tariff is covered by the private companies that operate thermal and large hydro generation in mainland Portugal, with payments proportional to installed generation capacity. The financing of the gas social tariff is covered by the gas network operators and suppliers, with the contribution proportional to the volume of gas delivered (for network operators) or sold (for suppliers) in the previous year.

Portugal has notable demand for liquefied petroleum gas (LPG), which covered 8% of oil products demand in 2019. Most LPG demand comes from heating and cooking by households that are not connected to the natural gas grid. In addition, many households with high LPG use live in buildings that require notable investments to support electrical heating and cooking. A large share of low-income households rely on LPG for heating and cooking. The government had planned a pilot project for 2021 to examine a potential LPG social tariff. However, there was limited interest from municipalities and LPG suppliers and in February 2021, the government cancelled the pilot project. Instead, the government aims to implement a programme that will support households in transitioning from LPG heating and cooking to electric heating and cooling (Silva, 2021).

Energy poverty

As defined in the NECP, Portugal is developing a National Long-Term Strategy to Tackle Energy Poverty. A draft strategy was open for public consultation from mid-April to mid-May of 2021 and the government aims to finalise the strategy by November 2021. The main objective of the strategy is to combat energy poverty, protect vulnerable consumers and actively integrate them into Portugal's energy and climate transition. The government notes that the strategy should diagnose and characterise energy poverty (including key indicators); establish objectives for reducing energy poverty in the medium and long term, at the national, regional and local levels; propose specific measures to achieve these objectives (including sources of financing); and develop strategies for monitoring progress. The pursuit of the main objective of tackling energy poverty will be based on the application of four guiding principles: 1) increased energy efficiency in homes; 2) reinforced access to energy services; 3) robust knowledge and access to information on energy in order to improve energy literacy; and 4) reducing the burden of energy consumption (DGEG, 2021).

The NECP notes that in addition to the National Long-Term Strategy to Tackle Energy Poverty, the following measures are foreseen to combat energy poverty and improve instruments that protect vulnerable consumers:

- establish a national system for assessing and monitoring energy poverty, including the number of households in energy poverty

- continue mechanisms to protect vulnerable consumers and study the introduction of new mechanisms
- develop programmes to promote and support energy efficiency and the integration of renewable energies to mitigate energy poverty
- promote and support local strategies to combat energy poverty
- disseminate information to mitigate energy poverty.

In addition, Portugal is preparing a National Strategy to Combat Poverty. In October 2020, a commission was created with responsibility for developing the strategy. The government notes that the strategy should adopt a broad approach to address all issues contributing to poverty and specifically notes combating energy poverty as one of the key objectives of the strategy. The strategy will be developed with support from certain Portuguese and European entities with expertise in combating poverty and also allows the commission to invite external experts, and representatives of services, institutions or entities with relevant backgrounds (Office of Strategy and Planning, 2020). The DGEG has noted that the development of the strategy presents an opportunity to determine which options could best address concerns over energy poverty.

Assessment

Portugal's energy policy focuses on three principal goals: 1) achieving carbon neutrality by 2050; 2) reducing energy import dependency; and 3) maintaining affordable access to energy. Portugal has set ambitious environmental and climate targets that are supported by measures to drive increased use of renewable energy and increased energy efficiency. Taken together with strong measures to combat energy poverty, Portugal aims to ensure a just energy transition. The IEA commends Portugal for having put in place an energy policy framework that guides the decarbonisation of its economy with a focus on efficient use of resources and creating wealth.

Portugal's NECP, RNC2050 and EN-H2 establish a strong set of strategies and measures for energy and climate that cover all sectors and link to policies on transport, research and innovation, agriculture and forestry, waste and wastewater, and financial policies. The NECP provides 2030 targets for GHG emissions, renewables and energy efficiency that aim to put Portugal on a path to achieving carbon neutrality in 2050. Noteworthy are: Portugal's plans to substantially grow its installed capacity of renewables, particularly through solar PV auctions; Portugal's drive to promote production and self-consumption of renewables, particularly involving citizens and energy communities; Portugal's ambition for broad use of renewables-based hydrogen; and relying on Portugal's natural carbon sinks, particularly forestry, to offset hard-to-abate GHG emissions.

The EU's economic recovery funding provides for Portugal a highly valuable opportunity to achieve its ambitious energy and climate targets for 2030 by frontloading the investments and reforms proposed in the NECP, RNC2050 and EN-H2, in particular actions that support the capital-intensive programmes related to energy efficiency in buildings and industry; the deployment of renewable electricity generation and supporting infrastructure; the electrification of transport, buildings and industry; and the production of sustainable biofuels and hydrogen. Strategic investments will not only contribute to reaching Portugal's climate and energy targets, but also to boosting employment, business competitiveness and quality of life.

The Commission for Climate Action is charged with the overall governance of the NECP and monitoring progress on the goals of the RNC2050. There is a strong need for the commission to ensure that implementation of the NECP and the EN-H2 are well co-ordinated and aligned with the goals of RNC2050. To achieve this, the IEA recommends that the commission use appropriate cost-benefit analyses to provide policy guidelines that drive the co-ordination and integration of energy policies with climate policies, as well as promote and monitor progress on the goals, targets and support measures set in the RNC2050, NECP and EN-H2. Strong co-ordination by the commission will also optimise alignment of energy policy with other policy areas (industry and economy, agricultural and forestry, environment, innovation and social). In line with this effort, the government should establish a broad stakeholder alliance that provides investors certainty on policy direction and implementation of decarbonisation measures.

Portugal is commended for having developed an economy-wide strategy for the production and use of hydrogen. Importantly, the EN-H2 sets ambitious goals for installed electrolysis capacity, the construction of a hydrogen fuelling infrastructure and shares of demand to be covered by hydrogen in the overall economy and specific sectors. The IEA emphasises the need for the DGEG to take a leading role in implementing and monitoring progress and updating the EN-H2. Implementation of the EN-H2 requires strong efforts in research and innovation, upscaling and deployment, all supported by international co-operation. The efforts require the development and implementation of an appropriate legal, policy and funding framework, and for oversight by the Commission for Climate Action.

The IEA notes Portugal's potential in developing commercial opportunities in the energy storage value chain. Appropriate policy measures and design of market structures are needed to ensure optimal development and use of pumped hydro and battery storage. There are opportunities to harness Portugal's lithium resources for battery value chains, but this requires the deployment of sustainable mining practices and strong support of local stakeholders affected by mining operations, as well as a clear strategy on the development of manufacturing and export capabilities.

Additional investments for the period to 2030 to keep Portugal on a path towards carbon neutrality are estimated to require approximately EUR 1 billion per year, and tripling to approximately EUR 3-3.5 billion per year between 2031 and 2040. With 75-80% of these investments going towards the building and transportation sectors, the IEA suggests that revenues from the ISP and carbon tax, and from the removal of fossil fuel subsidies, be used to support investments.

While the need to protect vulnerable households is understood, the IEA notes that social tariffs for energy products can unduly add costs to energy suppliers. The IEA recommends that the government use the development of the National Strategy to Tackle Energy Poverty and the National Long-Term Strategy to Combat Poverty to examine a full range of options that could address energy poverty by reducing energy demand. The IEA encourages the government to use cost-benefit analysis and consider all social dimensions to examine which support measures best serve the needs of vulnerable consumers, while minimising market distortions and aligning with decarbonisation goals. Especially critical are energy efficiency measures that reduce energy demand, promote the use of renewables and improve the comfort of residences.

The IEA recommends that the DGEG, ERSE and ADENE, along with retail energy suppliers and distribution network operators, take on a strong role in the development of the National Long-Term Strategy to Tackle Energy Poverty and the National Strategy to Combat Poverty. These stakeholders offer a first-hand perspective on how energy prices impact consumers, the behaviours and strategies consumers have to cope with issues of energy access and costs, and can offer insights on the programmes and measures they have developed to work with and assist consumers experiencing energy poverty. They can also offer insights on how Portugal's energy efficiency programmes could be adapted to better serve vulnerable consumers.

In line with efforts to address energy poverty and to drive decarbonisation through electrification, the government should examine the high shares of electricity prices that come from non-energy costs (taxes, tariffs, etc.), which raise prices for all consumers and reduce the ability of electricity to compete with fossil fuels.

Portugal is encouraged to continue harnessing the benefits of the digitalisation of the energy sector, including a host of co-benefits for economic sectors using energy. However, Portugal's gas and electricity networks and some energy infrastructures (LNG terminal, underground gas storage, refineries and natural gas generation) may be particularly vulnerable to cybersecurity threats. The IEA recommends that the National Strategy for Cyberspace Security be updated to include the energy sector. Particular attention needs to be paid to the development and implementation of risk reduction measures. Reviews and audits of energy infrastructure conducted by network operators, the ERSE, the DGEG, the ENSE and other competent agencies need to address cybersecurity risks. Results of reviews and audits should be used as inputs for the National Strategy for Cyberspace Security.

The Azores and Madeira autonomous regions set their own energy and climate policies and strategies. These islands still rely heavily on oil products, even for electricity generation. With the increasing introduction of renewable energy, oil demand is decreasing and some islands have already reached high shares of renewable electricity generation by leveraging a wide range of technologies (geothermal, wind, hydro, solar PV and energy storage). The Azores and Madeira are testing different approaches to increase the share of renewables, boost the use of EVs, and improve the energy efficiency of residential and commercial buildings. The Azores' and Madeira's programmes to support the energy transition appear to be more ambitious than those for mainland Portugal, and these island regions can pioneer living labs to test innovative solutions, like storage, smart grids, electric mobility and integration of very high shares of renewables.

Recommendations

The government of Portugal should:

- Strengthen oversight by the Inter-ministerial Commission on Climate Change, Air Policy and Circular Economy to ensure that the RNC2050, the NECP and the EN-H2 are aligned and effectively implemented according to a cost-benefit analysis.
- Establish a broad stakeholder alliance to drive rapid implementation of the measures in the Roadmap for Carbon Neutrality, the National Energy and Climate Plan and the National Hydrogen Strategy, and to provide investor certainty on policy direction.
- Accelerate the reform to align energy taxes with decarbonisation goals and ensure that the carbon tax drives emissions reductions in all sectors.
- Use the development of the National Long-Term Strategy to Tackle Energy Poverty and the National Strategy to Combat Poverty to review and update measures protecting vulnerable consumers to ensure that these measures are effective, and aligned with decarbonisation goals.
- Work with the autonomous regions of Madeira and Azores to pioneer innovative decarbonisation solutions and explore options for the integration of high shares of renewables.

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3. Energy and climate change

Key data (2018/19)

GHG without LULUCF* (2018): 63.5 Mt CO_2-eq, -25.9% since 2005, +8.0% since 1990

GHG with LULUCF* (2018): 55.6 Mt CO_2-eq, -37.2% since 2005, +7.4% since 1990

Energy-related CO_2 emissions (2019):

CO_2 emissions from fuel combustion: 42.4 Mt CO_2, -31% since 2005, +12% since 1990

CO_2 emissions by fuel: oil 58.1%, natural gas 27.9%, coal 11.7%, other 2.2%

CO_2 emissions by sector: electricity and heat generation 31.9%, transport 40.5%, industry 18.0%, services 5.4%, residential 4.2%

CO_2 intensity per GDP:** 0.129 kg CO_2/USD (IEA weighted average 0.197 kg CO_2/USD)

* Land use, land-use change and forestry (Source: https://di.unfccc.int/time_series).

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

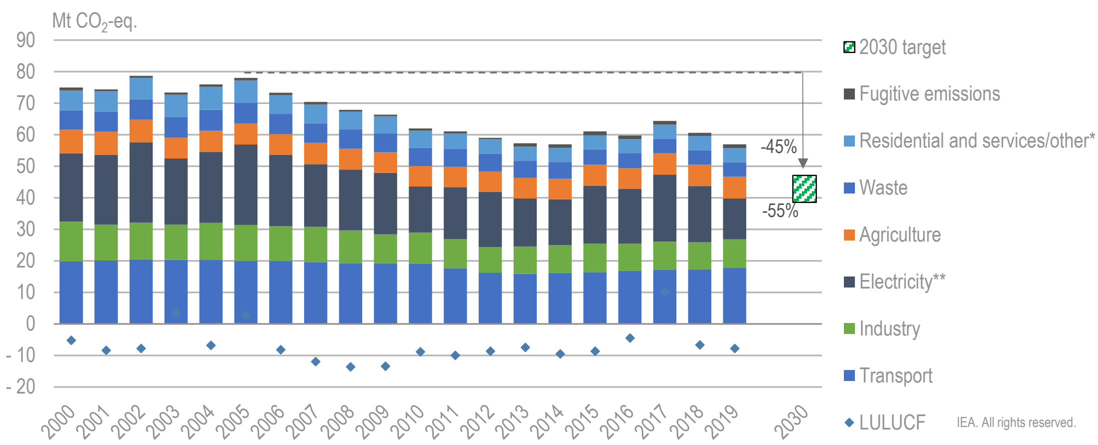
Overview

Portugal's greenhouse gas (GHG) emissions dropped steadily from 2005 to 2014, but have since increased and become more variable (Figure 3.1). In 2019, GHG emissions excluding land use, land-use change, and forestry (LULUCF) were 63.5 million tonnes CO_2 equivalent (Mt CO_2-eq), with most emissions coming from transport (28%), electricity generation (21%) and industry (14%). Since 2005, LULUCF has, on average, reduced annual GHG emissions by 10 Mt CO_2-eq. However, in 2017, extreme wildfires caused 10 Mt CO_2-eq of LULUCF-related GHG emissions.

Portugal has GHG emissions reductions targets defined by European Union (EU) directives and regulations and national laws. GHG emissions from Portugal's energy-intensive industrial facilities and large electricity plants are regulated under the EU Emissions Trading System (ETS). Portugal's National Energy and Climate Plan (NECP) sets a target for non-ETS GHG emissions to be reduced by 17% by 2030, and for total GHG emissions to be reduced by 45-55% by 2030 versus 2005 levels. The NECP supports Portugal's commitment to decarbonise the economy and pursue an energy transition, taking into account the trajectories towards carbon neutrality in 2050 defined in the Roadmap for Carbon Neutrality 2050 (RNC2050), which set goals to reduce total emissions by at least 85-90% by 2050 versus 2005 levels, and to use carbon sequestration to offset any remaining emissions.

The main measures supporting emissions reductions focus on increasing the share of electricity generation from renewables (from 54% in 2019 to 80% by 2030) combined with expanding electrification in all sectors (electricity should cover 32-33% of final energy demand by 2030, compared to 25% in 2019), and on reducing energy demand through energy efficiency (primary energy demand should be less than 21.5 million tonnes of oil equivalent [Mtoe] by 2030, compared to 22.1 Mtoe in 2019, and final energy demand less than 14.4-17.9 Mtoe by 2030, compared to 17.1 Mtoe in 2019) (Eurostat, 2021a). Portugal's National Hydrogen Strategy (EN-H2) sets goals for hydrogen produced from renewable energy to support emissions reductions, especially in hard-to-decarbonise sectors, and to achieve carbon neutrality by 2050.

Figure 3.1 Portugal's greenhouse gas emissions by sector, 2000-19 and 2030 target



Portugal's GHG emissions dropped steadily from 2005 to 2014, but have since increased and become more variable. Electricity, transport and industry are the main sources of GHG emissions.

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

** *Electricity* includes a small share of heat from co-generation. Co-generation refers to the combined production of heat and power.

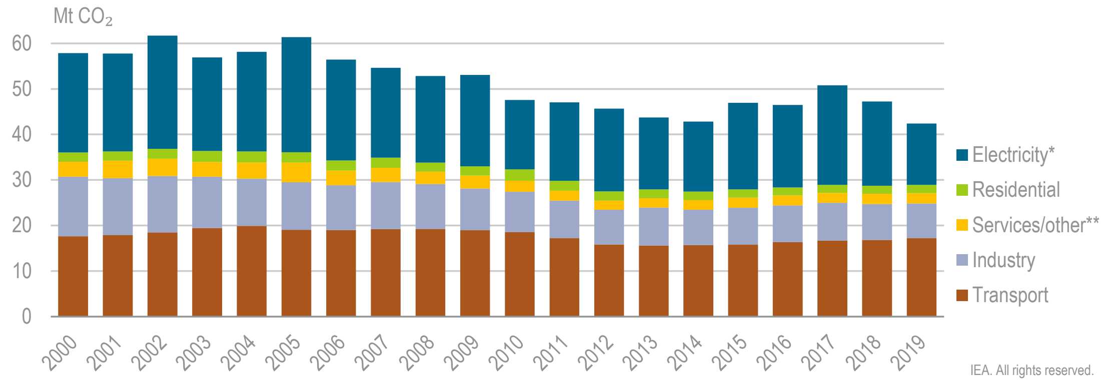
Notes: Mt CO_2-eq = million tonnes carbon dioxide equivalent. LULUCF = land use, land-use change and forestry.
Source: UNFCCC (2020a), *Portugal: 2020 National Inventory Report (NIR)*, https://unfccc.int/documents/215705.

Energy-related CO_2 emissions

In 2019, energy-related carbon dioxide (CO_2) emissions were 42.4 Mt CO_2-eq, with the largest share coming from transport (41%), followed by electricity generation (32%), industry (18%), services/other (5%) and residential (4%) (Figure 3.2). Energy-related CO_2 emissions experienced a relatively steady decline from 61.5 Mt CO_2-eq in 2005 to 42.8 Mt CO_2-eq in 2014, with reductions driven by a move to less carbon-intensive economic activities, increasing generation from renewable energy and a strong reduction in energy demand following the 2008 crisis. Since 2014, economic recovery has driven an overall increase in energy demand, but emissions trends have differed notably between sectors.

Portugal's transport sector emissions increased by 10% from 2014 to 2019 to reach 17.2 Mt CO_2-eq. The increase in transport emissions came mainly from higher use of freight trucks and passenger cars, which remain reliant on oil. Over the same period, emissions from the services/other sector increased by 10% to reach 2.3 Mt CO_2-eq, with emissions increases driven mainly by growing natural gas demand. Economic recovery led to a slight increase in residential energy demand, but thanks to the reduced carbon intensity of the residential energy supply (primarily because of lower use of oil), residential emissions dropped by 10% from 2013 to 2019 to reach 1.8 Mt CO_2-eq. Despite the economic recovery, energy demand from industry continued to decline, resulting in a drop in industrial CO_2 emissions of 9% from 2013 to 2019, to reach 7.6 Mt CO_2-eq.

Figure 3.2 Portugal's energy-related CO_2 emissions per sector, 2000-19



From 2005 to 2014, energy-related CO_2 emissions declined steadily. Since 2014, emissions have experienced notable variations driven by changing emissions from electricity generation.

* *Electricity* includes a small share of heat from co-generation. Co-generation refers to the combined production of heat and power.

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

Note: Mt CO_2 = million tonnes carbon dioxide.

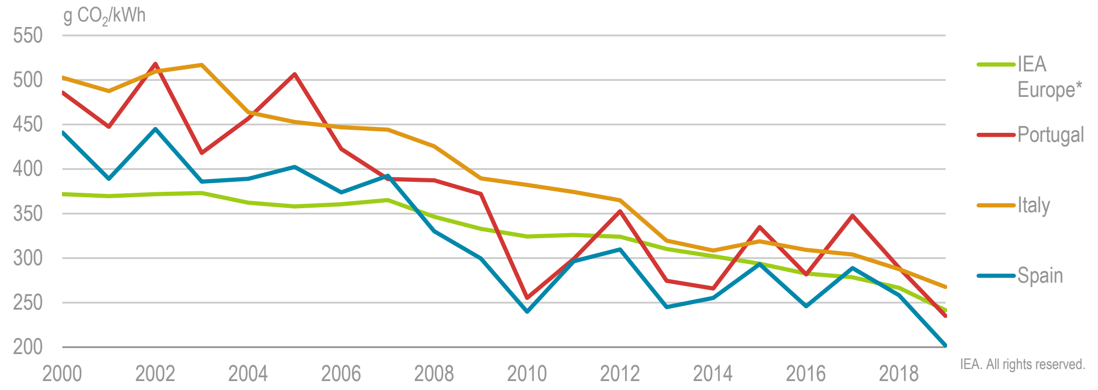
Source: IEA (2021), *CO_2 Emissions from Fuel Combustion* (database), www.iea.org/statistics.

Since 2014, economic recovery and higher levels of electrification have resulted in increased electricity demand. However, Portugal's CO_2 emissions from electricity generation vary greatly from year to year, mainly due to hydro availability, and have been the main driver of changes in energy-related CO_2 emissions. From 2014 to 2019, CO_2 emissions from electricity varied between 13.5 Mt CO_2-eq and 21.9 Mt CO_2-eq (from 32% to 43% of energy-related CO_2 emissions).

Electricity plays a major role in Portugal's energy system, covering 25% of final energy demand in 2019, and the carbon intensity of the electricity supply has a major impact on emissions. From 2000 to 2019, the carbon intensity of Portugal's electricity supply decreased by 52%, but with large year-on-year changes in comparison to European IEA countries (Figure 3.3). The main factors driving variability in Portugal's electricity CO_2 emissions are: variations in hydro generation driven by changes in annual rainfall that are typical for Portugal; changes in the relative shares of coal-fired and natural gas generation driven by market forces and policy; and changes in electricity trade, with Portugal being a net exporter of electricity for the first time from 2016 to 2018.

In 2019, oil accounted for 58% of energy-related CO_2 emissions, followed by natural gas (28%), coal (11%) and non-renewable waste (2%) (Figure 3.4). Oil-related CO_2 emissions experienced a strong decline from 2005 to 2012, driven mainly by a sharp drop in industry oil demand. Since 2014, oil-related CO_2 emissions have grown slowly, with a continuing decline in industry oil demand offset by growing oil demand from transport and steady oil demand for building heating. In 2019, oil-related CO_2 emissions had the largest yearly growth since 2005, due to increased transport oil demand, mainly from freight trucks and passenger cars.

Figure 3.3 CO_2 intensity of electricity generation in Portugal, Italy, Spain and IEA European average, 2000-19



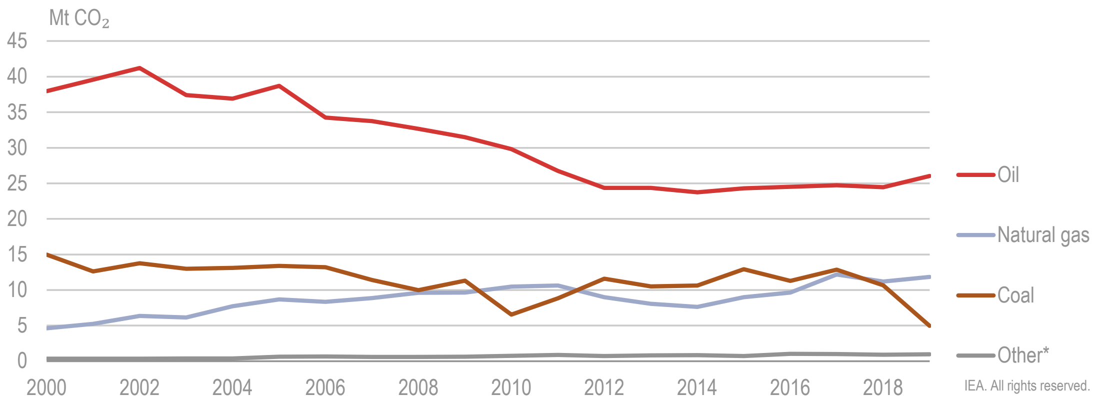
CO_2 intensity of electricity generation decreased by 52% from 2000 to 2019, but experiences large variations, driven by changes in hydro, gas and coal generation and electricity trade.

* *IEA Europe* gives the weighted average of European IEA member countries.

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

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

Figure 3.4 Portugal's energy-related CO_2 emissions by source, 2000-19



Oil is the largest source of energy-related CO_2 emissions in Portugal; emissions from oil and coal have declined, while those from natural gas have increased.

* *Other* includes emissions from non-renewable waste used in co-generation plants. Co-generation refers to the combined production of heat and power.

Note: Mt CO_2 = million tonnes carbon dioxide.

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

Portugal has a lower share of CO_2 emissions from natural gas compared to many IEA counties, as natural gas was only introduced into the energy system in 1997. Most natural gas-related CO_2 emissions in Portugal come from electricity generation and industry, with small levels of emissions from gas demand in buildings. Gas-related CO_2 emissions from industry grew steadily from 2000 to 2013 and have since been relatively stable.

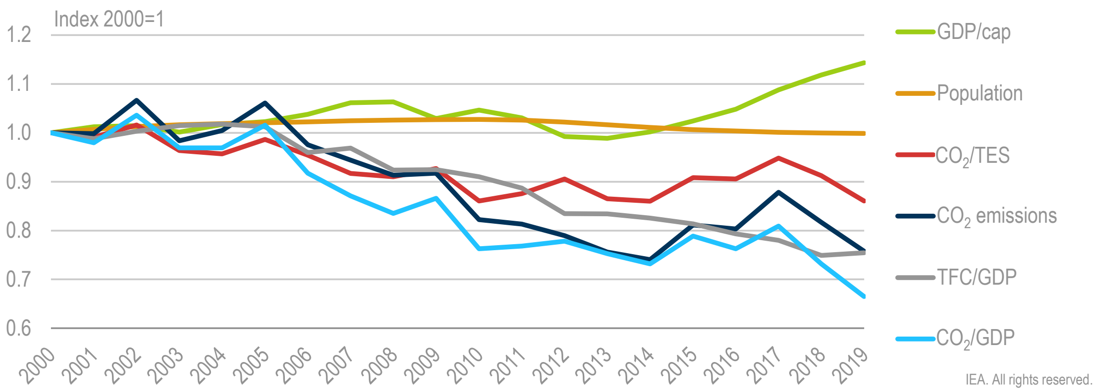
Gas-related CO_2 emissions from electricity generation increased from 2000 to 2019, but with a major drop from 2011 to 2014 when coal-fired and renewable generation took larger market shares.

Coal-related CO_2 emissions come almost entirely from coal-fired electricity generation and have varied notably since 2008. In 2019, coal accounted for 12% of energy-related CO_2 emissions. Since 2017, the competitive position of coal-fired generation has significantly eroded, leading to a strong drop in coal-related emissions. Portugal's largest coal-fired power plant closed in 2021 and the last remaining coal-fired power plant will close in November 2021. The phase-out of coal-fired generation is expected to result in increased CO_2 emissions for gas-fired generation, but an overall reduction in energy-related CO_2 emissions.

CO_2 emissions drivers and carbon intensity

From 2008 to 2014, energy-related CO_2 emissions experienced a 19% decline, due to several factors, including decreased economic activity (gross domestic product [GDP] per capita dropped by 7%), reduced energy intensity of the economy (total final consumption [TFC] per GDP fell by 10%), and decreased carbon intensity of the energy supply and the economy (CO_2 per total energy supply [TES] dropped by 5%, and CO_2 per GDP fell by 12%) (Figure 3.5). Despite continued improvements in energy efficiency and a slight decline in population, energy-related CO_2 emissions increased by 19% from 2014 to 2017, driven by higher economic activity (GDP per capita increased by 8%) and higher carbon intensity of the energy supply and the economy (CO_2 per TES increased by 10% and CO_2 per GDP increased by 11%). Energy-related CO_2 emissions declined again by 14% from 2017 to 2019, driven by a strong shift away from coal-fired generation, which greatly reduced the carbon intensity of the energy supply and the economy (CO_2 per TES decreased by 10% and CO_2 per GDP decreased by 18%).

Figure 3.5 Energy-related CO_2 emissions and key drivers in Portugal, 2000-19



Energy-related CO_2 dropped from 2000 to 2014, to later increase, in line with higher economic activity and a more carbon-intensive energy mix. It dropped again in 2018-19.

Notes: GDP = gross domestic product. cap: capita. TES = total energy supply. TFC = total final consumption. Real GDP in USD 2015 prices and purchasing power parity (PPP).

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

Greenhouse gas emissions targets

Portugal has GHG emissions reductions targets for 2020 and 2030 defined by EU directives and national laws (Table 3.1).

Table 3.1 Portugal's 2020 and 2030 emissions reduction targets

		2019	2020	2030
National targets Total greenhouse gas (GHG) emissions, excluding LULUCF	CO_2-eq reduction versus 2005 levels	-25.9%	-18% to -23%	-45% to -55%
EU targets Total non-ETS GHG emissions		-14.5%	+1%	-17%

Notes: LULUCF = land use, land-use change and forestry. ETS = Emissions Trading System.

Sources: UNFCCC (2020b), *GHG Total Without LULUCF* (database), https://di.unfccc.int/time_series; Eurostat (2021b), *Greenhouse Gas Emissions in ESD Sectors* (database), https://ec.europa.eu/eurostat/databrowser/view/T2020_35__custom_822590/default/table?lang=en.

GHG emissions from Portugal's large power plants and energy-intensive industrial facilities are regulated under the ETS. The ETS uses tradable emission allowances to drive emissions reductions in ETS sectors across the entire EU plus Iceland, Liechtenstein and Norway. The system has targets to reduce the total emissions from regulated facilities by 21% by 2020 and 43% by 2030 (both versus 2005 levels) (EC, 2021a).

Portugal has 2020 GHG emissions targets under the EU Effort Sharing Decision (ESD) and 2030 GHG emissions targets under the EU Effort Sharing Regulation (ESR). The ESD and ESR set national non-ETS GHG emissions targets in each EU member state, which in combination with the ETS targets aim for a 20% reduction in the EU's total GHG emissions by 2020 and a 40% reduction by 2030 (both versus 1990 levels). Portugal has already met the 2020 ESD target for non-ETS emissions, achieving a 14.5% reduction, while the target allowed a 1% increase (EEA, 2020). Portugal has also achieved emissions reductions in line with the 2020 national target for total GHG emissions.

EU member states (including Portugal) are required to submit an NECP to the European Commission (EC) specifying their 2030 ESR emissions reduction target and supporting measures (as well as 2030 targets and supporting measures for renewable energy and energy efficiency). Portugal's finalised NECP, submitted to the EC in 2019 and approved by Council of Ministers Resolution No. 53/2020 in July 2020, sets a target for Portugal's non-ETS GHG emissions to be reduced by 17% by 2030 versus 2005 levels, and for total GHG emissions to be reduced by 45-55% by 2030 versus 2005 levels.

In November 2020, the EC provided comments on Portugal's NECP, noting that a continuation of Portugal's current policies would drive its non-ETS GHG emissions 23% lower than required under the 2030 ESR target (EC, 2020). Under the European Green Deal, it is likely that the 2030 EU-wide GHG emissions reduction target will be increased from 40% to 55% (EC, 2021b). Although Portugal's 2030 emissions reduction target exceeds the emissions reductions required under the ESR, it is possible that Portugal will need to increase its 2030 GHG target to support achievement of the EU-wide 55% GHG reduction.

As an EU member state, Portugal is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) Paris Climate Agreement and reports GHG emissions to the UNFCCC to show its contribution to the EU's nationally determined contribution for GHG emissions reductions. In March 2020, the EU communicated a long-term strategy to the UNFCCC for EU-wide carbon neutrality by 2050. Portugal fully supports EU carbon neutrality by 2050 and has adopted its own long-term strategy for carbon neutrality (RNC2050), which indicates that Portugal's CO_2 emissions should be reduced by 85-90% by 2050, along with complete decarbonisation of electricity generation and transport. The RNC2050 notes that carbon sequestration will be used to offset any remaining emissions. The government estimates that it will take around EUR 1 trillion of public and private investments over the next 30 years to achieve the RNC2050's carbon neutrality goals (Government of Portugal, 2019).

Climate policy and emissions reduction measures

Portugal's climate policy and support measures focus on achieving emissions reductions and carbon neutrality through broad electrification (electricity should cover 32-33% of final energy demand by 2030, compared to 25% in 2019) combined with rapid expansion of the renewable share of electricity generation (from 54% in 2019 to 80% by 2030). Emissions reductions are also supported through energy efficiency measures that aim to reduce primary energy demand to less than 21.5 Mtoe by 2030, compared to 22.1 Mtoe in 2019, and final energy demand to less than 14.4 Mtoe by 2030, compared to 17.1 Mtoe in 2019. Portugal sees a key role for hydrogen to drive emissions reductions in hard-to-decarbonise sectors and end uses and in achieving carbon neutrality by 2050.

Economy-wide measures

A central aspect of Portugal's emissions reduction strategy is the Green Taxation Law (Law No. 82-D/2014), which was passed in 2014 to better align energy sector taxation with Portugal's decarbonisation goals. As part of the Green Taxation Law, Portugal established a carbon tax in 2015 that covers fossil fuel demand of consumers in all non-ETS sectors (Table 3.2). The carbon tax is charged as an additional amount on top of the energy products tax (ISP), which covers most energy demand in Portugal including fossil fuels, electricity and heat.

As of 2015, the carbon tax rate (EUR per tonne of CO_2) is calculated at the start of each year, based on the average price of ETS allowances over the period from 1 October of two years prior to 30 September of one year prior. The government may define a minimum value for the carbon tax rate if the average ETS price over the calculation period is below a certain level (this was done in 2018). The rate paid for the consumption of various fossil fuels is determined by conversion factors, with higher conversion factors assigned to fuels with higher emissions and environmental impacts. Revenue from the carbon tax and ETS allowance auctions are allocated to Portugal's Environmental Fund, which supports a wide range of government programmes, including some decarbonisation measures (EREK, 2020).

Table 3.2 Portugal's carbon tax by fuel, 2015-19

	2015	2016	2017	2018	2019	Unit	Conversion factor
Tax rate (EUR/tCO_2)	5.09	6.67	6.85	6.85	12.74		
Tax (EUR/unit of fuel)*							
– Natural gas	0.29	0.37	0.38	0.38	0.71	Gigajoule	0.06
– Gasoline	11.56	15.15	15.56	15.56	28.94		2.27
– Kerosene	12.49	16.37	16.81	16.81	31.26	1 000 litres	2.45
– Gas oil/diesel	12.60	16.51	16.95	16.95	31.53		2.47
– Liquefied petroleum gas	14.77	19.36	19.88	19.88	36.98		2.90
– Fuel oil	15.76	20.65	21.21	21.21	39.44		3.10
– Petroleum coke	13.72	17.98	18.47	18.47	34.35	1 000 kilogrammes	2.70
– Coal and coke	11.53	15.11	15.52	15.52	28.86		2.27
– Coal (electricity)	Exempt			1.55	2.83		

* *Tax (EUR per unit of fuel)* equals the tax rate (EUR per tonne of CO_2) x the conversion factor.

The ISP and carbon tax rates are the same for all consumers. There are not different rates for households or industrial consumers and rates do not vary with the level of demand. However, there are exemptions from the ISP and carbon tax for fuels used by economically vulnerable consumers, public transport, operations of ports, rail transport, and the designing and testing of engines. Products benefiting from reduced ISP tax rates include coloured diesel; heating oil; and fuels used in agriculture, forestry, aquaculture and fishing.

Portugal is also looking to reduce emissions across the entire economy through programmes supporting energy efficiency. It established the Energy Efficiency Fund (EEF) in 2010 to finance energy efficiency measures and promote behavioural change. Since 2012, the EEF has published 20 specific calls for projects covering a range of efficiency measures in transport, buildings and other areas. From 2012 to 2018, EEF financing for energy efficiency amounted to nearly EUR 14 million, with 4 278 beneficiaries (PNAEE, 2020). It is expected that future EEF calls will be designed to incentivise energy efficiency in public buildings.

Portugal sees a key role for hydrogen produced from renewable energy to support emissions reductions in hard-to-decarbonise sectors and end uses, to achieve carbon neutrality by 2050. The EN-H2 indicates that by 2030, hydrogen produced using renewable energy should cover 1.5-2% of Portugal's final energy demand, 2-5% of industry energy demand, 3-5% of domestic maritime shipping energy demand, 1-5% of road transport energy demand and 10-15% of the volume of gas delivered by the natural gas network. This would require deployment of an estimated 2-2.5 gigawatts (GW) of electrolysis capacity powered by renewable electricity by 2030, along with enabling legislation, regulations and standards. The EN-H2 also indicates that in the long term, renewable hydrogen could be used directly for electricity generation and energy storage.

Electricity measures

A central aspect of Portugal's emissions reduction strategy is decarbonisation of the electricity supply, with policies and measures pushing for reduced fossil fuel generation and increased renewable generation. In 2016, the government set a target for coal-fired electricity generation to be phased out by 2030. In 2018, Portugal introduced a progressive elimination of the ISP and carbon tax exemptions for coal-fired power. Since 2018, the competitive position of coal-fired generation in Portugal was significantly eroded by reduced tax exemptions, higher ETS prices, low natural gas prices and increasing generation from low-cost renewables. As a result, the private operators of Portugal's two coal-fired power plants announced in 2020 that both plants will close permanently in 2021. The 1.3 GW Sines coal-fired power plant closed in January 2021. The 0.6 GW Pego coal-fired power plant will stop burning coal in November 2021. The owner of this plant is examining the option of converting the plant burn biomass (Simon, 2021).

The NECP indicates that electricity generation from natural gas will be maintained until at least 2040, and that combined cycle gas turbine capacity could be maintained at the 2019 level of 3.9 GW or drop to 2.8 GW by 2030, depending on the development of other flexibility assets such as pumped hydro, battery storage and hydrogen. However, starting in April 2020, natural gas used for electricity generation (excluding co-generation[1]), was no longer fully exempt from the ISP or the carbon tax, and was subject to 10% of the ISP and 10% of the carbon tax. Both of these percentages will be progressively increased to 40% in 2023. This change is intended to support Portugal's energy transition by giving preferential tax treatment to electricity generation from renewable energy.

The NECP indicates that to meet 2030 targets for emissions reductions and renewable energy, Portugal's installed capacity of renewable electricity generation needs to grow from 14.1 GW in 2019 to 27.4 GW by 2030. Most of this growth is expected to come from a near tenfold increase in solar PV capacity, followed by a near doubling of wind capacity (including some floating offshore wind) and a notable expansion of hydropower capacity (especially for pumped hydro). Portugal has several measures supporting the deployment of renewable generation. Large-scale renewable energy projects commissioned before 2012, primarily onshore wind projects, receive a feed-in tariff (FIT) for 15 years from the start of operations. A new FIT was introduced in 2014 supporting renewable generation from small-scale and self-consumption projects. In 2019, the government established annual auctions for large-scale solar PV projects. That same year, a new legal framework was approved to promote energy communities and self-consumption of distributed renewable generation.

The government does not provide financial incentives for large hydropower projects, but has approved numerous hydro projects in recent years. In 2018, the government approved the construction of three new hydropower dams with 1.16 GW of capacity, of which 0.88 GW will be pumped hydro. Two of the dams are expected to start operating in 2021 and the third one in 2023 (Iberdrola, 2021). Several major transmission system projects supporting the integration of increased hydropower have been completed since 2016 and a major increase in transmission capacity to integrate solar PV generation is planned to start construction in 2021.

Transport measures

Portugal's transport policy is primarily focused on reducing emissions from road vehicles, which account for almost all GHG emissions from transport (95% in 2018) (UNFCC, 2020b). Portugal's system for road vehicle taxation encourages the purchase of lower

[1] Co-generation refers to the combined production of heat and power.

emission vehicles. The motor vehicle tax (ISV), paid when registering a vehicle, and the single road tax (IUC), which is paid annually, are both proportional to CO_2 emissions.

There is a strong focus on reducing emissions by transitioning to electric vehicles (EVs). The RNC2050 indicates that electricity should cover more than 30% of passenger vehicle mobility demand by 2030 and 100% by 2050. To drive increased EV uptake, Portugal introduced monetary incentives for battery electric vehicles (BEVs) in 2015. There is also favourable tax treatment for BEVs, which are exempt from the ISV and IUC taxes, and support for the deployment of EV charging infrastructure.

The National Investment Plan 2030 (NIP 2030) sets infrastructure investment priorities in the transport, environment and energy sectors from 2020 to 2030. The majority of the NIP 2030's investments in transport will support lower emissions. Rail receives the most funding, at EUR 10.5 billion, with EUR 4.5 billion supporting a new high-speed rail line from Lisbon to Porto and EUR 300 million for international high-speed rail connections. Around EUR 4.5 billion is dedicated to public transportation, with EUR 3.7 billion going to the metro systems in Lisbon and Porto, and EUR 590 million budgeted for decarbonisation of public transportation. The NIP 2030 also includes EUR 450 million for the decarbonisation of urban logistics and EUR 360 million for the promotion of electro mobility (Government of Portugal, 2020). Through the Environmental Fund, the government is supporting increased use of public transport through the Program to Support the Tariff Reduction in Public Transport, which started in 2019 and provides reduced fares for public transit across the country. The Environmental Fund also supports the Programme to Support the Densification and Strengthening of Public Transport Supply (PROTransP), which was introduced in 2019 with funding of EUR 15 million to strengthen current public transport services and implement new public transport services outside of metropolitan areas (Fundo Ambiental, 2021).

Lower emissions are also supported through the Management of Energy Consumption for the Transport Sector (RGCEST) scheme, which uses energy audits and demand reduction plans for private companies owning vehicle fleets with energy demand greater than 500 toe per year (IEA, 2017). The government has also developed a National Strategy for Bicycling and Active Mobility, which aims to increase the amount of bike lanes in Portugal from 2 000 km in 2018 to 6 500 km in 2023 and 10 000 km in 2030. In 2019, the government introduced subsidies for the purchase of new electric bicycles and regular bicycles, including cargo bikes (Boost, 2020).

Industry measures

The main programme supporting lower industrial GHG emissions is the System for Management of Intensive Energy Demand (SGCIE), which requires energy audits and energy demand reduction strategies from energy-intensive facilities (those with energy demand greater than 500 toe per year). Under the SGCIE, facilities develop an energy consumption rationalisation agreement (ARCE), which defines efficiency measures that must be implemented. Industrial facilities with an ARCE have a 100% exemption from the ISP and the carbon tax. In the State Budget for 2021, the government proposed to progressively eliminate the ISP exemption on energy products used by industrial facilities with an ARCE. If passed, the law would result in those installations paying 5% of the carbon tax in 2021, 10% in 2022, 30% in 2023, 65% in 2024 and 100% from 2025 onwards.

Buildings measures

Emissions reductions from buildings are supported through a range of programmes and measures pushing for improved energy efficiency (through both the renovation of existing buildings and a higher standard for new buildings), higher electrification and use of renewable energy. Under the National Buildings Energy Performance Certification System (SCE), all residential and commercial buildings must undergo an audit to receive an energy certificate when they are constructed and each time the building changes ownership or is leased. The SCE has contributed to better insulated buildings, resulting in lower emissions. Portugal also has several programmes offering low-cost loans for energy efficiency renovations and measures to reduce building emissions through the deployment of distributed renewable energy.

As of January 2019, all new buildings owned or occupied by a public entity need to satisfy nearly zero-energy buildings (NZEB) requirements. Starting in January 2021, all newly constructed or majorly renovated private buildings with an area greater than 1 000 square metres (m^2) need to satisfy NZEB requirements. Portugal's national building code requires the installation of solar thermal heating systems with a minimum size of 1.0 m^2 per building occupant (or other renewable energy systems providing a similar energy saving).

Climate adaptation

Portugal adopted the National Adaptation Strategy 2020 (ENAAC 2020) in 2015. The ENACC has three main objectives: 1) improve the level of knowledge about climate change; 2) drive the implementation of adaptation measures; and 3) promote the integration of adaptation across policy-making processes. In line with the objectives of the ENAAC, Portugal established the AdaPT programme with support from European Environment Agency grants (85%) and the Portuguese Carbon Fund (15%). AdaPT ran from 2013 to 2017 and raised awareness of climate impacts, increased the capacity to assess climate vulnerabilities, and supported the development of 27 local climate adaptation strategies by Portuguese municipalities and regions.

Portugal leveraged EU funding to develop the co-operative LIFE SHARA platform with Spain, which aims to strengthen the governance of adaptation to climate change and increase resilience to climate change across the Iberian peninsula (Life Shara, 2021).

In 2019, Resolution of the Council of Ministers No.130/2019 approved the Portuguese Action Plan for Adaptation to Climate Change 2030 (P-3AC). The P-3AC establishes nine lines of action for implementing adaptation measures and identifies responsible entities, monitoring indicators and potential sources of financing. The nine lines of action aim to reduce impacts in key areas where Portugal faces climate risks, including: increased frequency and intensity of wildfires, heat waves, periods of drought and extreme precipitation events, increased temperatures and susceptibility to desertification, and sea level rise and coastal erosion (APA, 2019).

All of the P-3AC action lines set 2020 and 2030 targets for the implementation of specific adaptation measures. Several of these targets relate to the energy sector, including a target for 100% of companies handling energy production, transport and distribution to have adaptation or contingency plans for extreme climate-related events by 2030. There is also a 2030 target for all municipalities to have a wildfire prevention plan that considers climate scenarios. In recent years, wildfires have impacted electricity transmission and distribution.

In September 2020, Portugal began developing a long-term climate change adaptation strategy, the National Roadmap for Adaptation 2100 (RNA 2100), which will assess the impacts, vulnerabilities and risks of climate change across the entire economy through 2100 and estimate the economic costs of climate change adaptation. The Portuguese Environment Agency is leading the development of the RNA 2100 in co-operation with a wide range of stakeholders, including the Bank of Portugal, the Directorate-General for Territory, the University of Lisbon, the Portuguese Institute of the Sea and the Atmosphere, and the Norwegian Directorate for Civil Protection. The budget for developing the road map is EUR 1.3 million, 31% of which is covered by European Environment Agency grants. The remaining amount is secured by the Portuguese Environment Agency (APA, 2020).

Assessment

Portugal has GHG emissions reductions targets set under national policy and EU directives and regulations. The NECP sets a target to reduce total GHG emissions (excluding LULUCF) by 45-55% by 2030 compared to 2005 levels, which is commendable. However, the recently agreed EU Green Deal calls for higher EU-wide climate ambitions, which might require Portugal to re-evaluate its 2030 target. In addition, the range of the 2030 target is quite large. Achieving a 55% GHG reduction requires significantly more and different types of measures compared to a target of 45% within a ten-year time frame. The government should set a more precise target, which will allow for a clear understanding of what measures and emissions reduction pathways for each sector are the most appropriate. This should be done in a timely manner, as measures that can contribute to the 2030 targets have a short time frame for development and implementation.

The RNC2050 sets goals for Portugal's entire economy to be carbon-neutral by 2050 and gives indicative pathways to achieve cost-effective decarbonisation at the sector level (industry, transport, buildings electricity, etc.). The 2050 carbon neutrality goals are especially crucial to frame a clear long-term strategy, and should encourage consistent and predictable measures from all sectors and investors in order to reach the country's climate goals. Portugal sees a key role for hydrogen to drive emissions reductions in hard-to-decarbonise sectors and end uses and in achieving carbon neutrality by 2050. The EN-H2 sets a goal for hydrogen from renewable energy to cover certain shares of total and sector-specific energy demand by 2030.

To achieve the climate targets, 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 an 80% renewable share in electricity by 2030, combined with strong goals for electrification. A new tender system for solar PV is driving increased deployment and the government has approved major projects for hydropower and the expansion of the transmission system to incorporate renewable generation. There is less focus on onshore and offshore wind, the use of sustainable biomass, and other CO_2-reduction technologies.

Portugal is also expecting notable emissions reductions to be achieved through energy efficiency and has 2030 efficiency targets and measures to reduce energy demand across the economy. However, progress on improving energy efficiency was limited in the previous decade and more efforts should be made to put energy efficiency first. This would make the transition to climate neutrality less dependent on the deployment of new energy production technologies.

With the climate targets and a wide range of supporting policies in place, the focus should shift to implementing the policies and measures and cost-effective emissions reductions to reach these targets. This requires the involvement of a broad set of actors, and feedback loops (plan-do-check-act) with objective monitoring of progress.

The government estimates that it will take around EUR 1.1 trillion of public and private investments over the next 30 years to achieve the RNC2050's carbon neutrality goals. To be able to finance this transition, the Environmental Fund (which efficiently combines several former smaller funds) will be crucial, together with other national funds, EU funds and private investment. Currently, the revenues from Portugal's carbon tax and EU-ETS allowance auctions, which fluctuate with EU-ETS prices, are allocated to the Environmental Fund. The scheme for raising revenues for this fund should be more predictable and stable, and at a higher level to match the climate neutrality goals.

The budget of the Environmental Fund is split over several spending programmes and diverse objectives, such as socially oriented subsidies and contributing to paying the FIT for renewables, as well as other direct subsidies for various climate initiatives. The Energy Efficiency Fund finances a wide variety of efficiency measures and projects. The allocation of climate funds should be transparent and based on clear and objective criteria, which are aligned with and focused on climate targets, so as to give a clear signal to all actors. Applications for subsidies should be reviewed with minimal bureaucracy and the disbursement of funds to selected projects expedited.

The P-3AC defines priority areas targets and measures for adaptation to mitigate adverse effects from climate change in all sectors, including several targets and measures aimed at the energy sector. Adapting the energy sector to climate change should be a core priority for the Portuguese government, given the energy sector's key role in meeting GHG emissions reductions and energy security goals.

Climate change has a strong influence on the proper functioning of the energy system (e.g. variability of hydropower, cooling for thermal power plants, forests as a biomass resource and carbon sink, impacts of wildfires and storms on electricity transmission and distribution). Detrimental impacts from climate change would be amplified by growing cooling demand and increased flooding risk. The integration of climate adaptation into other policy areas is key for efficient implementation; however, this increases the need for overall co-ordination on both implementing the P-3AC's measures and monitoring the progress on climate adaptation targets.

Recommendations

The government of Portugal should:

- Review the overall and sector-specific 2030 GHG emissions reduction targets to ensure they support the more stringent EU-wide target and to narrow the bandwidth of the overall target to provide clarity to all actors.
- Enable cost-effective emissions reductions by involving all actors, particularly citizens and regional authorities, in implementing the measures defined in the NECP, P-3AC and RNC2050, and establishing an independent process to monitor, review and, as needed, update measures.
- Finalise the development of the National Roadmap for Adaptation 2100 to anticipate and adapt to adverse impacts of climate change beyond 2030.
- Increase the budgets for the Environmental Fund and Energy Efficiency Fund, simplify and speed up administrative processes, and focus funding on measures aligned with climate targets.

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4. Energy efficiency

Key data (2019)

Total final consumption (TFC): 16.8 Mtoe (oil 49.4%, electricity 25.5%, bioenergy 12.7%, natural gas 10.8%, heat 1.5%, waste 0.5%, coal 0.1%) -11% since 2009

TFC by sector: transport 35.4%, industry 34.4%, residential 15.8%, services/other 14.4%

TFC per capita: 1.6 toe/capita (IEA average* 2.9 toe/capita), -9% since 2009

TFC per GDP:** 49 toe/USD million (IEA average:* 65 toe/USD million), -18% since 2009

* Weighted average among the 30 IEA member countries.

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

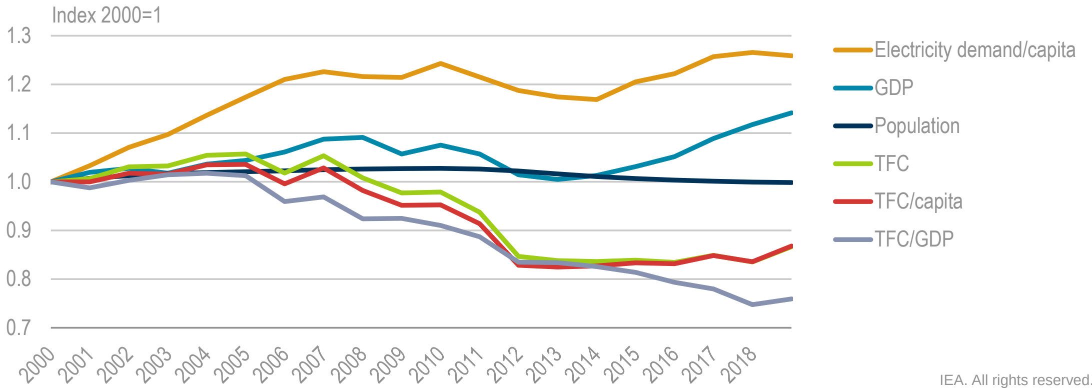
Overview

The 2008 financial crisis drove a sharp reduction in Portugal's total final consumption (TFC) of energy that persisted through 2019 (Figure 4.1). Portugal's TFC peaked in 2005 at 20.5 million tonnes of oil equivalent (Mtoe), declined to 16.4 Mtoe in 2012, and was 16.8 Mtoe in 2019. Portugal's economy began to recover in 2014 (gross domestic product [GDP] grew by 12.7% from 2014 to 2019) and has shown signs of decoupling from energy demand, with TFC per GDP dropping by 8% between 2014 and 2019. Lasting impacts of the 2008 economic crisis contributed to Portugal's population decreasing by around 280 000 from 2011 to 2019, to reach 10.27 million. Portugal experienced an increase in TFC per capita, which grew by 5% from 2012 to 2019.

Portugal has experienced a structural change in energy demand. Demand from the transport, residential and services/other sectors recovered along with the economy, while industry energy demand continued to decline. In 2016, transport overtook industry for the first time, to become the sector with the highest energy demand. Electricity demand per capita increased by 25% from 2000 to 2019, reflecting higher electrification, especially in the residential and services/other sectors.

In 2019, Portugal's primary energy consumption (PEC) was 22.1 Mtoe and final energy consumption (FEC) 17.1 Mtoe. Under the European Union (EU) Energy Efficiency Directive (EED), Portugal has 2020 targets to reduce PEC to 22.5 Mtoe and FEC to 17.4 Mtoe, and 2030 targets to reduce PEC to 21.5 Mtoe and FEC to 14.9 Mtoe. It is likely that Portugal will achieve its 2020 targets; in 2019, FEC was already below the target. Strong and sustained implementation of energy efficiency measures will be needed to support achievement of the 2030 targets.

Figure 4.1 Portugal's energy demand (total final consumption) and key demand drivers, 2000-19



The 2008 financial crisis resulted in a sharp reduction in Portugal's energy demand (TFC). While the economy began to recover in 2015, energy demand has remained relatively flat.

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

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

Energy intensity

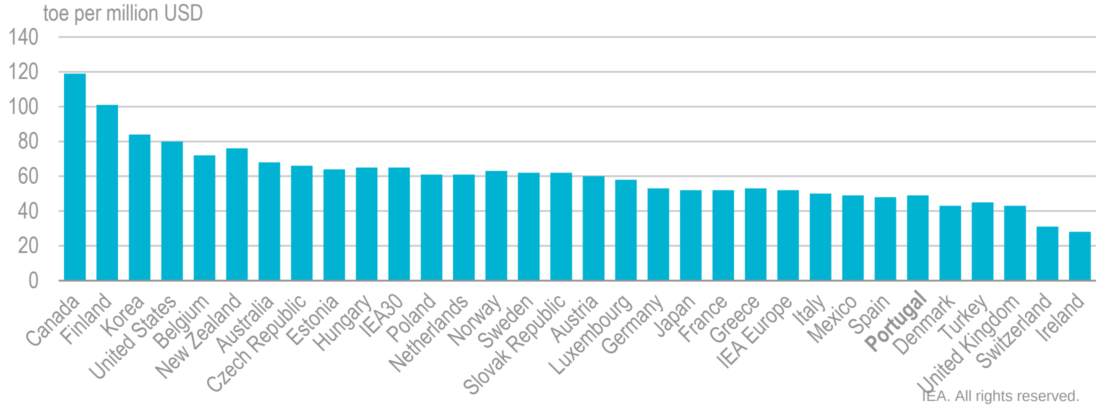
Portugal's energy intensity per capita and energy intensity per GDP are low compared to most IEA member countries (Figure 4.2). In 2019, Portugal's TFC per GDP was 49 toe per USD million PPP, the sixth-lowest among IEA member countries. In terms of TFC per capita, Portugal ranked the fourth-lowest among IEA member countries in 2019, at 1.6 toe per capita. This is related to the structure of the Portuguese economy, which is concentrated on the services sector and tourism. Portugal's energy intensity per GDP decreased by 18% from 2009 to 2019, following a trend similar to that seen in other EU countries.

Energy demand by sector

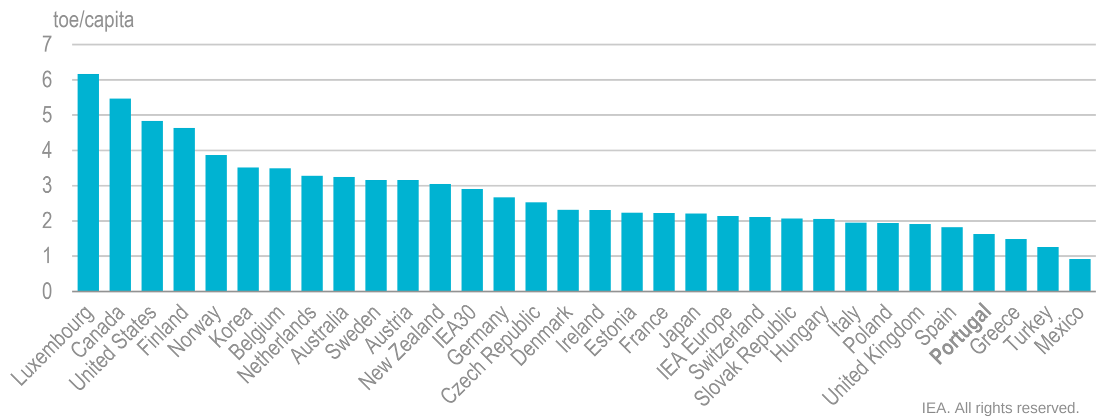
Energy demand in all sectors was significantly reduced by the 2008 financial crisis (Figure 4.3). From 2008 to 2014, industry demand dropped by 22%, residential demand by 18%, transport demand by 17% and services/other demand by 2%. From 2014 to 2019, Portugal's improving economy led to a growth of energy demand in the transport sector (up by 9%) and the residential and services/other sectors (both up by 3%); however, industry sector demand continued to decline (down by 1%). Historically, the industry sector had the highest energy demand in Portugal. However, in 2016, transport overtook industry for the first time, to become the sector with the highest demand.

Figure 4.2 Energy intensity in IEA member countries, 2019

Energy demand per GDP (TFC/GDP*)



Energy demand per capita (TFC/capita)

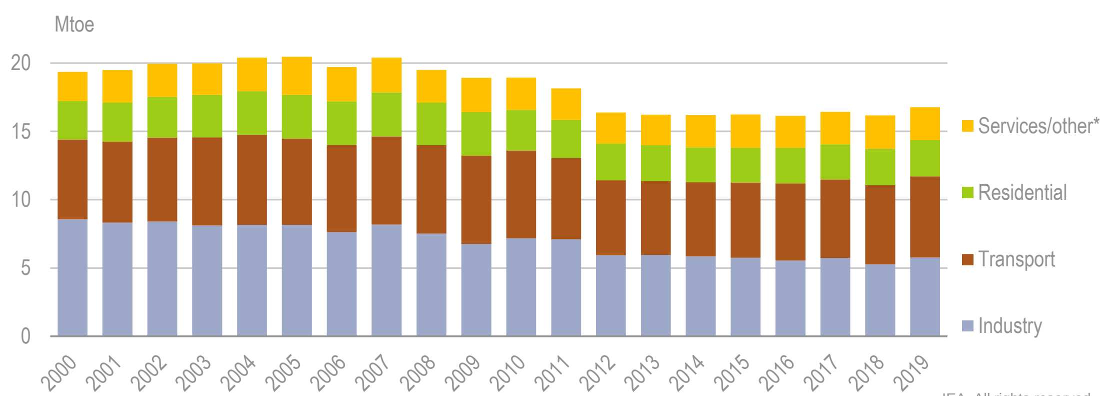


* GDP data are in billion USD 2015 prices and PPPs (purchasing power parities).

Notes: GDP = gross domestic product. TFC = total final consumption. toe = tonne of oil equivalent. USD = United States dollar.

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

Figure 4.3 Total final consumption in Portugal by sector, 2000-19



The 2008 crisis reduced demand in all sectors. Economic recovery increased demand in transport, residential and services/other sectors, but industry demand continued to decline.

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

Note: Mtoe = million tonne of oil equivalent.

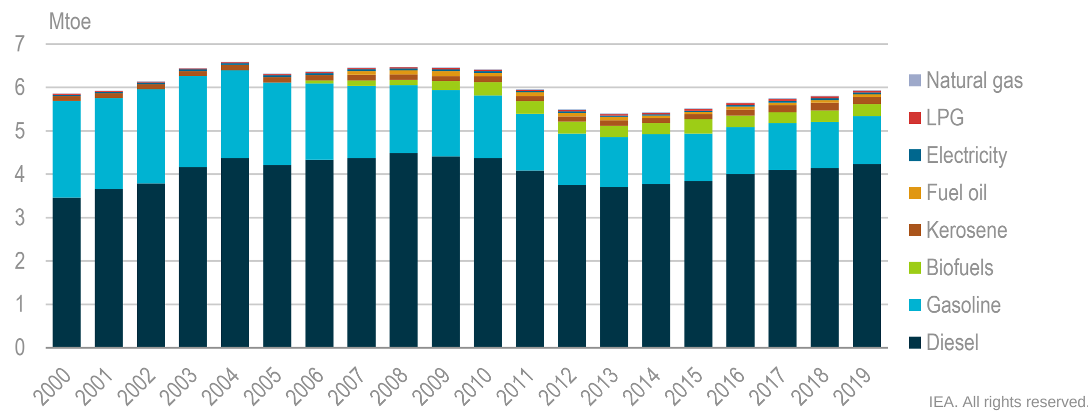
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Transport

In 2019, the transport sector had the highest energy demand in Portugal, 5.9 Mtoe and 35% of TFC. Transport demand decreased notably following the 2008 crisis and overall was down by 8% from 2009 to 2019. Transport demand has been increasing since 2013, but has not returned to pre-crisis levels (Figure 4.4). In 2019, transport demand was covered primarily by diesel (71%) followed by gasoline (19%) and biofuels (5%), with smaller shares from a variety of fossil fuels. Electricity accounted for just 0.7% of transport energy demand and came primarily from rail, along with a small but growing fleet of electric vehicles.

In 2019, road transport accounted for 95% of transport energy demand, followed by aviation (3%), shipping (1%) and domestic rail (1%). Cars and light trucks accounted for 55% of total road transport energy demand, freight trucks for 41%, and buses for 3%. Passenger vehicle ownership in Portugal dropped during the financial crisis, but has been growing since 2012, and reached 514 vehicles per 1 000 inhabitants in 2018, above the pre-crisis level and close to the EU median of 513 vehicles per 1 000 inhabitants. From 2008 to 2018, the energy intensity (megajoules [MJ] per passenger-kilometre) of Portugal's private vehicle fleet and bus fleet decreased by 4% and 32%, respectively. In contrast, freight truck energy intensity (MJ per tonne-kilometre) increased by 4%.

Figure 4.4 Transport total final consumption in Portugal by fuel, 2000-19



Transport demand decreased notably following the 2008 crisis. Since 2013, demand has been increasing, but has not returned to pre-crisis levels and remains dominated by diesel.

Notes: Mtoe = million tonne of oil equivalent. LPG = liquified petroleum gas. Transport sector demand excludes international aviation and navigation.

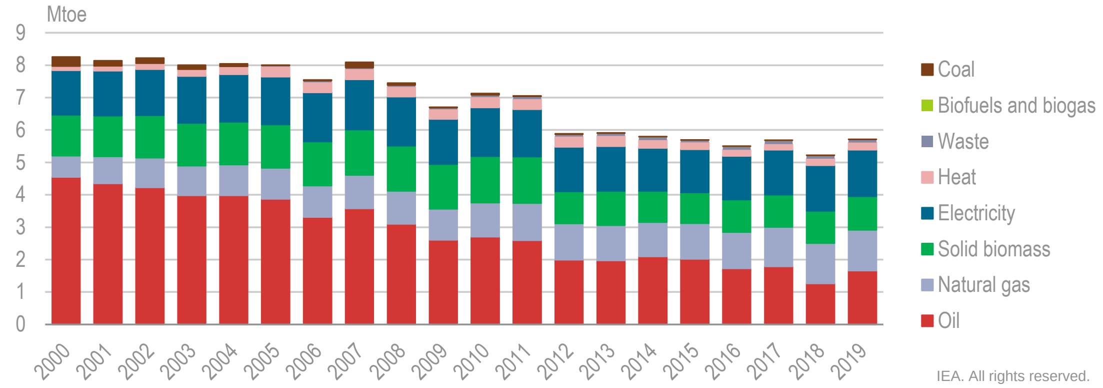
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Industry

In 2019, industrial energy demand was 5.8 Mtoe and 34% of TFC (Figure 4.5). Portugal's industrial energy demand was strongly impacted by the 2008 crisis. From 2008 to 2012, industrial energy demand fell by 20% and there was a major structural shift to less energy-intensive industries. Industrial activity began to grow in 2012; however, industrial energy demand continued to decline through 2018 as a result of improved efficiency and a continued structural shift to less energy-intensive activities. From 2009 to 2019, industrial demand for gas increased by 31%. There was a small (3%) increase in industrial demand for electricity, while demand decreased for coal (-83%), oil (-36%), heat (-26%) and bioenergy (-25%).

In 2019, three industries – paper, pulp and print; non-metallic minerals (cement, ceramics, glass); and chemical and petrochemical – accounted for 68% of Portugal's industrial energy demand (Figure 4.6). From 2008 to 2018, the efficiency (MJ per USD) of the non-metallic minerals industry improved by 29%, while the efficiency of chemical and petrochemical industry improved by 27%. All other industries experienced improvements in efficiency of 20-33%, except for paper, pulp and print, where efficiency dropped by 18%; construction (no change); and services (3% improvement).

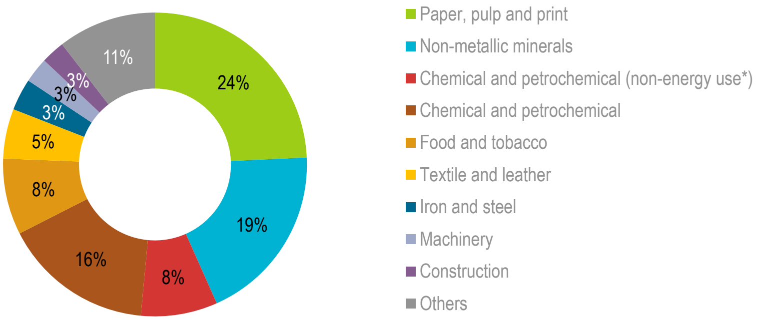
Figure 4.5 Industry total final consumption in Portugal by source, 2000-19



Despite increased industrial activity since 2012, industry energy demand has continued to decline, driven by improved efficiency and a structural shift to less energy-intensive activities.

Notes: Mtoe = million tonne of oil equivalent. Includes non-energy use in the chemical and petrochemical sector.
Source: IEA (2021), IEA World Energy Statistics and Balances (database), www.iea.org/statistics.

Figure 4.6 Industry total final consumption in Portugal by subsector, 2019



Paper, pulp and print and non-metallic mineral subsectors covered almost half of the energy demand by industry in Portugal in 2019.

* *Non-energy use* in the chemical and petrochemical sector refers to those fuels which are used as raw materials and are not consumed as a fuel or transformed into another fuel.

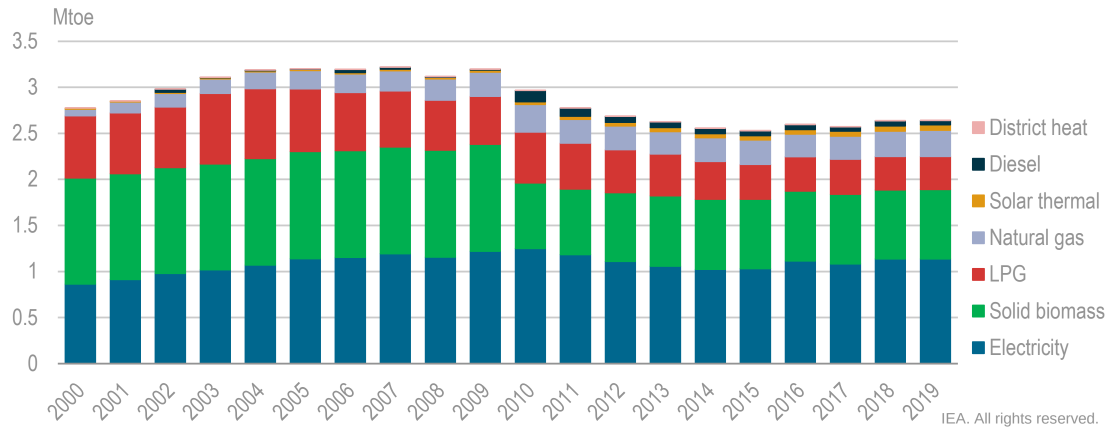
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Residential sector

In 2019, residential sector energy demand was 2.7 Mtoe and 16% of TFC. Residential demand was notably affected by the economic downturn in Portugal, falling by 21% from 3.2 Mtoe in 2009 to 2.5 Mtoe in 2015 (Figure 4.7). Since 2015, residential demand has slightly increased, but is still well below pre-crisis levels, partly because of lower energy intensity (gigajoule per square metre [GJ/m²]) of space heating (decreased by 38%), and lower energy intensity (GJ per dwelling) of water heating (decreased by 12%) and appliances (decreased by 7%).

Together, electricity and solid biomass have consistently covered the largest share of residential energy demand (66-74% from 2008 to 2019). However, while the share of demand covered by electricity has seen an overall increase, from 38% in 2008 to 43% in 2019, the share of solid biomass in residential demand dropped from 36% in 2009 to 28% in 2019, with almost all of the decrease occurring in 2010. Natural gas consistently covered around 10% of residential demand from 2008 to 2018. Residential liquefied petroleum gas (LPG) demand has been decreasing since 2010, to around 14% of residential demand in 2019. Solar thermal has experienced slow but steady growth and covered 2% of residential demand in 2019. There is almost no district heating in the residential sector (EHP, 2019).

Figure 4.7 Residential total final consumption in Portugal by source, 2000-19



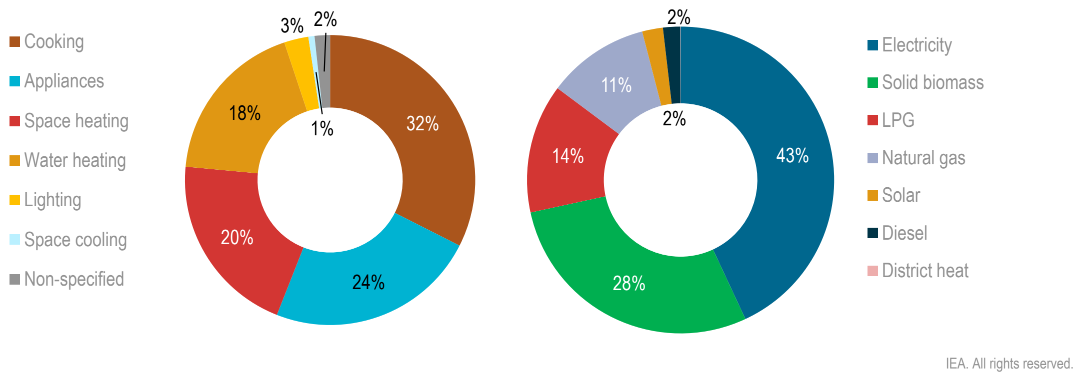
In 2019, bioenergy and waste and electricity covered altogether almost three-quarters of the total residential demand, which has been mostly stable since 2012

Notes: Mtoe = million tonne of oil equivalent. LPG = liquefied petroleum gas.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

In 2018, residential energy demand was covered by electricity (43%), solid biomass (29%), LPG (14%) and gas (10%), with the highest share (32%) of residential energy demand coming from cooking (Figure 4.8). Electrical residential appliances accounted for one-quarter of total residential energy demand, while 20% of this demand came from space heating, for which solid biomass was the primary energy source. Water heating accounted for 18% of residential demand and was mainly provided by oil (43%) and gas (30%).

The breakdown of residential energy demand is based on a household survey conducted by the Directorate-General for Energy and Geology (DGEG) in 2010. This survey assigned all kitchen energy demand (stove, oven, refrigeration, appliances, etc.) to the category of cooking. This categorisation is not in line with data reporting from other EU countries, which makes a comparison with demand breakdown in other countries problematic. In December 2020, Statistics Portugal (the national statistics institute) starting conducting the first new survey of residential energy demand since 2010. This survey uses an updated methodology that should allow a more accurate comparison with other EU countries. The new survey should be completed in April 2021 and the DGEG has indicated that going forward it aims to conduct a survey at least every five years to ensure that policy makers have accurate data on residential energy demand.

Figure 4.8 Residential energy demand in Portugal by use (2018) and by fuel (2019)



Cooking and appliances covered more than 50% of residential energy demand in 2018, mainly powered by electricity.

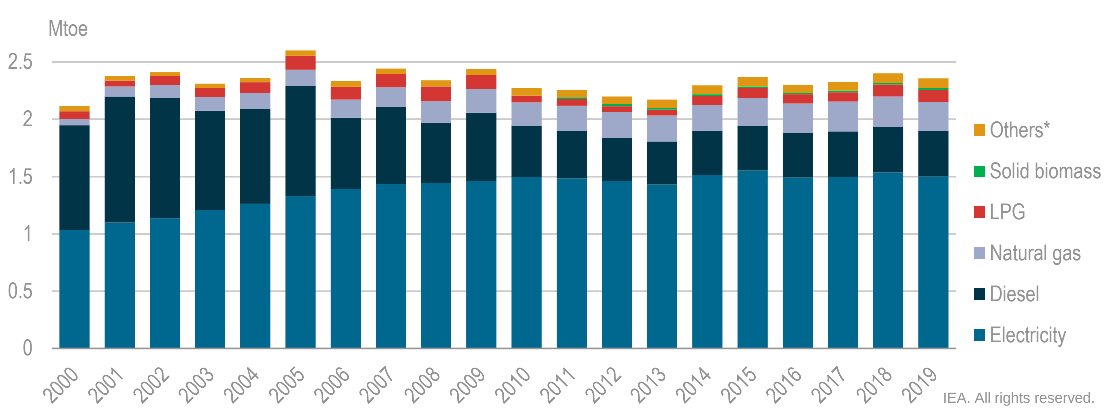
Note: LPG = liquefied petroleum gas.

Sources: IEA (2020), *Energy Efficiency Indicators 2020*, www.iea.org/statistics; IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Services/other sector

In 2019, energy demand in the services/other sector (commercial and public services, agriculture, forestry, and fishing) was 2.4 Mtoe and 14% of TFC. Electricity has consistently covered the largest share of the services/other sector demand (62% in 2019), followed by diesel (16%), natural gas (10%) and LPG (4%) (Figure 4.9).

Figure 4.9 Total final consumption in services/other in Potugal by source, 2000-19



Electricity is the main energy source for the services/other sector, followed by oil, whose share has decreased in the last decades.

* *Others* includes solar thermal, district heating and geothermal.

Notes: Mtoe = million tonne of oil equivalent. LPG = liquefied petroleum gas.

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

From 2008 to 2018, gas demand increased by 22% and electricity demand was up by 3%, while demand for all other fuels dropped. In contrast to the residential sector, where solid biomass plays a major role in building heating, there is almost no bioenergy used in the services/other sector. Commercial and public service buildings accounted for 80% of the energy demand from the services/other sector, while 16% came from agriculture and forestry, and 4% from fishing.

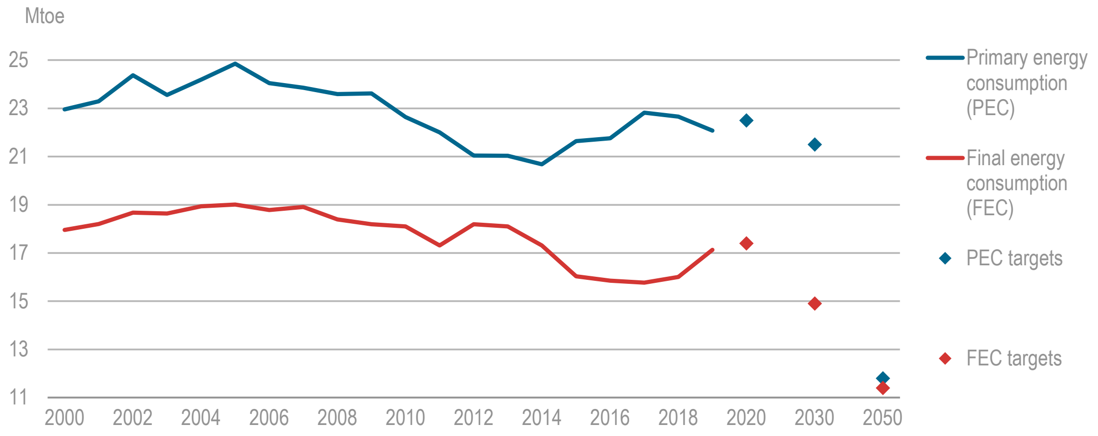
Targets

Portugal's 2020 and 2030 energy efficiency targets are driven by the EU EED and its 2050 energy efficiency goals are set by the Roadmap for Carbon Neutrality 2050 (RNC2050) (Figure 4.10). Under the EED, EU member states set national energy efficiency targets to contribute to the EU-wide 2020 target of a 20% reduction in energy consumption compared to a business-as-usual projection (EC, 2020a). Portugal set 2020 targets of reducing PEC to 22.5 Mtoe (942 petajoule [PJ]) and FEC to 17.4 Mtoe (729 PJ). In 2019, Portugal's PEC was 22.1 Mtoe (925 PJ) and FEC was 17.1 Mtoe (715 PJ) (Eurostat, 2021). In December 2020, analysis from the European Environmental Agency indicated that Portugal should be able to achieve its 2020 energy efficiency targets (EEA, 2020).

Portugal's 2030 energy efficiency targets are derived from the EU Clean Energy Package, which includes an updated EED that sets a 2030 target of a 32.5% reduction in EU-wide energy consumption compared to a business-as-usual projection. Under the Clean Energy Package, each EU member state was required to submit a National Energy and Climate Plan (NECP) to the European Commission by the end of 2019 proposing contributions to the EU-wide 2030 targets for energy efficiency, as well as greenhouse gas (GHG) reductions (see Chapter 3) and renewable energy (see Chapter 5). Portugal's NECP set 2030 energy efficiency targets for PEC of 21.5 Mtoe (900 PJ) and for FEC of 14.9 Mtoe (624 PJ).

In November 2020, the European Commission provided comments on Portugal's NECP, noting that the targets for PEC and FEC are "modest" (EC, 2020b). It is likely that the 2030 EU-wide GHG emissions reduction target will be increased from 40% to 55%. IEA analysis indicates that about half the emissions reduction needed to achieve the 55% GHG reduction by 2030 target will need to come from energy efficiency measures. As such, it is likely that Portugal will need to increase its 2030 energy efficiency targets to support an EU-wide emissions reduction of 55%.

Figure 4.10 Portugal's primary energy consumption and final energy consumption, 2000-19 and targets for 2020, 2030 and 2050



Despite a recent increase in primary and final energy consumption, Portugal should be able to meet its 2020 energy efficiency target. Further action is needed to achieve 2030 targets.

Note: Mtoe = million tonne of oil equivalent.

Sources: Eurostat (2021), Primary energy consumption and final energy consumption, *Eurostat Complete Energy Balances* (database), https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_bal_c

Portugal's RNC2050 commits to achieving carbon neutrality across the entire economy by 2050. Energy efficiency is expected to play a major role in achieving this goal, as reduced demand in all sectors will allow for renewables and other low-carbon energy sources to more easily cover the remaining energy demand. Under the RNC2050, PEC is expected to drop to less than 12.8 Mtoe (536 PJ) by 2040 and less than 11.8 Mtoe (493 PJ) by 2050. FEC is expected to drop to less than 12.4 Mtoe (520 PJ) by 2040 and less than 11.4 Mtoe (477 PJ) by 2050.

Key institutions

The DGEG has the main responsibility for energy efficiency policy at the national level, including the transposition of EU directives and the development, implementation and evaluation of energy efficiency policies and measures, including standards, regulations and technical specifications. The Portuguese Energy Agency (ADENE) co-operates in the management of Portugal's energy efficiency programmes with entities including the Energy Services Regulatory Entity (ERSE), the National Civil Engineering Laboratory (LNEC) and the Portuguese Environment Agency. The Institute for Mobility and Transport is a public institute that supports the government in implementing and evaluating policies for the transport sector, including improving road and rail transport efficiency. Municipal authorities are responsible for implementing energy efficiency policy at the local level. Portugal's regional energy agencies support municipalities in reducing energy demand by preparing technical studies and implementing and monitoring energy efficiency measures, with a focus on energy infrastructure.

Policy and support measures

The majority of Portugal's energy efficiency policies and measures are based on EU directives. In particular, the EED mandates that Portugal must:

- require energy suppliers to realise at least a 1.5% reduction of annual energy demand for final consumers through an energy efficiency obligation (EEO) scheme, or alternative measures that achieve the same savings
- require large companies to regularly audit energy demand and identify efficiency measures
- provide incentives to support energy audits by small and medium-sized enterprises
- develop a national building renovation strategy and implement measures to improve energy efficiency in public buildings
- ensure that national governments purchase only products, services and buildings with high energy efficiency performance.

General measures

In line with the EED, Portugal established the Local Energy Agreement as an alternative measure to achieve the EEO's demand reduction target. The Local Energy Agreement includes a joint strategy among municipalities to reduce the energy consumption of public administration buildings and establishes a requirement for all entities covered by the EU Emissions Trading System (ETS) to report implemented efficiency measures. From 2014 to 2020, the Local Energy Agreement supported a 2.5 Mtoe reduction in FEC. In 2019, the agreement was extended with an updated target to reduce FEC by 6.7 Mtoe (281 PJ) from 2021 to 2030.

The Portuguese Electricity Demand-Side Efficiency Promotion Plan (PPEC), managed by the ERSE with the support of the DGEG, is a competitive tender mechanism which has been in place since 2007 to improve the efficiency in electricity supply and demand. Under the PPEC, electricity suppliers; network operators; government agencies; research centres; higher education institutions; and consumer, business and municipal associations can propose energy efficiency measures, which are reviewed and selected for support by the ERSE through a competitive process based on a cost-benefit analysis. The DGEG also plays a role in approving the funding by examining if proposed projects are aligned with Portugal's overall energy policy goals. To be considered for PPEC funding, efficiency measures should aim to permanently reduce electricity consumption in a measurable manner, induce energy-saving behaviours or allow more informed decision making. Measures supported by the PPEC can be counted towards the achievement of the EEO requirements (ADENE, 2018).

The sixth edition of the PPEC was open for proposals from 2017 to 2018 and resulted in proposals for 224 efficiency projects, of which 75 projects proposed by 33 entities were approved for financial support for a total of EUR 23 million. The majority of this support went to energy suppliers (57%) and energy agencies (23%), with smaller shares to business associations (9%), municipal associations (7%), higher education institutions/ research centres (3%) and consumer associations (1%). The projects funded under the sixth PPEC had to start implementation in 2019 and are expected to result in energy savings of 126.4 kilotonne of oil equivalent (ktoe) (5.29 PJ) from 2019 to 2037. (ADENE, 2018). In 2020, the rules governing the PPEC underwent a public consultation, with the intention for the PPEC to be expanded to include efficiency measures for other energy carriers, including natural gas, and projects implemented by other stakeholders, including non-governmental organisations. The new rules are expected to be published in 2021, before the seventh edition of the PPEC is launched for projects that will have to start implementation in 2022.

Portugal 2020 is a partnership agreement between Portugal and the EC that was established to support the achievement of a variety of targets for 2020 that Portugal must meet under EU directives, including for energy efficiency. Portugal 2020 is supported through five EU funds with an overall budget of EUR 25 billion and includes 16 operational programmes for the period 2014-20. The main programme supporting energy efficiency measures under Portugal 2020 is the Operational Programme for Sustainability and Efficient Use of Resources (POSEUR). POSUER provides funding to support the deployment of energy efficiency measures and has a budget of EUR 200 million for energy efficiency in housing, EUR 200 million for energy efficiency in public administration buildings and EUR 102 million for sustainable mobility. Other operational programmes under Portugal 2020, such as Norte2020, Alentejo2020, Centro2020, CRESC Algarve2020 and Lisboa2020, support regional measures to improve energy efficiency (EC, 2014).

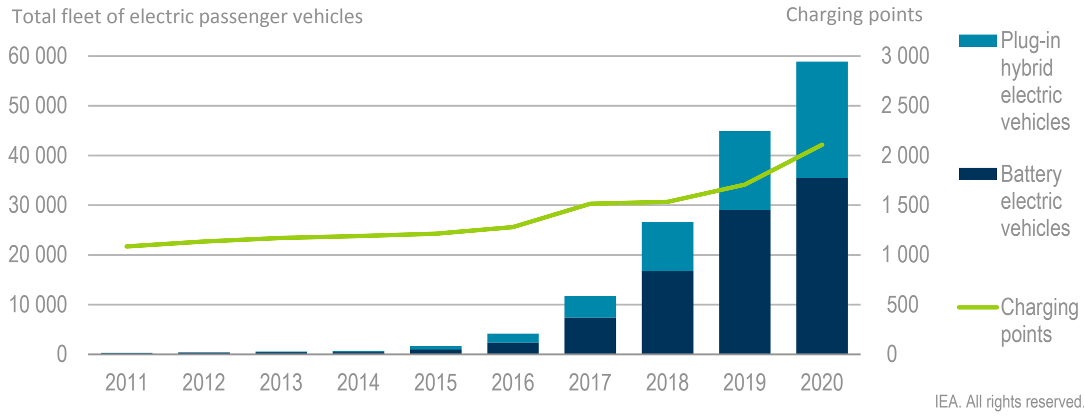
Portugal established the Energy Efficiency Fund (EEF) in 2010 to finance energy efficiency measures and promote behavioural change. Since 2012, the EEF has published 20 specific calls for projects covering a range of efficiency measures in transport, buildings and other areas. From 2012 to 2018, EEF financing for energy efficiency amounted to nearly EUR 14 million, with 4 278 beneficiaries (PNAEE, 2020). It is expected that future EEF calls will be designed to incentivise energy efficiency in public buildings.

The government is also looking to increase energy efficiency by supporting energy services companies (ESCOs). The number of ESCOs active in Portugal has increased significantly, from less than 10 in 2010 to more than 150 in 2020. The growth of ESCOs has been supported by the development of the legal framework for energy performance contracts (EPC) in the public sector and the adoption of the Regulation of Energy Services Companies Qualification System (SQESE) in 2012. ESCOs in Portugal offer a wide variety of energy efficiency services, but have mainly focused on lighting for municipalities. In 2017, EUR 12 million of investments were mobilised through the EPCs, to renovate the street lighting systems in several municipalities. In 2018, two inter-municipal associations signed EPCs for EUR 30 million to refurbish 100 000 streetlights. Lisbon signed an EPC to replace 20 000 incandescent lamps of the traffic lighting system with LEDs (a demand reduction of 94%).

Transport

Portugal's transport energy efficiency measures are primarily focused on improving the efficiency of road vehicles, which account for almost all transport demand (94% in 2018). Portugal's system for road vehicle taxation is designed to encourage the purchase of efficient vehicles. The motor vehicle tax (ISV), paid when registering a vehicle, is proportional to CO_2 emissions (which are closely correlated with vehicle efficiency) and the single road tax (IUC), which is paid annually, is also proportional to CO_2 emissions and engine capacity (cubic metres). There is a strong policy focus on transitioning to electric vehicles (EVs), which are more efficient compared to diesel and gasoline vehicles. The RNC2050 indicates that electricity should cover 36% of passenger vehicle mobility demand by 2030 and 100% by 2050. Portugal has a small but rapidly growing EV fleet and has increased the number of EV charging points (Figure 4.11).

Figure 4.11 Electric vehicles and charging points in Portugal, 2011 to October 2020



Both plug-in hybrid and battery electric vehicles have seen a significant increase in registrations. There has also been a notable increase in the number of charging stations.

Source: EAFO (2020), *Portugal*, www.eafo.eu/countries/portugal/1749/summary.

The EU European Alternative Fuels Observatory estimated that at the end of 2020, there were 35 504 battery EVs (BEVs) and 25 372 plug-in hybrid EVs (PHEVs) in Portugal, equal to just over 1% of the total passenger vehicle fleet, which is the ninth-highest share among EU countries and is higher than the EU median value of 0.51%. In 2019, new EV registrations reached 12 705 and 5% of annual new vehicle registrations. As of October 2020, registrations of new EVs reached 14 176 year-to-date and 12% of new registrations, although the number of total vehicle registrations decreased notably due to the Covid-19 pandemic. New registrations have been increasing for both BEVs and PHEVs, but as of October 2020, BEVs accounted for the majority of the EV fleet (60% BEV and 40% PHEV) (EAFO, 2020).

To drive increased EV uptake, Portugal introduced monetary incentives for BEVs in 2015. The incentives are cash payments from the government to private citizens, which are paid following the purchase of a BEV. PHEVs are not eligible for the incentive. In 2019, the incentives for BEVs was increased and supported with a budget of EUR 3 million. In 2020, the budget for BEV incentives was increased to EUR 4 million; however, incentives were restricted to BEVs with a total purchase price less than EUR 62 500. In addition, a new incentive was created under the same programme for the purchase of non-electric conventional bicycles and cargo bikes.

The 2021 State Budget provides EUR 4 million for BEV incentives and maintains the same levels and types of incentives, with the BEV passenger vehicle incentives set a EUR 3 000 for private citizens and EUR 2 000 for enterprises. The incentive is EUR 3 000 for BEV light freight vehicles, 50% of the purchase price up to a maximum of EUR 350 for two-wheeled BEVs and 10% of the purchase price up to a maximum of EUR 100 for non-electric bicycles. The 2020 BEV incentive programme supported the purchasing of 1 388 BEV passenger vehicles, 60 BEV light freight vehicles, 1 036 two-wheeled BEVs (mostly electric bicycles) and 649 bicycles. Incentive applications for around 400 passenger BEVs could not be supported because the budget had already been allocated (Fundo Ambiental, 2018).

There is favourable tax treatment for BEVs and other zero-emission vehicles, which are exempt from the ISV and IUC. These taxes are proportional to CO_2 emissions for all vehicles and a 75% reduction of the ISV is granted to PHEVs. Starting in 2020, PHEVs were required to meet certain requirements to receive the tax reduction (electric range over 80 km, battery capacity of at least 0.5 kWh per 100 kg, and emissions of less than 50 grammes of carbon dioxide per km). There are additional benefits for EVs, including free parking in many municipalities.

The national and local governments are supporting EV uptake by directly purchasing EVs. In 2019, the national government purchased 600 EVs for the government fleet, and set a target to have a fleet of 1 200 EVs by 2020. A joint decree from the Minister of Environment and Energy Transition and the Minister of Finance, in effect since March 2019, requires 50% of government purchases of light-duty vehicles (including passenger vehicles) to be BEVs. Some municipalities, such as Braga and Coimbra, have purchased electric buses for their public transportation systems (EC, 2020c). The NECP indicated that the government plans to encourage the renovation of bus fleets by co-funding clean buses, particularly electric and hydrogen buses. The NECP also indicates that the government will support the creation of a charging network for electric buses.

The government is working to develop EV charging infrastructure through the MOBI.E electric mobility programme. MOBI.E requires charging stations to have both technical interoperability (possibility to charge any brand of vehicle) and service interoperability (access to any charging point through a standardised registration process) and to be open to any service provider.

Under MOBI.E, the government launched a first phase of charging infrastructure development in 2012, with targets of installing 1 300 EV charging points in 25 municipalities across the country and 50 quick charging points on key highways. In 2016, a second round of development was launched under MOBI.E, aiming for a minimum of 2 394 charging points by the end of 2020. In October 2020, Portugal's EV charging network had 2 109 charging stations (EAFO, 2020). The NECP notes several action items to help increase the share of EVs that the government plans to implement by 2025 or 2030. These include promoting EVs for urban micro-logistics, promoting two-wheeled EVs (which are now eligible for the BEV subsidy), promoting the development of the public EV charging network, promoting EV charging in private buildings and promoting EV smart charging of electric with bidirectional energy flows.

The Management of Energy Consumption for the Transport Sector (RGCEST) scheme aims to reduce the energy demand of commercial vehicle fleets. RGCEST applies to companies that own a vehicle fleet with an energy demand greater than 500 toe per year. Under RGCEST, these companies are required to carry out an energy audit every three years to develop an energy consumption rationalisation plan (PRCE), which contains specific efficiency measures to be implemented within three years. The audits and plans have to be developed by technicians recognised by the DGEG. The PRCE must be approved by the DGEG and companies are required to submit annual reports on their progress in implementing measures. Half the cost of the audit and developing the PRCE (up to EUR 7 500) can be covered by the EEF (IEA, 2017).

In 2019, the Council of Ministers approved the National Investment Plan 2030 (NIP 2030), which sets infrastructure investment priorities in the transport, environment and energy sectors from 2020 to 2030. The NIP 2030 indicates that transportation sector investment over this period will total EUR 21.7 billion (EUR 17.7 billion of public investment and EUR 4.0 billion of private investment), with the majority of transport investments targeting areas that will improve energy efficiency. Rail receives the most funding, EUR 10.5 billion, with EUR 4.5 billion supporting a new high-speed rail line from Lisbon to Porto and EUR 300 million for international high-speed rail connections. Around EUR 4.5 billion is dedicated to public transportation, with EUR 3.7 billion going to the metro systems in Lisbon and Porto, and EUR 590 million budgeted for the decarbonisation of public transportation. The NIP 2030 also includes EUR 450 million for the decarbonisation of urban logistics and EUR 450 million for the promotion of electro mobility (Government of Portugal, 2020).

The Programme for the Reduction of Public Transport Fares (PART) supports reduced fares to increase public transportation ridership and reduce economic inequalities. PART started operating in 2019 with a budget of EUR 101.3 million from the Environment Fund and EUR 2.6 million (2.5% of the total) from municipalities. The co-founding share from municipalities will rise to 10% in 2020 and 20% in 2021. At least 60% of PART funds must be used to reduce transport fares, any remaining budget can be used to increase the supply of public transport (EC, 2019). In 2019, 98.6% of PART funding went to tariff reduction measures and 1.4% for supply increase measures. Analysis from the Institute for Mobility and Transport on the year-on-year variation during the first year of PART implementation (2019) shows an increase in the sales of public transportation passes (up 22%) and passengers (up 7%) (IMT, 2020). The Environmental Fund also supports the Programme to Support the Densification and Strengthening of Public Transport Supply (PROTransP), which was introduced in 2019 with funding of EUR 15 million to strengthen current public transport services and implement new public transport services outside of metropolitan areas (Fundo Ambiental, 2021).

The government has also developed a National Strategy for Bicycling and Active Mobility. The strategy aims to increase the number of commuting trips taken via bicycles to 7.5% in the entire country and 10% in urban areas by 2030. It aims to invest around EUR 1 billion to increase the amount of bike lanes in Portugal from 2 000 km in 2018 to 6 500 km in 2023 and 10 000 km in 2030. Other measures include adding cycling as a core subject in physical education curriculum of primary and secondary schools, integrating biking with public transport, financial incentives for bicycles, promoting cargo bikes for urban logistics, developing a database on cycling statistics, traffic calming measures, and the improvement and effective enforcement of the road code to improve bicycle safety (Boost, 2020). In 2019, the government introduced subsidies of EUR 250 for purchasing new electric bicycles.

Aiming to boost energy efficiency of company vehicles fleets, ADENE introduced the MOVE+ labelling system in 2020. MOVE+ uses a variety of metrics, including electric mobility integration to classify a company's vehicle fleet efficiency on a scale from F (less efficient) to A+ (more efficient). MOVE+ also allows the identification of opportunities for reducing a fleet's operating costs and environmental impacts, e.g. through the promotion of best practices and the introduction of EVs. At the end of 2020, 100 professionals had been trained to perform MOVE+ audits and 21 companies with fleets totalling more than 4 000 vehicles and completed MOVE+ audits.

RNC2050 supports the energy transition in the transport sector with an "avoid-shift-improve" strategy. It aims to "avoid" the need for mobility by planning complete, mixed-use neighbourhoods that decentralise economic activity and enable shorter commutes or increase the frequency of teleworking; "shift" demand away from personal automobile use toward public transport and other modes; and "improve" technology for alternative mobility, especially in urban areas, including increased vehicle electrification, car sharing and carpooling. RNC2050 also aims to improve the efficiency of the transport fleet through wider deployment of EVs and hydrogen-powered vehicles. Decarbonisation of heavy transport is one of the five key initiatives of the National Strategy for Hydrogen (EN-H2), published in August 2020, which includes 2030 targets for hydrogen to cover 1-5% of road transport demand and 3-5% of domestic maritime transport demand by 2030.

Industry

The System for Management of Intensive Energy Demand (SGCIE) is Portugal's main programme to promote energy efficiency in industry. Under the SGCIE, energy-intensive facilities (those with energy demand greater than 500 toe per year) must complete an energy audit every eight years. Based on the results of the audit, the facilities prepare an energy consumption rationalisation plan (PREn) that identifies energy efficiency measures that must be undertaken over the next eight years. For facilities with an annual demand greater than 1 000 toe, the PREn measures must support a 6% reduction in demand. For facilities with an annual demand between 500 toe and 1 000 toe, the measures must support a 4% reduction in demand. Facilities with a demand less than 500 toe per year can participate in the SGCIE on a voluntary basis. In 2019, 16.1% of facilities with a demand less than 500 toe per year chose to participate in the SGCIE.

Once approved by the DGEG, the PREn becomes an energy consumption rationalisation agreement (ARCE), which defines measures that must be carried out by the facility. An execution and progress report (REP) must be delivered every two years, assessing the implementation of the ARCE. ADENE uses the REP to determine if a facility can access governmental support for energy efficiency measures. In cases where the ARCE is not being implemented, the REP determines what penalties can be applied. The SGCIE is being reviewed to increase the number of facilities covered; potential changes include lowering the annual demand threshold for mandatory participation bellow 500 toe per year, increasing the frequency of energy audits and energy rationalisation plans, and increasing voluntary participation.

Currently, facilities with an ARCE are 100% exempt from the energy product tax (ISP) and the carbon tax on their use of industrial fuels and electricity. As a result, the share of energy-related taxation in overall energy prices is significantly lower for industrial consumers compared to residential and commercial consumers. In the 2021 State Budget, the government proposed to progressively eliminate the carbon tax exemption on energy products used by industrial installations with an ARCE. If passed, the law would result in those installations paying 5% of the carbon tax in 2021, 10% in 2022, 30% in 2023, 65% in 2024 and 100% from 2025 onwards.

Buildings

Around two-thirds of Portugal's building stock was constructed before any energy performance requirements were in place. Portugal first introduced energy performance requirements for residential buildings in 1990 and for commercial buildings in 1998. The current legal framework for building energy efficiency came into force in 2013 with the transposition of the 2010 update of the EU Energy Performance Buildings Directive (EPBD). EPBD requirements from this update include a common framework for computing the energy performance of buildings, minimum energy performance requirements, the development of a national plan for nearly zero-energy buildings (NZEBs), building energy certification, regular inspection of heating and cooling systems, and independent control systems for certifications and inspection reports. The EPBD was amended by the EU in 2018 with new measures aiming to accelerate the rate of energy efficiency building renovations and strengthen the energy performance of new buildings (EC, 2018). Portugal transposed the updated EPBD in 2020.

Under the National Buildings Energy Performance Certification System (SCE), in effect since 2009, all residential and commercial buildings in Portugal must be audited to receive an energy certificate when they are constructed and each time the building changes ownership or is leased. The SCE has supported effective application of EPBD energy efficiency requirements related to building envelope insulation, heating and cooling systems in new buildings and buildings under major renovation (Vaquero, 2019). The SCE is run by ADENE with the collaboration of the LNEC. From 2009 to the end of 2019, 1 159 906 energy certificates had been issued in Portugal (1 018 457 for residential and 141 449 for commercial buildings), with 20% of the residential certified buildings (207 662 units) being of class B or higher. Since the start of the programme in 2009, around 4 million efficiency measures have been implemented, with an average investment of EUR 8 500 per certificate for residential buildings and EUR 14 200 per certificate for commercial buildings. Portugal is in the process of updating its energy certification system to meet the requirements of the revised EPBD, and expects the updated certification system to be implemented in 2021.

The Financial Instrument for Urban Renovation and Revitalisation 2020 (IFRRU 2020) was created in 2014, with funding from POSEUR, the European Investment Bank and the Council of Europe Development Bank. IFRRU 2020 provides co-financing for loans supporting deep renovation of buildings that are 30 years old or older. The share of the loan provided by IFRRU has an interest rate of zero, resulting in a cost of capital lower than would be available at normal interest rates (IFRRU 2020, 2020a). The renovations supported by IFRRU use the detailed information in the SCE building certificate to determine which efficiency measures should be implemented. The programme started in 2015 and will run through 2025, with a total budget up to EUR 1.4 billion. As of 2020, IFFRU 2020 (2020b) had invested EUR 731 million to support renovation projects, resulting in annual energy savings of 31 ktoe per year.

The Casa Eficiente 2020 Programme, introduced in 2018, provides loans on favourable terms for renovations to improve the environmental performance of private housing with a special focus on energy and water efficiency. Casa Eficiente 2020 has a budget of EUR 200 million for 2018-21, with EUR 100 million from the European Investment Bank and EUR 100 million provided by participating private banks (Caixa Geral de Depósitos, Millennium BCP and Novo Bank).

A number of laws passed since 2013 provide a legal framework to support the construction of NZEBs. As of January 2019, all new buildings owned or occupied by a public entity need to satisfy NZEB requirements. Starting in January 2021, all newly constructed or majorly renovated private buildings with an area greater than 1 000 square metres (m²) need to satisfy NZEB requirements.

The Energy Efficiency Programme for Public Administration (ECO.AP) is a set of building energy simulation tools used by the government to provide a preliminary assessment of current energy performance and the potential impact of energy efficiency measures. The programme set an initial target of reaching a 30% reduction of energy demand from government buildings by 2020. Since 2011, public administration entities must nominate local energy managers, implement energy efficiency measures and report their consumption using the ECO.AP Barometer tool, which publicly discloses the energy performance of all public buildings and services. ECO.AP was developed by the LNEC in collaboration with ADENE, with co-funding from POSEUR.

Portugal's energy labelling of appliances and the requirements for minimum energy performance standards are based on EU directives and regulations. The labelling system applies mainly to products intended for the final consumer and less to equipment which is sold in the business-to-business market. More recently, however, an increasing number of products are being labelled, reflecting the desire to expand the promotion of efficient equipment along the value chain. In terms of public awareness, Portugal ranks higher than the EU average on the knowledge of labels and influence on purchasing equipment (EU, 2020).

In 2013, ADENE launched the Class+ system for labelling products used in building renovations. This system aims to address the absence of mandatory EU efficiency labelling for windows. Private companies can request their products to be labelled on a voluntary basis to distinguish themselves in the market. Under the Class+ system, 35 000 labels were issued for windows used in renovation projects from 2013 to 2018. In 2021, ADENE plans to extend the Class+ labelling system to buildings insulation and to introduce other product-specific labelling systems.

To promote energy efficiency at the water-energy nexus in buildings, ADENE introduced the AQUA+ system in 2020. AQUA+ audits, evaluates and rates water use infrastructure (the building water supply system, pools, irrigation), including those with high energy consumption, such as hot water production and water distribution, along with rainwater harvesting and grey water reuse. At the end of 2020, 150 professionals had been trained to perform AQUA+ audits in residential buildings and in 2021 training will be extended to hotels and other commercial buildings and AQUA+ will aim to increase the integration of water-energy nexus criteria into new construction and renovation projects.

Portugal has developed some measures for lighting efficiency, such as taxation on the production and importing of low-efficiency light bulbs. This tax is proportional to the difference in energy demand of a light bulb compared to the high efficiency alternative for the same level of lumens, and to the reference carbon price. For example, incandescent light bulbs are taxed at EUR 0.41 per unit and high-pressure mercury vapour lamps at EUR 6.77 per unit. The revenues from the tax support other efficiency measures, including the Energy Efficiency Fund.

As part of the European Green Deal, the EU launched the renovation wave initiative in December 2019. Under this initiative, each EU member country must submit a new long-term building renovation strategy to foster investment in the renovation of residential and commercial buildings. In February 2021, the government published the Portuguese Long-Term Renovation Strategy promoting building renovation through indicative objectives for renovated area, primary energy savings and reduction of hours of discomfort for 2030, 2040 and 2050 (Table 4.1). The strategy also defines measures to help achieve these objectives.

Table 4.1 Long-Term Renovation Strategy objectives, 2030, 2040 and 2050

Objective	2030	2040	2050
Renovated area (m^2)	363 680 501	635 637 685	747 953 071
Primary energy savings (versus 2018)	11%	27%	34%
Reduction of hours of discomfort (versus 2018)	26%	34%	56%

Portugal has social tariffs that provide lower electricity and natural gas costs for households that meet certain socio-economic requirements. Since 2016, the tariff has been automatically awarded to qualifying households. In 2019, around 14% of Portuguese households benefited from at least one of the social tariffs, with around 800 000 households receiving the electricity social tariff and around 35 000 households receiving the gas social tariff (ERSE, 2020).

The government had planned a pilot project for 2021 to examine a potential LPG social tariff. However, due to the limited interest from municipalities and LPG suppliers, in February 2021 the government cancelled the LPG social tariff pilot project. Instead, the government aims to implement a programme that will help households to transition from LPG heating and cooking to electric heating and cooling (Silva, 2021).

Assessment

In 2019, Portugal's primary energy consumption was 22.1 Mtoe and final energy consumption was 17.1 Mtoe. Portugal has 2020 targets to reduce PEC to 22.5 Mtoe and FEC to 17.4 Mtoe. European Environmental Agency estimates indicate that Portugal will achieve its 2020 energy efficiency targets. Portugal's NECP sets 2030 energy efficiency targets for PEC of 21.5 Mtoe and for FEC of 14.9 Mtoe. The European Commission has indicated that these targets are modest and noted that while the NECP provides a good level of detail on the various energy efficiency measures and programmes, there are no clear data indicating the level of energy savings expected. So it remains unclear if current measures are sufficient to reach the 2030 energy efficiency target. In addition, the updated EU-wide GHG reduction target of 55% may require Portugal to increase its 2030 energy efficiency targets.

Energy intensity in Portugal is low compared with other IEA countries. This is related to the structure of the Portuguese economy, which is concentrated on the service sector and tourism. Achieving the 2030 energy efficiency targets will require considerable effort, especially in improving the energy intensity of buildings and transport, which require more ambitious policies and legal frameworks, as well as significant investments.

Energy efficiency requires strong co-ordination of national, regional and local authorities. At the national level, several organisations share responsibilities for promoting energy efficiency, including the ERSE, the DGEG, the Portuguese Environment Agency, the National Laboratory of Energy and Geology, ADENE, and the Institute for Mobility and

Transport. These organisations should work hand in hand to proactively and collaboratively develop appropriate policy options, implementation and follow-up. Cross-agency initiatives or task forces can be a good mechanism for prioritising whole-of-government challenges like energy efficiency improvements. There is also a need for multi-level stakeholder dialogue that includes businesses, regional and local governments, and civil society, who are ultimately responsible for implementing many of the energy efficiency measures. The buy-in and active co-operation of all stakeholders is needed for effective implementation of energy efficiency.

In 2019, the transport sector was responsible for 35% of total final energy consumption, industry 34% and buildings 25%, with the remaining 6% coming from agriculture, forestry and fishing. Industry has historically been the largest energy-consuming sector, but industrial demand has been declining since 2005. In comparison, transport demand has slowly increased and has accounted for the largest share of energy demand since 2016.

Around 94% of transport sector demand is covered by oil products, in particular diesel, which accounts for 71% of final energy use in the transport sector. Currently, electricity represents only 1% of final energy use in transport. Road transport is the primary mode for freight and passengers. The European Alternative Fuels Observatory estimated that at the end of 2020, there were 35 504 BEVs and 25 372 PHEVs in Portugal, together equal to just over 1% of the total passenger vehicle fleet, which is the ninth-highest share among EU countries and is higher than the EU median value of 0.51%.

Portugal set an ambitious objective for decarbonisation of the transport sector, in particular through the deployment of EVs. However, this ambitious goal needs to be underpinned by solid policies and implementation measures to increase the number of electric vehicles, with a strong focus on expanding the charging network and continuing to offer charging schemes for consumers that are flexible and open to new players. The government has introduced notable subsidies and tax advantages for electric vehicles that should help to drive deployment. The NECP contains numerous action items to expand EV charging infrastructure; however, details on these programmes and their implementation are limited and it remains unclear how charging infrastructure will be rapidly expanded in line with the government's goals for transport decarbonisation.

It is also important to prioritise sustainable, affordable, widespread and easy-to-use infrastructure for public transportation, biking and walking in cities, as well as to improve the long-distance rail network to connect major cities and to support rail freight, which is significantly more efficient than road freight. The rail network should be modernised and better connected to the rest of Europe to accommodate for a larger share of freight, as well as Portugal's growing tourism sector. More clarity is needed on policy and support measures for decarbonising maritime transport, which is responsible for a significant share of Portugal's imports in all areas. In addition, the future role of sustainable biofuels and hydrogen within the transport sector is unclear. A road map for the decarbonisation of heavy-duty vehicles, rail, maritime and aviation is needed.

In 2019, around 1 200 industrial facilities participated in the SGCIE, the main programme driving industrial energy efficiency. However, the SGCIE seems to exclude a significant number of industrial facilities and companies and only a small number of companies attempt to use public incentives to invest in energy efficiency. The government needs to improve industrial energy efficiency legislation, extending the SGCIE requirements to conduct energy audits and set energy-saving objectives to a larger number of industrial energy consumers. This can be achieved by changing SGCIE registration from facility-based to company-based, which would significantly increase its scope. It is also important to allocate sufficient resources to follow up, support and ensure the implementation of the energy-saving objectives and measures that companies proposed under the SGCIE.

Under the SCE, all residential and commercial buildings in Portugal must undergo an audit to receive an energy rating certificate when they are constructed and every time the building changes ownership or is leased. In 2019, nearly half of the building stock had an SCE certificate (around 2 million dwellings/buildings). The SCE certificate database offers a wealth of information on the building stock that could be used to inform energy efficiency and distributed renewable energy programmes, and identify business opportunities for the construction sector.

A significant share of Portugal’s population has difficulties maintaining thermal comfort in their homes. In 2019, around 20% of the population lived in conditions of energy poverty, while around 14% of Portuguese households benefit from at least one of the social tariffs, with around 800 000 households receiving the electricity social tariff and around 35 000 receiving the gas social tariff (ERSE, 2020; EU Energy Poverty Observatory, 2020).

Social tariffs that reduce energy costs can increase energy demand unless actions are also taken to improve the efficiency of buildings and appliances available to low-income households. Financing renovations of residential buildings owned and rented by vulnerable consumers who benefit from social tariffs will contribute to a more transparent and well-functioning energy market, as well as reduce the levels of energy and heat poverty across the country. Use of the EEO should be considered in this context, as well as the opportunity created by the EU Recovery and Resilience Facility. This would also contribute to the creation of jobs and growth in the construction sector. The government should ensure that the energy efficiency related measures are considered during the development of the National Strategy to Tackle Energy Poverty and the National Strategy to Combat Poverty and that measures addressing energy poverty support the achievement of decarbonisation goals.

Actors involved in the design and implementation of building efficiency programmes such as the IFRRU and Casa Eficiente 2020 can build on achieved successes and lessons learnt. For the IFRRU 2020 programme, the DGEG and ADENE provided technical support in designing the programme, adjusting the energy performance certification schemes and identifying budget limits by types of measures. Regarding the Casa Eficiente 2020 programme, uptake is impeded by high interest rates. Energy renovation programmes need to target specific building types and building ownership structures to be more attractive to owners and investors, and it is likely that a combination of grant and loan support is needed. The government should also consider dedicated programmes targeting the renovation of homes owned and occupied by vulnerable consumers.

Building renovation programmes should take a holistic approach that includes all of the actors involved and examines the opportunity for combining energy efficiency with distributed renewable energy, digitalisation and other measures. The integration of digital and distributed energy technologies (PV, solar thermal, battery storage) and electrification (heat pumps, induction cooking) into renovation projects and requirements for the inclusion of these measures into new housing would contribute towards cost-effective achievement of Portugal’s targets for energy efficiency, renewables and electrification. Where possible, the government should combine programmes for building energy efficiency, electrification and distributed renewable energy (including supporting technologies like energy storage and demand response).

In December 2020, Statistics Portugal started conducting the first new survey of residential energy demand since 2010. The new survey should be completed in April 2021 and the DGEG has indicated that going forward, it aims to conduct a survey at least every five years to ensure that policy makers have accurate data on residential energy demand. The IEA strongly encourages Portugal to conduct these surveys on a regular basis and to ensure that the data collected are used to drive policy making and are made easily available to the various agencies and entities working on energy efficiency.

There are strong opportunities for energy efficiency in non-residential buildings, especially through the deployment of digital tools to support demand-side management. It is important to ensure that these buildings are well maintained and operated efficiently. In this context, smart metering and building automation can open new opportunities.

The main driver for the promotion of energy efficiency in the public sector is the ECO.AP programme. However, this programme might not be sufficient to reach the proposed 30% energy-saving target by 2020, which corresponds to a reduction of 205 ktoe between 2008 and 2020. In 2019, the officially reported savings since 2008 were only 61 ktoe. The implementation of public procurement rules regarding energy efficiency investments and energy services as well as the lack of resources needed for outreach at the national, regional and local levels are key barriers to achieving the ECO.AP programme’s 2020 target and overall long-term objectives.

Real estate investors need to have a clear picture of the future requirements for the building sector and a stable legal framework. The finalised long-term renovation strategy and other building sector legislation will be important instruments to promote the structural changes needed to boost the energy performance and the comfort of buildings in Portugal.

In relation to EU directives such as the EED and the EPBD, the primary energy factor (PEF) is used to relate PEC with FEC for target setting. The PEF indicates how much primary energy (fuel or renewable source) is used to obtain a unit of electricity or usable thermal energy in FEC. A lower PEF reflects a higher average efficiency of an energy system. Currently, in the EU, the PEF is set to 2.5 (Directive 2012/27/EU), but discussion is underway to reduce it, to better reflect the high share of renewables in the EU energy system (Esser and Sensfuss, 2016). Portugal already has a high share of renewables, especially in electricity generation (54% of generation in 2019) and is aiming to substantially increase this share to 80% of generation by 2030. The government should consider lowering the PEF used for the building energy performance certification system (currently set to 2.5) to align it with the high and increasing share of renewable electricity and the ambition for a decarbonised economy based on electrification.

Behavioural sciences are increasingly being used to inform policy design to support the uptake of energy efficiency by consumers. The government should ensure that data on consumer behaviour are collected and used to inform overall energy efficiency policy and the design of support programmes, especially in relation to the uptake of EVs, increased use of public transport, biking and walking, and electrification and efficiency measures in buildings. Information on consumer behaviour should be made easily available to all stakeholders to drive energy efficiency implementation in Portugal, including by regional energy agencies.

Recommendations

The government of Portugal should:

- Use lessons learnt from current policies and funding programmes to design high-impact policies, improve the co-ordination of policy implementation among the responsible institutions in charge of promoting energy efficiency, and monitor the implementation of support measures.
- Prioritise deep renovation of public buildings and residences owned or rented by vulnerable consumers in order to reduce energy poverty, increase thermal comfort and support the achievement of decarbonisation goals.
- Develop a clear strategy for rapid electrification and the use of sustainable biofuels and hydrogen in the transport sector. Reduce the use of private cars and promote the use of railway to transport people between major cities and for international freight.
- Reform the energy management scheme (SGCIE) to increase the number of companies covered and increase its energy-saving ambition. The DGEG and ADENE should follow up and support companies to access technical and financial resources to implement cost-effective energy efficiency measures.
- Strengthen the technical and financial resources of regional energy agencies to support cities and regions in implementing energy programmes. Regions, cities and civil society should be involved in the co-creation, design, implementation and follow-up of national policies and programmes.

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5. Renewable energy

Key data (2019)

Renewables in total final energy consumption (TFEC): 4.4 Mtoe/28%

IEA median renewables share: 15.5% of TFEC

Renewables in electricity generation: 27.4 TWh (wind 26.4%, hydro 17.0%, bioenergy 6.5%, solar 2.6%)

Renewable shares:* gross final consumption 30.6%, electricity 53.8%, heating and cooling 41.6%, transport 9.1%

EU total renewable shares:* gross final consumption 19.7%, electricity 34.1%, heating and cooling 22.1%, transport 8.9%

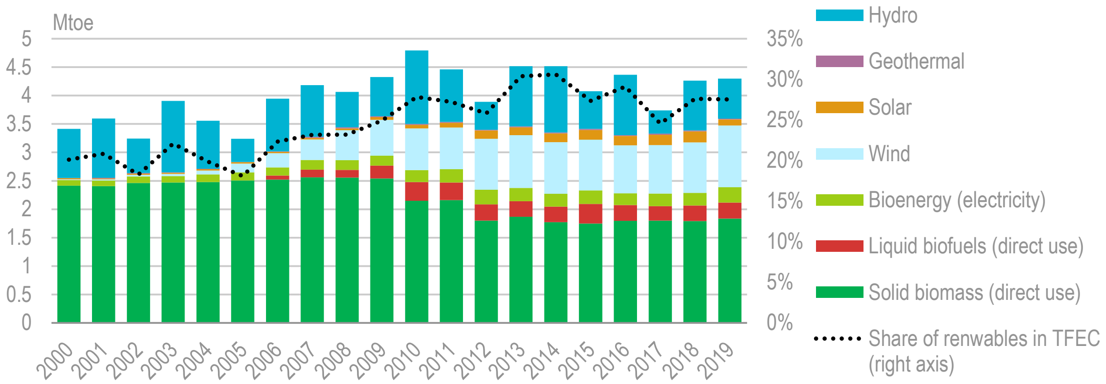
* Computed according to Eurostat definitions for consistency with EU targets.

Overview

From 2000 to 2019, Portugal's renewable energy supply increased by 26%, to reach 4.4 million tonnes of oil equivalent (Mtoe) and 28% of total final energy consumption (TFEC) (Figure 5.1). This increase was driven mainly by a notable expansion in wind generation, along with a small but recently growing solar photovoltaic (PV) generation. Biomass, used primarily in industry and for residential building heating, is still the largest source of renewable energy in TFEC, but has been steady at just over 2 Mtoe since 2012. The renewable energy supply varies significantly from year to year because of high seasonal variability of Portugal's large hydropower generation fleet. In 2019, Portugal's share of renewables in TFEC (28%) was the eighth highest among IEA member countries and well above the 2019 IEA median of 15.5% (Figure 5.2).

Under the European Union (EU) Renewable Energy Directive (RED), Portugal has targets for renewables in gross final consumption (31% by 2020 and 47% by 2030), electricity (60% by 2020 and 80% by 2030), heating and cooling (34% by 2020 and 38% by 2030), and transport (10% by 2020 and 20% by 2030). Portugal's Roadmap for Carbon Neutrality 2050 (RNC2050) aims for renewables to play a key role in the decarbonisation of the economy, with goals for renewables to cover 71-72% of final energy consumption by 2040 and 86-88% by 2050. In 2019, renewables accounted for 30.6% of gross final energy consumption, 54% of electricity generation, 42% of heating and cooling demand, and 9% of transport demand (Figure 5.3). Portugal's policy to achieve its renewables targets is focused on increasing renewable electricity generation while accelerating the electrification of all demand sectors and decarbonising the gas supply with biomethane and renewable hydrogen.

Figure 5.1 Renewable energy in total final energy consumption in Portugal, 2000-19

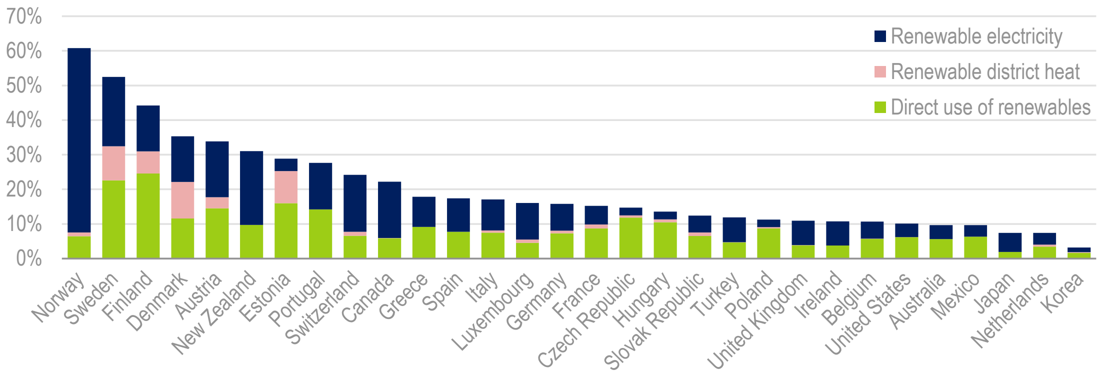


From 2000 to 2019, Portugal's renewable energy supply increased by 29%, to reach 4.4 Mtoe and 28% of TFEC.

Notes: Mtoe = million tonne of oil equivalent. TFEC = total final energy consumption.

Sources: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics; EC (2021), *Energy from Renewable Sources*, https://ec.europa.eu/eurostat/web/energy/data/shares.

Figure 5.2 Renewable energy in total final energy consumption, IEA comparison, 2019

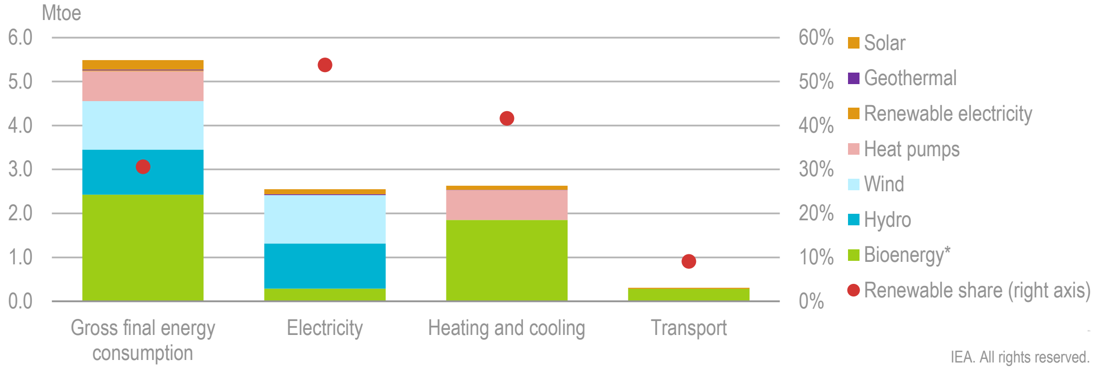


In 2019, Portugal's share of renewables in TFEC (28%) was the eighth highest among IEA member countries and well above the IEA median of 15.5%.

Note: *Bioenergy* includes solid biomass, renewable waste, liquid biofuels and biogas and excludes non-renewable waste.

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

Figure 5.3 Renewable energy in key metrics, Portugal, 2019



Bioenergy has the largest share of renewable energy supply in Portugal followed by wind and hydro generation, heat pumps, and small contributions from solar and geothermal.

* *Bioenergy* includes primary solid biofuels, renewable waste, liquid biofuels and biogas, and excludes non-renewable waste.

Note: Mtoe = million tonne of oil equivalent. Shares of renewables computed using the Eurostat definition for consistency with EU and national targets.

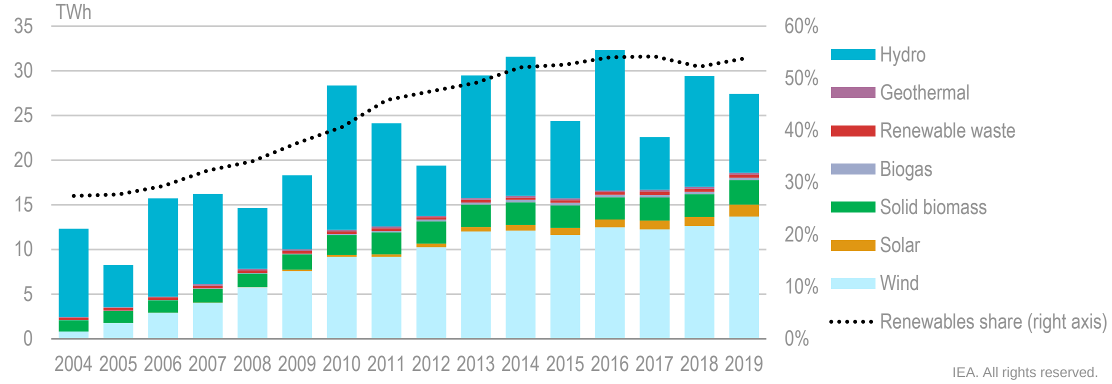
Source: EC (2020a), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

Renewable energy supply

Renewable electricity

From 2004 to 2019, the share of renewable energy in Portugal's electricity generation grew from 27% to 54%, to reach 27 TWh (Figure 5.4).

Figure 5.4 Renewable energy in electricity generation in Portugal, 2004-19



Renewable electricity from wind increased significantly between 2004 and 2013, but has stabilised in recent years. Hydropower fluctuations are smoothed out in the Eurostat share computation.

Notes: TWh = terawatt hour. Share of renewables is computed using the Eurostat definition for consistency with EU and national targets.

Sources: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics; EC (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

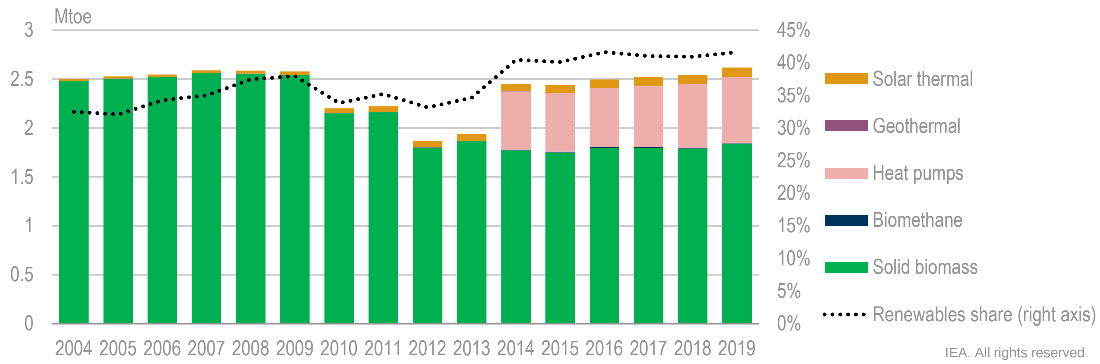
This growth was driven primarily by a rapid increase in wind generation from 2004 to 2013, which was supported through a feed-in tariff (FIT) for renewable generation. Portugal eliminated the FIT for renewable energy projects commissioned after November 2012, contributing to a sharp decline in the deployment of wind generation. From 2013 to 2018, wind generation remained relatively stable between 11.6 terawatt hours (TWh) and 12.6 TWh, but notably increased to 13.7 TWh in 2019.Electricity generation from renewables experiences major year-to-year variation driven by fluctuations in hydropower generation, which are linked to the different levels of annual rainfall, typical of the Portuguese climate. From 2008 to 2019, hydropower generation ranged between 6.8 TWh and 16 TWh. Generation from bioenergy (solid biomass, renewable waste and biogas) has not grown significantly since 2011, accounting for 6.5% of total generation (3.4 TWh) in 2019. Solar PV generation grew rapidly from 0.3% (0.16 TWh) in 2009 to 2.6% (1.3 TWh) in 2019. Geothermal, utilised only in the autonomous island region of the Azores, accounted for 0.4% of Portugal's generation in 2019 (0.22 TWh), with minimal growth since 2009.

The EU methodology for calculating the renewable share in electricity generation uses normalisation formulas for generation from hydro and wind generation. This normalisation has the effect of smoothing out the contribution of hydro and wind, as it averages the capacity factor of hydro generation over 15 years and wind generation over 5 years. As a result, the share of renewables in electricity for the purpose of estimating progress towards EU renewable energy targets has been relatively constant, at just above 50% from 2014 to 2018.

Renewable heating and cooling

In 2019, renewables covered 41.6% of Portugal's gross final energy consumption for heating and cooling. Solid biomass was by the largest source of renewable heating and cooling (70%), followed by heat pumps (26%), solar thermal (4%) and very small contributions from grid injected biomethane (0.3%) and geothermal (0.1%) (Figure 5.5).

Figure 5.5 Renewable energy in heating and cooling, Portugal, 2004-19



Renewable energy in heating and cooling consists mainly of direct use of solid biomass, although heat pumps have played a notable role since 2014.

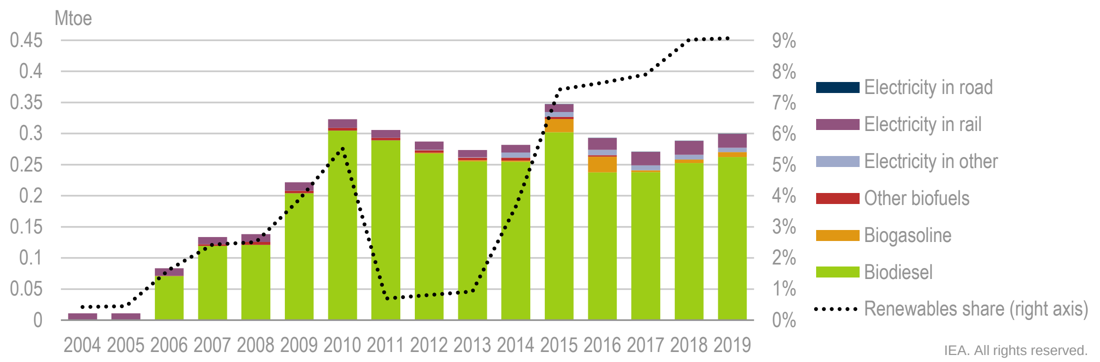
Notes: Mtoe = million tonne of oil equivalent. Share of renewables is computed using the Eurostat definition for consistency with EU and national targets.

Source: EC (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

Renewable transport

In 2019, renewables accounted for 5% of Portugal's transport energy demand. Biodiesel blended into road transportation fuels accounted for 87% of the renewables used in transport, along with small shares of biogasoline blended into road transport fuels and renewable electricity mostly supporting rail transport (Figure 5.6). From 2004 to 2010, EU accounting rules allowed a wide range biofuels to be considered when calculating the share of renewable energy in transport. Starting in 2011, the EU introduced sustainability criteria mandating that only certain advanced biofuels could be counted as renewables. EU accounting rules were also updated so that multipliers are applied to the shares of advanced biofuels and renewable electricity. Portugal's adoption of the EU standards for biofuel sustainability standards were delayed from 2011 to 2014; as such, during this period, only a small fraction of biofuels, produced from waste and/or residues, were counted towards the renewable share, although a notable share of biodiesel continued to be blended into road transport fuels. Under EU calculations, Portugal's renewable energy share was 9.1% in 2019.

Figure 5.6 Renewable energy in transport, Portugal, 2004-19



Renewables in transport come mostly from biodiesel blended into road transport fuels. The large variation in the renewable share results from changes in EU accounting rules.

Notes: Mtoe = million tonne of oil equivalent. Share of renewables is computed using the Eurostat definition for consistency with EU and national targets.

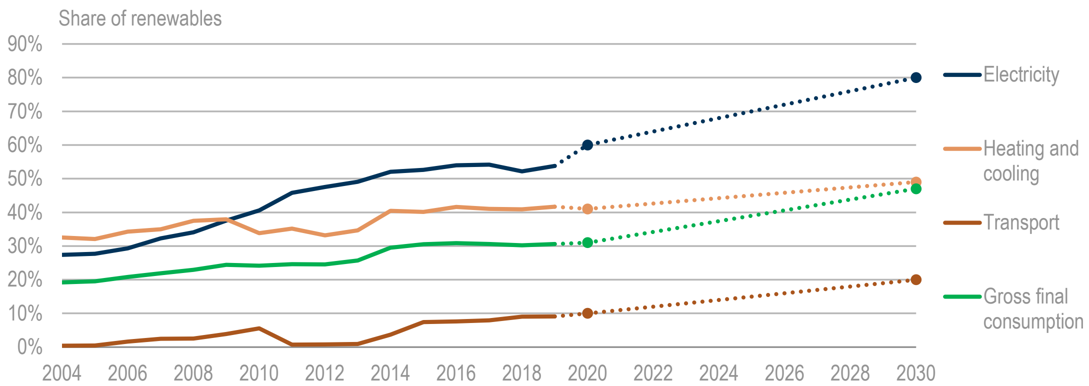
Source: EC (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

Targets

Under the RED, Portugal has 2020 and 2030 targets to achieve certain shares of renewable energy in gross final energy consumption, along with sub-targets for renewables in electricity generation, heating and cooling, and transport (Figure 5.7). Portugal's RNC2050 aims for renewables to play a key role in decarbonising the entire economy, with goals for renewables to cover 71-72% of final energy consumption by 2040 and 86-88% by 2050. Under the EU Clean Energy Package, the RED was updated to set an EU-wide target for a 32% renewable share in gross final energy consumption by 2030. Under the Clean Energy Package, each EU member state was required to submit a National Energy and Climate Plan (NECP) to the European Commission (EC) proposing national targets that contribute to the achievement of EU-wide 2030 targets for renewable energy, greenhouse gas (GHG) reductions and energy efficiency, and defining the measures to support these targets. Portugal's NECP was submitted to the EC in 2019 and was approved by Cabinet Resolution No. 53/2020 in July 2020.

As of 2019, Portugal had already achieved the 2020 target for renewables in heating and cooling. In December 2020, the European Environment Agency noted that Portugal is expected to achieve the 2020 targets for renewables in transport and gross final energy consumption, while further effort is needed to achieve the 2020 target of 60% for renewables in electricity (EEA, 2020). In November 2020, the EC provided comments on Portugal's NECP, noting that the 2030 targets for renewable energy are sufficiently ambitious to support achievement of the EU-wide 2030 target (EC, 2020b). However, it is likely that the 2030 EU-wide GHG emissions reduction target will be increased from 40% to 55%. IEA analysis indicates that about half of the emissions reduction needed to achieve a 55% GHG reduction target will need to come from increased renewables deployment (IEA, 2020). It is possible that Portugal will need to increase its 2030 renewable energy targets (and GHG and energy efficiency targets) to help achieve the EU-wide 55% GHG reduction.

Figure 5.7 Portugal's 2020 and 2030 renewable energy targets and status, 2004-19



Renewable energy share	2019 status	2020 targets	2030 targets
Gross final energy consumption	30.6%	31%	47%
Electricity	54%	60%	80%
Heating and cooling	42%	41%	49%
Transport	9%	10%	20%

Under EU directives, Portugal has 2020 and 2030 targets for renewable energy in gross final consumption, electricity, transport, and heating and cooling.

Source: EC (2021), *Energy from Renewable Sources* (database), https://ec.europa.eu/eurostat/web/energy/data/shares.

Policies and support measures

Renewable electricity

Portugal intends to achieve a significant portion of its renewable energy targets and long-term decarbonisation goals through electrification in all demand sectors combined with decarbonisation of its electricity supply. The NECP indicates that to achieve 2030 targets, the installed capacity of renewable electricity generation needs to grow from 14.1 gigawatts (GW) in 2019 to 27.4 GW by 2030 (Table 5.1). Most of this growth is expected to come from a near tenfold increase in solar PV capacity, followed by a near doubling of wind capacity (including some floating offshore wind) and some expansion of hydropower capacity (especially for pumped hydro). The RNC2050 indicates that electricity should cover 32-33% of Portugal's energy demand in 2030 and 66-68% in 2050 (electricity covered 25% of energy demand in 2018). The RNC2050 also has 2050 goals for 100% of the electricity supply to come from domestic renewable energy and for the transport sector to be fully decarbonised, primarily through electrification.

Portugal has several measures to support renewable energy deployment. A FIT drove strong deployment of wind generation from 2004 to 2012. As a result of the financial crisis, Portugal eliminated the FIT for renewable energy projects commissioned after November 2012. Qualifying projects commissioned before this date continue to receive FIT payments of EUR 74-270 per megawatt hour (MWh) for 12-25 years from the project commissioning, with payment level and period of eligibility depending on technology[1] (Jimeno, 2019).

Table 5.1 Renewable generation capacity, 2019 status and targets for 2020, 2025 and 2030

Generation capacity (GW)	2019	2020	2025	2030
Hydro	4.5	4.3	4.6	4.6
Hydro with pumped storage	2.8	2.7	3.6	3.6
Hydro: Total	**7.3**	**7**	**8.2**	**8.2**
Onshore wind	5.2	5.4	6.7	9.0
Offshore wind: Floating	0	0.03	0.1	0.3
Wind: Total	**5.2**	**5.43**	**6.8**	**9.3**
Solar PV: Centralised	0.4	1.5	5.8	7.0
Solar PV: Decentralised	0.5	0.5	0.8	2.0
Solar PV: Total	**0.9**	**2.0**	**6.6**	**9.0**
Concentrated solar power	0	0	0.1	0.3
Biomass	0.7	0.4	0.4	0.5
Geothermal	0.03	0.03	0.03	0.06
Wave	0.0004	0.001	0.03	0.07
Total	**14.1**	**14.9**	**22.1**	**27.4**

Following the economic recovery, the government reintroduced a limited FIT in 2014, supporting small-scale PV, biogas, biomass and hydro projects. The updated FIT is only available for small production units (UPP), with a maximum capacity of 250 kilowatts (kW). In 2018, the government increased this FIT to EUR 95 per MWh. PV and hydro receive the full FIT rate, while biomass and biogas receive 90% of the full rate (Jimeno, 2019). The government is also supporting small-scale distributed generation by encouraging the development of energy communities and self-consumption of renewable electricity. New regulations passed in 2019 give a seven-year exemption on payment of 50-100% of grid access tariffs for energy communities and self-consumption of renewable electricity.

In 2018, the government approved the construction of the Alto Tâmega Hydroelectric Complex on the Tâmega River in northern Portugal. The complex will consist of three new

[1] 74-75 EUR/MWh for wind for 15 years or 33 GWh, 91-95 EUR/MWh for hydro up to 10 MW for 25 years, 102-117 EUR/MWh for biogas for 25 years, 102-119 EUR/MWh for biomass for 15 years, 257 EUR/MWh for PV for 20 years or 34 GWh, and 270 EUR/MWh for geothermal for 12 years.

dams with a total installed capacity of 1.16 GW, of which 0.88 GW will be pumped hydro. The project is being constructed by Iberdrola at an estimated cost of more than EUR 1.5 billion. The project started construction in 2018 with project operation expected to start in 2023 or 2023 (Iberdrola, 2021).

In February 2019, the government approved the 2018-27 infrastructure development plan of the electricity transmission service operator (TSO), REN. Based on comments from the Energy Services Regulatory Authority (ERSE) in July 2018, REN updated the plan to include additional infrastructure investments to support the integration of renewables, including two new transmission lines to support the deployment of PV projects in Portugal's southern regions of Alentejo and Algarve, which have one of the best solar PV resources in Europe (Bellini, 2019).

In June 2019, Decree-Law No. 76/2019 amended the grid connection process for projects with a capacity greater than 1 MW, with the aim to foster renewables deployment while ensuring that the grid can support the integration of expanding renewable generation. Under this law, electricity generation projects (including renewable energy) must be granted a network capacity reserve title (TRC) by the relevant network operator (TSO or distribution service operator [DSO]) before the project can apply for a production licence, which is needed to start construction and to deliver electricity to the grid. There are three options for the granting of a TRC.

- **General access:** If there is sufficient network capacity available, the network operator grants the TRC. The applicant must pay a security deposit of EUR 10 000 per mega-volt ampere (MVA) of capacity, which is refunded upon the issue of a production licence.
- **Direct agreement:** In the absence of sufficient network capacity, the applicant and the network operator may enter into an agreement under which the applicant will finance all network-related costs required to connect the project. The applicant must pay a security deposit corresponding to the greater amount of either 5% of the related grid investment to connect or EUR 10 000/MVA of capacity.
- **Auctions:** The government can also conduct auctions of TRCs for specific geographic areas. Auctions are announced in the Portuguese Official Gazette and the Directorate-General for Energy and Geology (DGEG) website posts auction rules, criteria for awarding bids, remuneration and other details (CMS, 2020). OMIP, the operator of the Iberian electricity market (MIBEL), is responsible for running the auction process (OMI, 2020).

Each year, the TSO and DSO publish network characterisation reports on their websites. One of the elements covered in the reports is the available network capacity for new connections per electrical substation or group of electrical substations. Since the adoption of the amended grid connection process in 2019, the TSO has awarded a significant number of TRCs under the general access and direct agreement options. There have also been two auctions of TRCs for PV projects.

From June 2019 to March 2020, the TSO received 731 connection requests for a total of 63.5 GW under the general access option that allocates existing network capacity. Due to the limited reception capacity of the transmission network, the TSO was only able to allocate 13 TRCs totalling 971 MW (88.2 MW to wind projects and 882.8 MM to solar PV projects). Over the same period, the TSO received 741 connection requests, for a total of 142 GW under the direct agreement options that requires projects to pay for the needed network upgrades to support their connection. As of 2020, the TSO had reached initial agreements to issue 14 TRCs totalling 3.5 GW (all to PV projects) and is in the final stages of negotiation with the project developers, with final contracts expected to be signed in 2021.

Due to the large number of applications for TRCs under the general access and direct agreement options, the DGEG prepared a special directive in February 2020 regarding the process to evaluate and prioritise pending TRC requests, which included projects for solar PV and wind, including many with associated battery storage. The TSO is co-operating with the DGEG to support timely evaluations of these TRC applications.

The first auction for TRCs was held in August 2019. It only allowed bids from solar PV projects in the southern regions of Alentejo and Algarve and required that projects contribute to lowering electricity tariffs. The auction awarded TRCs to 23 PV projects with a total capacity of 1.15 GW. Winning bids were below historic electricity spot market prices, with the lowest bid at EUR 14.7/MWh. Projects selected in the 2019 auction must be operational before 2023 or they will lose the awarded capacities titles (Bhambhani, 2019).

The government planned to hold two PV auctions in 2020; however, as a result of the Covid-19 pandemic, the first auction was delayed (from April to July) and the second auction was cancelled. The July 2020 auction was for 0.7 GW of capacity titles and awarded 0.67 GW (with the lowest bid at EUR 11.1/MWh). This auction also required deployment in the southern regions of Alentejo and Algarve. Winning projects were awarded permanent grid access and 15-year power purchase agreements. Eight of the 12 auction slots, totalling 483 MW (72% of the awarded capacity), went to projects under a bid option requiring energy storage and should result in the deployment of at least 100 MW and 100 MWh of battery storage.

Because of the structure of the auction, the majority of the winning projects will be required to make annual payments to the TSO averaging EUR 37 000 per MW of project capacity per year. These payments are intended to cover the cost of grid infrastructure required to securely connect the PV projects. Projects selected in the 2020 auction need to be operational before 2024 (Inspiratia, 2020).

Starting in 2021, the government plans to hold two PV auctions per year to award a total capacity of 1.0 GW. To address concerns over limited grid capacity, the government is exploring various locations for future PV auctions, including an option for floating PV deployed on hydropower reservoirs (Scully, 2020).

In April 2020, the government fast-tracked the permitting and grid connection of 220 small-scale PV projects with a total capacity of 30 MW. This action was taken as part of the overall response to limit the impacts of the Covid-19 pandemic on the economy and Portugal's energy transition (Bellini, 2020).

The government sees a role for Portugal to play in demonstrating the viability of floating offshore wind generation and has approved six sites for floating offshore wind deployment. The NECP indicates that floating offshore wind capacity should reach 0.3 GW by 2030. Portugal's first floating offshore wind project, WindFloat Atlantic, became fully operational in July 2020. The project consists of three floating turbines with a total capacity of 25 MW, which are connected via a 20 kilometre-long subsea cable to the substation at Viana do Castelo (Offshore, 2020). Government policy for onshore wind is focused on repowering of existing wind farms. The NECP also notes that Portugal has significant onshore wind generation potential that has yet to be explored, but does not specify which policies or measures will support increasing onshore wind capacity in line with the target for 9 GW in 2030.

Renewable heating and cooling

Portugal has already achieved the 2020 target for a 41% share of renewables in heating and cooling. The NECP set a target for this share to increase to 49% by 2030, with solid biomass continuing as the main source followed by heat pumps.

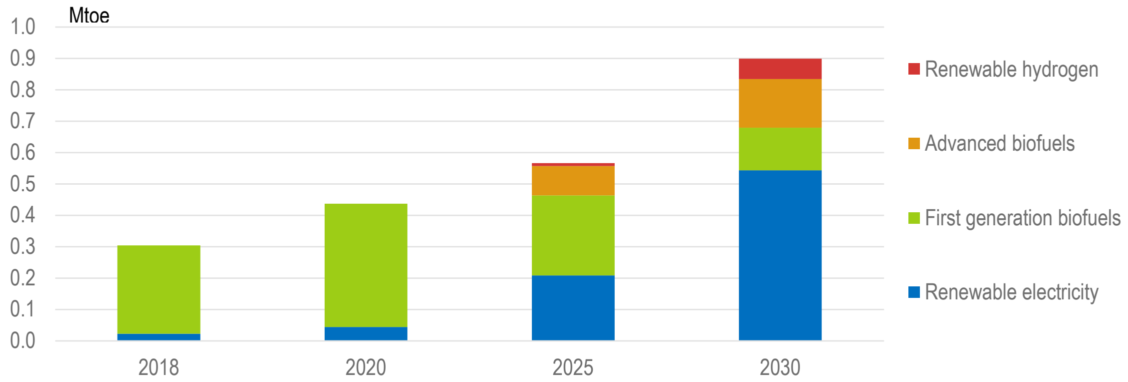
Portugal's national building code requires the installation solar thermal heating systems with a minimum size of 1.0 square metre (m^2) per building occupant (or other renewable energy systems providing a similar energy saving). The obligation only covers certain buildings, e.g. those with a roof oriented from southeast to southwest. Portugal has a 2020 target for 2.2 million m^2 of solar thermal collectors. In 2016, Portugal had around 1.2 million m^2 of collectors (SHC, 2020).

Portugal is in the process of applying the nearly zero-energy building (NZEB) standard to all new construction, which will be included in the Long-term Strategy for Building Renovation. This and other aspects of building regulations and building-related energy efficiency policy set requirements and offer support for distributed renewable energy covering heating and cooling, and electricity generation through various building and industry energy efficiency programmes (see Chapter 4).

Renewable transport

Portugal's NECP aims to increase the share of renewables in transport primarily though increased use of renewable electricity, along with a transition to advanced biofuels and the introduction of renewable hydrogen (Figure 5.8). Support for the electrification of transport is focused on the deployment of electric vehicles (EVs) and EV charging infrastructure (see Chapter 4). The RNC2050 indicates that electricity should cover 36% of passenger vehicle mobility demand by 2030 and 100% by 2050.

Figure 5.8 Renewables in transport, 2018 status and 2020, 2025 and 2030 targets, Portugal



Note: Mtoe = million tonne of oil equivalent.

Source: EC (2019), *Portugal: National Energy and Climate Plan 2021-2030 (NECP 2030)*, https://ec.europa.eu/energy/sites/ener/files/documents/pt_final_necp_main_en.pdf.

Portugal introduced a biofuel blending obligation in 2009 to support the achievement of the 2020 target for a 10% share of renewables in transport. The obligation requires fuel suppliers to blend a certain share of biofuels into automotive diesel and gasoline, with the share increasing progressively from 6% in 2009 to 10% in 2020. In 2010, Portugal reduced the energy products tax (ISP) from domestic small-scale biofuels producers (those producing less than 40 000 tonnes per year), which resulted in a total tax savings of EUR 5 million for small-scale biofuels producers from 2014 to 2017.

In December 2017, Portugal passed a law transposing EU Directive 2015/1513, which promotes the production and use of advanced biofuels and seeks to limit the use of first-generation biofuels (those produced from crops that can be used as food or animal feed). The National Plan for the Promotion of Biorefineries, approved in October 2017, promotes the production advanced biofuels. Decree-Law 8/2021 set biofuels blending targets for 2021 and the government is working to transpose the EU requirements for biofuels. The NECP shows a slight reduction in overall biofuels consumption in transport by 2030, but with a notable growth in the share of advanced biofuels and a focus on EVs.

Renewable gases

The government has goals to decarbonise Portugal's gas supply through rapidly scaling up the production of a variety of renewable gases, primarily biomethane, through 2030. The government also indicates a key role for hydrogen and synthetic methane (both produced from renewable energy) in relation to long-term decarbonisation goals. The National Strategy for Hydrogen (EN-H2), approved in August 2020, foresees EUR 7-9 billion of investments by 2030 (85% coming from the private sector) to rapidly scale up the production and use of hydrogen made using renewable energy (primarily via electrolysis). The EN-H2 sets 2030 targets for renewable-based hydrogen to cover:

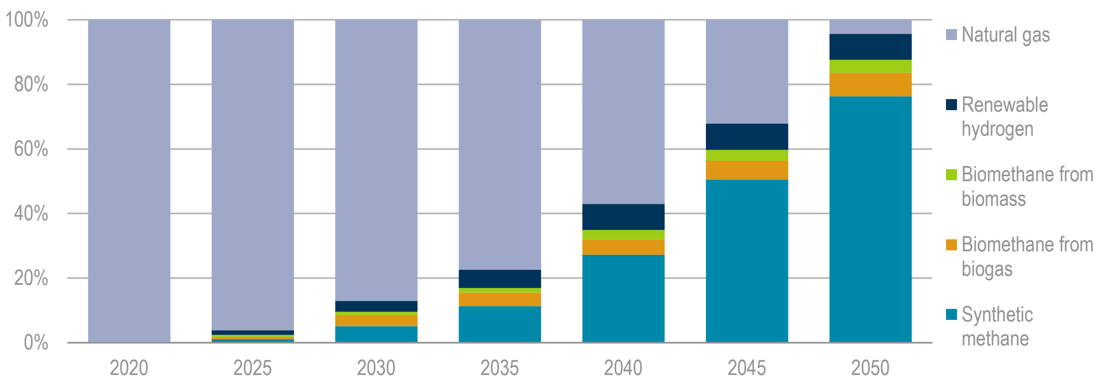
- 1.5-2% of final energy demand
- 2-5% of industry energy demand
- 3-5% of domestic maritime shipping energy demand
- 1-5% of road transport energy demand, supported by the deployment of 50-100 hydrogen filling stations
- 10-15% of the volume of gas delivered by the natural gas network.

The EN-H2 indicates that the hydrogen supply needed to achieve the envisaged level of hydrogen production will come from the deployment of 2-2.5 GW of electrolysis capacity by 2030. The electrolysis deployment target will be supported with EUR 500-550 million in government funding for operational costs and EUR 400-450 million in funding from the EU European Recovery Fund for capital costs. The EN-H2 indicates that in 2030, hydrogen produced in Portugal will be used primarily as an industrial feedstock for fuels and chemicals along with notable use for electricity and heat generation, injection into the natural gas network, and in transport. The EN-H2 indicates the around 36% of Portugal's 2030 hydrogen production would be exported. The EN-H2 notes that achieving progress on the targets of hydrogen production and use will require a notable effort to establish enabling legislation, regulations and standards.

The largest project detailed in the EN-H2 is a hydrogen production complex in the port of Sines. In July 2020, the private consortium managing the Sines project released an initial plan aiming for quick deployment of a 10 MW electrolyser pilot project and 1.0-1.5 GW of electrolyser capacity by 2030, with an estimated cost of EUR 400-450 million (Djunisic, 2020). In July 2020, the government selected 37 hydrogen plus renewable energy projects, including the Sines Project, for its application to the EU's Important Project of Common European Interest scheme for hydrogen (Goncalves, 2020). The EU released a Hydrogen Strategy in July 2020 indicating its plans to invest EUR 24-42 billion by 2030 to develop 40 GW of electrolysis capacity in Europe and another 40 GW in neighbouring regions (EC, 2020c).

The government has goals for the injection of renewable gases into the natural gas grid and sees this as a key option to support the achievement of renewable energy targets and long-term decarbonisation goals (Figure 5.9). The EN-H2 sets 2030 goals for 10-15% of the volume of gas delivered by natural gas networks to be hydrogen produced from renewable energy, and for biomethane to cover 4.5% of total energy demand (also primarily through injection into the natural gas grid). By 2050, the government intends for almost all of the gas delivered via the natural gas network to be renewable gas, with the largest share coming from synthetic methane.

Figure 5.9 Share of gases in Portugal's gas network by energy content, 2020 to 2050



Source: Lexology (2020), *A Simplified Guide to the Portugeuse Hydrogen Strategy*, www.lexology.com/library/detail.aspx?g=1492dd16-64f6-4d7a-a0eb-c88bce3b975f.

Decree-Law No. 62/2020 allows injection of renewable gases and low-carbon gases into the natural gas grid and defines a new market actor, the gas producer, that clarifies the status and role of renewable gas producers in market regulations. The law indicates that the EU standards for renewable gases will be used to determine eligibility for grid injection, while low-carbon gases must have a carbon footprint lower than 36.4 grammes of carbon dioxide equivalent (g CO_2-eq) per megajoule (MJ) to be injected into the gird.

The ERSE and the DGEG are still in the process of developing regulations to define the technical, quality and security requirements for renewable gases (including for grid injection) and licensing procedures for renewable gas producers. The NECP also indicates that by 2021, the government will assess the value of setting 2030 binding targets for grid injection of renewable gases and by 2022 a system of guarantees of origin for renewable gases will be implemented. The DGEG is developing the platform for pre-registration of gas producers and published the first call for proposals for production of renewable gases at the end of 2020.

Assessment

In 2019, renewables accounted for 30.6% of Portugal's gross final energy consumption (mostly from renewable electricity and direct use of bioenergy). Using EU calculations, renewables covered 54% of electricity generation (mainly wind and hydro), 42% of heating and cooling demand (mainly biomass and heat pumps), and 9% of transport demand (mainly biodiesel blended with road transportation fuels). Portugal has targets for renewable energy in gross final energy consumption (31% by 2020 and 47% by 2030), electricity generation (60% by 2020 and 80% by 2030), heating and cooling (41% by 2020 and 49% by 2030), and transport (10% by 2020 and 20% by 2030).

Portugal has already achieved the 2020 target for renewable heating and cooling and is expected to achieve the 2020 targets for transport and gross final energy consumption, but could miss the 2020 target for electricity. Further effort is needed to achieve all of the 2030 renewable energy targets. The 2030 EU-wide GHG emissions reduction target will likely be increased from 40% to 55% and it is possible that this will require Portugal to increase its 2030 renewable energy targets.

Portugal plans to meet its 2030 renewable energy targets by greatly expanding renewables electricity generation and increasing electrification across the entire economy. Under the NECP, Portugal aims to almost double the installed capacity of renewable electricity, from 14.1 GW in 2019 to 27.4 GW by 2030. Most of this increase would come from a near tenfold increase in solar PV capacity, a near doubling of wind capacity (including some floating offshore wind) and notable expansion of hydropower capacity (especially pumped hydro). The RNC2050 indicates that electricity should cover 32-33% total energy demand in 2030 and 66-68% in 2050. Electricity covered 25% of Portugal's energy demand in 2019. The RNC2050 also has 2050 goals for 100% of the electricity supply to come from domestic renewable energy and for the transport sector to be fully decarbonised, primarily through electrification. These are ambitious goals, which require a rapid and sustained deployment of renewable energy projects and notable electricity infrastructure investments to accommodate and safely integrate higher shares of variable PV and wind generation.

In 2019, the process to connect to the electricity grid was amended with the aim to foster renewables deployment while ensuring that the grid can support the integration of expanding renewable generation. Under the new process, all electricity generation projects must be granted a network capacity reserve title by the relevant network operator before the project developer can apply for a production licence. Network capacity reserve titles can be granted under standard procedures if the needed grid capacity is available; if not, the project developer must pay any costs related to grid infrastructure needed to connect the project. Network capacity can also be awarded through competitive auctions. The first auction was held in 2019 and awarded 1.15 GW of PV capacity. The 2020 auction awarded 0.67 GW of PV capacity with 72% going to projects required to build energy storage, which should result in the deployment of at least 100 MW and 100 MWh of battery storage. Projects from the 2019 auction must be operational by 2023; for the 2020 auction the deadline is 2024.

The government should develop a timetable for PV auctions that supports the achievement of the ambitious renewable energy targets. Auctions should have transparent procedures and bidding options that are advertised well in advance, based on international best practices. They should also take into account the lessons learnt from Portugal's previous auctions and auctions conducted by other countries. This would help to reduce risk, attract investors and lower deployment costs. Auctions should also select areas for project deployment that balance renewable resource quality, grid connection costs, and environmental and social concerns. Expanding the option of PV plus storage, or establishing auctions for storage, could also help with the integration of PV and other variable renewables and improve overall system flexibility. To help increase the rate of PV deployment, the government could also look at increasing the capacity offered in each auction and reducing the time between winning a bid and starting the operation of the project.

The government sees wind generation as playing a major role in the achievement of renewable energy targets. An FIT drove strong deployment of wind generation from 2004 to 2012. As a result of the financial crisis, Portugal eliminated this FIT for renewable energy projects commissioned after November 2012. Since 2012, the pace of wind project deployment has slowed. While the government strategy for wind generation focuses on repowering existing onshore wind farms, only a limited number of repowering projects have occurred and these projects were not offered a higher capacity grid connection. It remains unclear how the 3.6 GW of new onshore wind capacity indicated in the NECP will be deployed by 2030.

The government should take steps to ensure that repowering of wind sites can attract the needed investments and lead to increased generation. The government should also explore the option for new onshore wind projects, accounting for the latest (and future) technology developments in terms of turbines, resource mapping and wind forecasting. Such an assessment should account for environmental and public acceptance issues. Wind farm repowering and new wind farms should continue to consider local profit sharing. The government should also consider opening the current auction process to all renewable technologies or establishing wind-specific auctions.

The government is also pushing for Portugal to become one of the first countries in the world with significant floating offshore wind capacity and has approved six sites for floating offshore wind deployment. Portugal's first floating offshore wind park, with a capacity of 25 MW, became fully operational in July 2020. The NECP indicates that floating offshore wind capacity should reach 300 MW by 2030. The government should consider if floating offshore wind could make a larger contribution to renewable and decarbonisation goals, especially in the long term. Floating offshore wind can access very strong wind resources, avoids the complications of siting onshore wind and would help to diversify Portugal's future electricity mix. IEA analysis indicates that floating offshore wind will experience notable cost reductions in the coming years (IEA, 2019).

Hydropower has been a core aspect of Portugal's electricity system for decades and the government is planning on a continued expansion of hydro capacity to support the achievement of renewable energy targets. In 2018, the government approved the construction of a 1.16 GW hydro project, of which 0.88 GW will be pumped hydro. Construction has begun and the plant should start operating in 2022 or 2023. Hydro (especially pumped hydro) will be very helpful in supporting the integration of the high shares of variable PV and wind generation.

The EU Emissions Trading System scheme and the carbon tax applicable to coal and natural gas electricity generation support the competitiveness of renewables. In 2020, the additional cost from the Emissions Trading System and the carbon tax resulted in merchant renewable energy generators being placed ahead of coal and natural gas electricity generation in the merit order for market dispatching.

The government is supporting small-scale distributed generation by encouraging the development of energy communities and self-consumption of renewable electricity. The process of developing energy communities in Portugal is just beginning, but the limited deployment seen through 2020 indicates that there are numerous barriers that need to be addressed in terms of consumer education and empowerment, and the administrative processes for energy communities should be reviewed and simplified. The government should consider providing more assistance to regional energy agencies so they can assist local actors in forming energy communities. The government should also examine what role energy communities and distributed renewable generation can play in enhancing grid flexibility and supporting growth in EV charging infrastructure.

Bioenergy is the largest source of renewable energy in Portugal, covering 15% of the renewable energy supply in 2018. Solid biomass has by far the largest share of Portugal's bioenergy supply (78% in 2018) and is used mainly for industrial applications, primarily for co-generation, with the pulp and paper industry being the largest user. There is also notable use of solid biomass for residential heating and some electricity generation. Liquid biofuels accounted for 12% of the bioenergy supply in 2018 and almost all renewable energy in transport. A very small share of Portugal's electricity and heat generation comes from biogas.

Portugal offers some policy support for bioenergy. Biomass and biogas projects developed before 2012 will continue to receive payments under Portugal's original FIT for 15 years from the start of project operations for biogas, and for 25 years for biomass. The FIT established in 2014 supports biomass and biogas electricity generation, and there is a biofuels blending mandate for transportation fuels. The government would like to move away from biogas to projects that upgrade biogas to biomethane and inject it into the gas grid, and has set a 2030 target for biomethane to cover 4.5% of total energy demand (primarily through injection into the natural gas grid). However, there is not a clear policy to support the investments needed for the desired scaling up of biomethane productions.

There is a need to clearly identify the role sustainable bioenergy can play in all sectors to support the achievement of Portugal's 2030 renewable energy targets and long-term decarbonisation goals. This includes determining the types of uses, level of demand, clear sustainability requirements and domestic production capacity. A cost-benefit analysis should be conducted to determine which sectors and end uses can make the best use of limited bioenergy resources, and key technical, policy and regulatory barriers need to be identified and addressed with a clear strategy for cost-effective use of bioenergy.

Portugal is commended for having developed a National Strategy for Hydrogen with quantified 2030 targets for final consumption; injection into the national gas grid; and use in the industry, road transport and domestic maritime transport sectors. Importantly, Portugal has also set highly ambitious targets for installed electrolysis capacity and the construction of a hydrogen fuelling infrastructure. The IEA emphasises the need for the DGEG to take a leading role in operationalising, monitoring and reviewing the EN-H2 strategy. Implementation requires strong efforts in research and innovation, upscaling and deployment, all supported by international co-operation. The efforts require the development and implementation of an appropriate legal, policy and funding framework, and for the oversight by the Commission for Climate Action.

Recommendations

The government of Portugal should:

- Clearly identify the role sustainable bioenergy needs to play in all sectors to support cost-effective achievement of the 2030 and 2050 targets, and implement a policy that facilitates the development of a sustainable domestic bioenergy supply.
- Develop and publish a timetable for solar PV auctions and set higher auction volumes and requirements to accelerate deployment, increase investor confidence and reduce grid integration costs.
- Develop a clear policy that supports strong deployment of onshore and offshore wind generation, including the repowering of existing wind farms.
- Remove barriers to energy communities to accelerate the deployment of decentralised renewables in a manner that enhances system flexibility and avoids unfair impacts on the electricity tariffs of other consumers.

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6. Energy research, development and demonstration

Key data (2019)

Public energy RD&D spending:* EUR 53 million

Public energy RD&D share of GDP:** 0.025 (IEA median:*** 0.035)

* Source: DGEEC (2021a), *Research and Development (IPCTN)* (database), www.dgeec.mec.pt/np4/206.

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

*** Median of 25 IEA member countries for which 2019 data are available.

Overview

Portugal's overall research, development and demonstration (RD&D) policy is guided by a complex set of documents and processes that reflect the large number of actors involved in setting and implementing RD&D policy. While energy RD&D is given a significant role in Portugal's RD&D policy, there is no dedicated policy framework for energy RD&D. The National Energy and Climate Plan (NECP), the Roadmap for Carbon Neutrality (RNC20500) and the National Hydrogen Strategy (EN-H2) call for a sustained and dedicated effort on energy RD&D to support the achievement of Portugal's ambitious decarbonisation goals. The Technological and Business Innovation Strategy 2018-2030 serves as the main reference for innovation policy in Portugal through 2030, while 15 thematic agendas for research and innovation (including an agenda on sustainable energy systems) identify areas of RD&D aligned with Portugal's overall policy goals and RD&D capabilities.

Portugal's spending on energy RD&D fell in the aftermath of the 2008 financial crisis, but has grown in recent years as the economy has recovered. From 2013 to 2018, annual public spending on energy RD&D increased from EUR 42 million to EUR 65 million, with a decline to EUR 53 million in 2019. Private spending on energy RD&D also increased in line with economic recovery, growing from EUR 41 million in 2015 to EUR 69 million in 2019. To help to achieve its energy sector targets, Portugal is aiming to increase spending on energy RD&D, especially through higher leverage of European Union (EU) funds.

Institutions

The Ministry for Science, Technology and Higher Education, and the Ministry for the Economy and Digital Transition are the main institutions responsible for Portugal's RD&D

policy and funding. The Ministry for the Environment and Climate Action, and the Ministry for Planning are also involved in RD&D.

The Directorate-General for Energy and Geology (DGEG) within the Ministry for the Environment and Climate Action is responsible for monitoring and reporting on the funding, implementation and results of energy RD&D. In line with recommendations from the previous IEA energy policy review of Portugal, the DGEG created a Research and Innovation Unit that is responsible for the promotion and monitoring of renewable energy technologies and conducts strategic studies, research and scenario-based analysis that provides inputs on national policy design, including the NECP and the EN-H2.

The Foundation for Science and Technology (FCT) is a public agency under the responsibility of the Ministry for Science, Technology and Higher Education whose mission is to boost Portugal's RD&D capabilities in all fields. The FCT manages programmes that award the majority of Portugal's public RD&D funding. The FCT also supports the participation of Portugal's RD&D community in international projects and encourages the transfer of knowledge between public RD&D entities and industry (FCT, 2021a). In 2019, 41% of Portugal's public RD&D funding was awarded by the FCT, with funds coming from the state budget and EU Structural Funds. The share of the FCT's funding coming from the EU increased from 15.7% in 2017 to 27% in 2019 and is expected to reach around 37% in 2020.

The National Innovation Agency (ANI) is a state-owned agency funded by the Ministry for Science, Technology and Higher Education and the Ministry for the Economy and Digital Transition. The ANI supports technology and business innovation to strengthen Portugal's competitiveness in global markets. The ANI's responsibilities include stimulating private RD&D investment, promoting partnerships between Portugal's RD&D entities and industry, and increasing the participation of Portugal's RD&D entities and industry in international RD&D programmes (ANI, 2019a).

The National Laboratory of Energy and Geology (LNEG) is the national laboratory conducting RD&D with a focus on energy. The LNEG runs two main research centres: the Laboratory of Energy (LEN) and the Laboratory of Geology and Mines (LGM). The LEN's work is organised under three units (bioenergy and biorefineries, renewables and energy efficiency, and materials for energy). The LGM's work on energy RD&D includes geothermal energy, geological CO_2 storage and hydrogeology. The LNEG also includes a network of accredited labs supporting research in biofuels and biomass, materials and coatings, and solar energy (LNEG, 2021a).

The National Laboratory for Civil Engineering (LNEC) undertakes, co-ordinates and promotes scientific research and technological development focused on civil engineering, including for public works (dams, harbours, airfields, roads and railways infrastructures), buildings, housing and urban planning, water resources, coastline and environment, transport, materials and other industrial products. The LNEC provides RD&D services to public and private, national and foreign entities and contributes to innovation, dissemination of knowledge and technology transfer. The LNEC assists the government in developing policy, and provides technical support to government entities in particular with regard to quality and safety of public works, protection of natural and built heritage, and modernisation and innovation of infrastructure, particularly in the building sector (LNEC, 2021).

The Directorate-General for Statistics on Education and Science (DGEEC) within the Ministry for Science, Technology and Higher Education conducts the National Scientific and Technological Potential Survey (IPCTN), which collects data on ongoing RD&D activity, including funding levels and types of research. The IPCTN is conducted annually through surveys sent to private companies, non-profits, government research entities and universities. Results from the IPCTN are used by Statistics Portugal (the government's national statistics institute) to evaluate RD&D funding (DGEEC, 2021a).

For the 2019 IPCTN, the DGEEC contacted 12 049 entities with the potential to execute RD&D activities; 10 483 (87%) responded to the survey with 4 707 indicating they had carried out RD&D activities. The 2019 IPCTN introduced for the first time a breakdown of annual RD&D expenditure by sector. For the 2019 IPCTN, the DGEEC also co-operated with the DGEG to improve data collection detailing research topics within the domain of energy RD&D, which had not been included in past IPCTNs. The government is developing a methodology to extract more precise estimates of private sector energy-related RD&D spending from tax information.

The National Agency for Energy (ADENE) is a private, non-profit public benefit association with the mission to develop public interest activities in the areas of energy and water efficiency. The ADENE also promotes innovation and technology transfer in the area of energy through partnerships with the RD&D institutions of the national scientific system, companies and international counterparts. ADENE also supports the IPCTN survey.

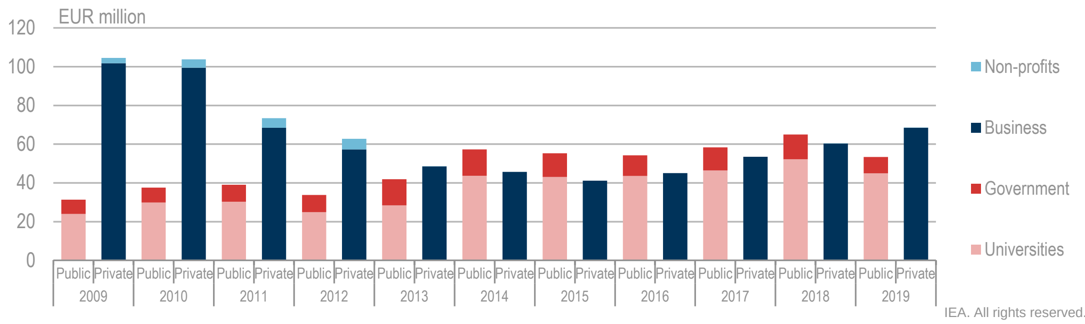
Funding

In the aftermath of the 2008 financial crisis, Portugal's public spending on energy RD&D ranged from EUR 31 million in 2009 to EUR 42 million in 2013. In line with Portugal's economic recovery, public funding for energy RD&D increased notably in 2014. From 2014 to 2018, annual public spending on energy RD&D varied between EUR 55 million and EUR 65 million, with a slight decline to EUR 53 million in 2019 (Figure 6.1).

Over the decade from 2009 to 2019, 78% of public spending on energy RD&D supported universities and 22% supported government research centres. Private spending on energy RD&D was significantly impacted by the 2008 financial crisis, dropping from EUR 104 million in 2010 to EUR 41 million in 2015. Since 2015, private spending on energy RD&D has steadily recovered, to reach EUR 69 million in 2019.

In 2019, total public and private energy RD&D spending was EUR 122 million, with the largest shares of funding going to energy efficiency (38%) and renewable energy (19%) (Table 6.1). In 2019, Portugal's budget for public energy RD&D was 0.025% of gross domestic product (GDP), below the median among IEA member countries (0.0354% of GDP) (Figure 6.2).

Figure 6.1 Public and private energy RD&D spending in Portugal, 2009-19



Public spending on energy RD&D increased significantly in 2014, but has since fluctuated, with a notable drop in 2019. Private spending on energy RD&D has increased steadily since 2015.

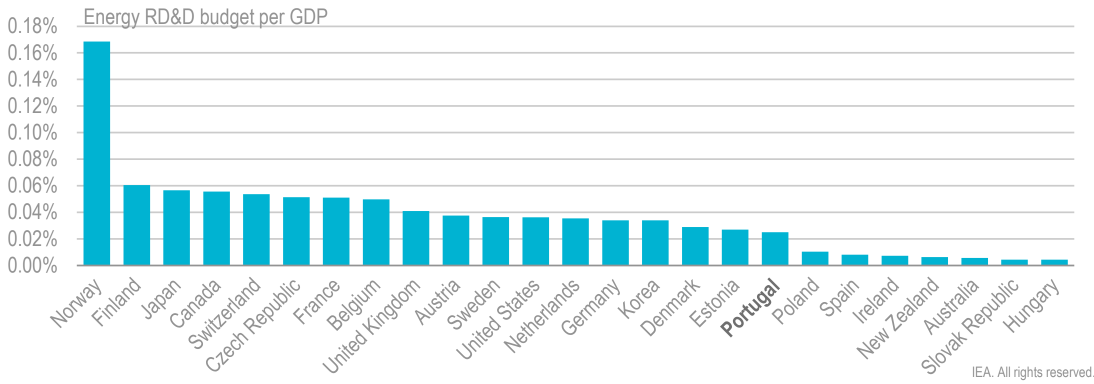
Source: DGEEC (2021a), *Research and Development (IPCTN)* (database), www.dgeec.mec.pt/np4/206.

Table 6.1 Public and private energy RD&D spending in Portugal by area, 2019

Energy RD&D area	Private		Public		Total
	Companies	Non-profits	Government	Academia	
Energy efficiency	23.9	–	4.4	15.9	46.2
Fossil fuels (oil, gas, coal)	4.3	–	–	0.9	5.2
Renewable energy sources	12.1	0.03	1.1	9.9	23.2
Nuclear fission and fusion	0.2	–	–	4.0	4.3
Hydrogen and fuel cells	0.9		1.0	2.8	4.7
Other energy production and storage technologies	8.8	–	–	4.7	13.5
Other cross-cutting technology or RD&D	10.8	0.1	2.0	4.0	16.9
Other energy fields	5.4	–	–	2.7	8.2
Total	68.5	0.13	8.5	44.9	122.0

Source: DGEEC (2021a), *Research and Development (IPCTN)* (database), www.dgeec.mec.pt/np4/206.

Figure 6.2 Public energy-related RD&D budget per GDP in IEA countries, 2019



Portugal ranked below the IEA median in terms of public energy RD&D budget as a share of GDP.

Note: Data not available for the Greece, Italy, Luxembourg, Mexico and Turkey.
Source: IEA (2021), *Energy Technology RD&D Budgets 2021* (database), www.iea.org/statistics.

International collaboration

Portugal co-operates on RD&D with the EU and other EU member states through the numerous RD&D initiatives and programmes organised by the EU, including the European Strategic Energy Technology Plan (SET Plan) and Horizon Europe (HEU). The EU funds RD&D in all member states (including Portugal) through a research and innovation framework programme that is updated every seven years. Horizon 2020, the research and innovation framework programme for 2014-20, provided a total of EUR 80 billion for RD&D in the EU. Horizon 2020 awarded funding through a competitive process open to all EU public and private RD&D entities and aimed to increase public-private partnerships and international co-operation. Horizon 2020 provided EUR 1.1 billion for RD&D in Portugal, with over EUR 225 million going to energy-related RD&D, including EUR 98 million for secure, clean and efficient energy; EUR 57 million for climate action, the environment, resource efficiency and raw materials; EUR 45 million for smart, green and intelligent transport; EUR 24 million for advanced manufacturing and processing; and EUR 11 million for nuclear energy (EC, 2020a).

Horizon Europe, the EU research and innovation framework programme for 2021-27, was launched in February 2021 under the Portuguese Presidency of the European Council. Horizon Europe aims to provide a total around EUR 100 billion in RD&D funding, will continue to support energy-related RD&D (one of the programme's five focus areas is climate-neutral and smart cities) and sets goals to increase international co-operation on RD&D (EC, 2020b). Portugal is aiming to be granted EUR 2 billion in funding from Horizon Europe, with Portuguese RD&D entities indicating that there will be significant funding requests developed for energy RD&D projects (Sousa, 2020). The government has informed the European Commission that Portugal will participate in the European Partnership for Clean Energy Transition, with an indicative amount of EUR 30 million.

The Portugal in Europe Research and Innovation Network (PERIN) was established in 2017 to support and monitor the participation of Portugal's science and technology community in EU programmes (including Horizon Europe). PERIN is composed of seven of Portugal's main RD&D entities, including the FCT and the ANI, and works to increase the share of EU RD&D funding granted to Portugal and to foster co-operation between Portugal's science and technology community and other European research entities (PERIN, 2021).

The NECP notes that Portugal's participation in the EU SET Plan has resulted in clear benefits for international collaboration on new technologies and in collaborative responses to EU-wide challenges. Portugal participates in nine out of the ten SET Plan implementation groups and aims to continue its collaboration under the SET Plan to support the achievement of national and EU goals for RD&D.

The LNEG is a member of the executive committee of the European Energy Research Alliance (EERA), the biggest research community in Europe. The EERA was created to align the RD&D activities of individual research organisations with the SET Plan's priorities and to establish a joint programming framework at the EU level. The EERA is built on the principle of voluntary participation of research organisations through contributions to EERA joint programmes. The LNEG is active in eight joint programmes: 1) bioenergy; 2) concentrated solar power; 3) geothermal; 4) photovoltaic solar energy; 5) smart cities; 6) wind; 7) energy systems integration; and 8) digitalisation for energy (EERA, 2021).

Portugal currently participates in 7 out of 39 IEA technology collaboration programmes, including those on industry-based biorefineries, energy flexible buildings, renewable energy and hydrogen. Portugal is not participating in energy RD&D and innovation initiatives led by Mission Innovation and is not part of the Clean Energy Ministerial, but should consider joining both of these collaborative efforts.

Support measures

Portugal provides financial and fiscal support for RD&D through a variety of mechanisms. The majority of public funding for RD&D is issued through programmes run by the FCT and financed by the state budget and EU funds. From 2015 to 2017, the FCT budget was steady at around EUR 380 million, but increased notably in 2018 to EUR 451 million and again in 2019 to EUR 511 million. Over 97% of the FCT budget supports RD&D, with the remaining budget supporting the FCT's staff and operations.

The FCT provides RD&D funding through a wide range of instruments, most of which are based on competitive processes overseen by panels of international experts where award decisions are driven by scientific merit and the quality of the proposal. FCT funding programmes include tenders for RD&D projects; grants, scholarships and employment programmes for individual researchers; support of public private RD&D collaboration; and direct funding of public research institutions. Most of the FCT funding programmes are open to all areas of research, but some tenders target specific research areas. A notable share of FCT funding goes to energy RD&D (FCT, 2021a).

The Innovation Support Fund (FAI) uses competitive tenders to support innovation and technology development in the areas of renewable energy and energy efficiency, including support for partnerships between public RD&D entities and industry. Funding is available for research, pilot and demonstration projects and for technical, scientific and behavioural studies. The FAI tenders issued in 2018 offered EUR 2.1 million in funding for RD&D focused on geothermal energy. Those issued in 2019 offered EUR 2.0 million in funding for RD&D focused on advanced biofuels (FAI, 2021).

The Innovation, Technology Transfer and Circular Economy Fund (FITEC) finances collaborative projects that support knowledge transfer between universities, companies and research centres. Priority areas for funding include energy efficiency and the circular economy. FITEC is a joint effort of the Ministry for Science, Technology and Higher Education; the Ministry for the Economy and Digital Transition; and the Ministry for the Environment and Climate Action, and is managed by the Portuguese Financial Institution for Development (IFD) (EREK, 2018). FITEC was created in 2016, with a budget of EUR 100 million to be awarded by 2022. One of the key initiatives it funds is the Interface Programme, which was established in 2017 to accelerate technology transfer from universities to companies, boost the certification of new products resulting from research projects, and increase the competitiveness of Portuguese companies in national and international markets (ANI, 2019b).

In 2015, Portugal introduced the System of Tax Incentives for Business RD&D (SIFIDE), which allows private companies to deduct the costs of certain RD&D activities from revenues subject to Portugal's corporate income tax, excluding any costs reimbursed by the national government or EU funds. RD&D costs eligible for the SIFIDE deduction must be either research expenses for acquiring new scientific or technical knowledge, or development expenses related to discovering or substantially improving raw materials, products, services or manufacturing. Deductions can be claimed for costs including expenses of staff directly involved in RD&D, operating expenses for RD&D projects, or the cost of patents and contracts with public RD&D entities. The amount of the deduction ranges from 55% to 120% of the qualifying costs depending on the type of expense. In 2018, the SIFIDE was extended through 2025 (ANI, 2021).

Policy

Portugal's energy RD&D policy is guided by numerous documents and strategies. The NECP, the RNC2050 and the EN-H2 are the key documents setting overall energy sector targets and goals for 2030 and 2050. All three of these documents note the need for a sustained effort on energy RD&D to support the achievement of Portugal's ambitious decarbonisation goals, especially in relation to hard-to-decarbonise sectors and end uses like industry and heavy transport. Portugal's Long-Term Renovation Strategy also notes the need for RD&D to meet renovation goals and energy policy targets for buildings.

Overall, RD&D policy is guided by a complex set of documents, regulations and processes that reflect the large number actors involved in setting and implementing RD&D policy. The Technological and Business Innovation Strategy 2018-2030 serves as the main reference for innovation policy in Portugal through 2030, while 15 thematic agendas for research and innovation identify key opportunities for RD&D aligned with Portugal's overall national policy goals and RD&D capabilities. Energy RD&D is given a significant role in Portugal's RD&D policy, but there is no dedicated policy framework guiding energy RD&D.

The NECP sets funding targets, general goals and action strategies for energy and climate-related RD&D. The RD&D priorities set in the NECP are intended to align Portugal's RD&D efforts with the NECP's 2030 targets for reducing greenhouse gas (GHG) emissions, increasing renewable energy and improving energy efficiency, and the RNC2050's goals for economy-wide carbon neutrality by 2050. The NECP sets 2030 targets for combined public and private spending on overall RD&D to increase to 3% of GDP and for combined public and private spending on energy RD&D and on climate and water RD&D to both increase to 0.2% of GDP. In 2019, total public and private spending on energy RD&D was 0.07% of GDP.

The NECP calls for energy RD&D to focus on the following areas: energy management smart systems and new infrastructures, energy storage, low-carbon technologies, energy efficiency and hydrogen as an energy source. The NECP notes that Portugal's energy RD&D support measures and implementation programmes should drive pilot projects, the creation of industrial clusters focused on new technologies, business models based on low-carbon products and services, participation in international RD&D and training, and capacity building and mobility for researchers. The NECP also calls for energy RD&D programmes to support the commercial deployment of products and services developed in RD&D projects. The NECP defines the following action strategies, which are intended to offer guidance on priorities to the entities conducting energy RD&D in Portugal:

- promote RD&D projects supporting the transition to a carbon-neutral economy
- stimulate RD&D in the area of energy efficiency
- encourage RD&D in renewable energy, storage and hydrogen, advanced biofuels and other 100% renewable fuels
- promote RD&D projects supporting the sustainable management of agriculture and forestry (with energy aspects relating to sustainable use of bioenergy)
- promote RD&D projects supporting a low-carbon, more innovative and competitive industry.

Portugal's EN-H2 calls for RD&D to support a rapid increase in the production and use of hydrogen based on renewable energy. The EN-H2 notes that given the early stage of renewable hydrogen development, the focus of RD&D should be kept up-to-date and that the criteria for assessing hydrogen RD&D proposals should consider the potential to increase production, lower costs and increase demand, as well as the adequacy of supporting infrastructures; compatibility with overall energy sector plans, goals and targets; and contribution to Portugal's overall RD&D ecosystem.

From 2014 to 2020, Portugal's RD&D policy framework was defined by the National Strategy for Research and Innovation for Intelligent Specialization 2014-2020 (ENEI). The ENEI set 15 strategic priorities, including a strategic priority for energy RD&D that called for a focus on the following areas (FCT, 2014):

- optimisation of energy production and transport and complementary management (renewable, non-renewable, new fuels and hydrogen, fuel cells, nuclear fusion, CO_2 capture and storage, real-time energy systems management, energy storage)
- end use of energy, energy efficiency and its impacts (smart cities, net-zero energy buildings, transport, consumption patterns and consumer behaviour, distribution of electricity and natural gas, climate change)

- applications of new technologies and smart energy networks (information and communications technologies, smart grids)
- integration into European energy markets (modelling, planning, regulation, new market models).

Analysis conducted by the DGEEC on the breakdown of national RD&D expenditures supporting the 15 priority areas of the ENEI showed that from 2014 to 2019, expenditures related to energy increased from EUR 100 million to EUR 144 million and ranged from 4% to 5% of total expenditures among the 15 priority areas. In 2019, only five other priority areas had more funding than energy (DGEEC, 2021b). Under the ENEI, the ANI also produces a biennial innovation report focused on monitoring RD&D programmes and identifying research trends and stakeholders active in RD&D.

Resolution of the Council of Ministers No. 32/2016 introduced several new measures to support a more robust and coherent RD&D system. Key measures included the development of the 15 thematic agendas for research and innovation to guide RD&D through 2030, the creation of collaborative laboratories (CoLABs) to support public private RD&D co-operation, and increased tax incentives for RD&D.

The 15 thematic agendas for research and innovation identify key opportunities for RD&D that are aligned with Portugal’s overall national policy goals and RD&D capabilities. They are developed through a bottom-up collaborative process bringing together experts from academia, research centres, companies, public organisations and civil society, which is intended to increase co-operation and knowledge sharing. The FCT provides technical and logistical support for the development of the agendas, which began in 2016. As of February 2021, the majority of the agendas had been developed; however, they are intended to function as living documents that reflect Portugal’s evolving RD&D priorities and capabilities (FCT, 2021b).

The thematic agenda on sustainable energy systems focuses on energy RD&D that supports Portugal’s decarbonisation goals, specifically calling for RD&D to increase energy efficiency and to support a 100% renewable electricity supply based on domestic resources, a 25% reduction in transport GHG emissions compared to 2005 levels, and the replacement of all fossil fuel-based heating and cooling with low-carbon alternatives. The thematic agenda on sustainable energy systems is structured around four priority energy vectors: 1) renewable resources and energy efficiency/sufficiency; 2) flexible and smart electricity systems; 3) energy conversion and storage for heat and power production; and 4) transport and mobility. The RD&D priorities of thematic agenda on sustainable energy systems are:

- smart cities and buildings: sufficiency and energy efficiency in urban spaces, housing and services
- energy efficiency and sustainability in industry and agriculture
- the consumer-producer and their central role in the advanced management of the electrical system and in the efficiency of consumption
- digitisation of the electrical system, smart grids, and integration and optimisation of renewable variable generation over time exploring advanced solutions for operational flexibility
- decarbonisation of energy: production of electricity and heat from renewable sources

- new fuels produced from renewable sources (including solar chemistry and hydrogen), biofuels and associated technologies
- energy storage for electricity and heat production
- decarbonising mobility and transport in all sectors
- carbon capture, utilisation and storage (CCUS) in energy conversion processes regarding synthetic fuels.

Other thematic agendas relevant for energy RD&D include the agendas on the circular economy, climate change, ocean, industry and manufacturing, and urban sciences and cities for the future (FCT, 2021c).

Portugal's Interface Programme was established in 2017 to increase co-operation between public research entities and industry. One of key initiatives of the Interface Programme are CoLABs, which bring together public RD&D entities, universities, companies, business associations and government organisations to co-operate on shared RD&D objectives. Tenders for CoLABs were issued in 2017, 2018 and 2019, resulting in the establishment of 28 CoLABs. Several CoLABs focus on energy RD&D in areas including biorefineries, the circular economy, energy storage, buildings and energy services. From 2018 to 2020, the 28 CoLABs received a total of EUR 70 million in public funding from FITEC. The Interface Programme also aims to enhance Portuguese products, through innovation, increased productivity, value creation and the incorporation of technology into the production processes of national companies (FCT, 2021d).

The FCT manages the tender process that establishes CoLABs and provides funding supporting CoLAB RD&D activities. The selection process is based on scientific and technological merit, potential to stimulate innovation and scientific employment, relevance and impact of the proposed research, as well as institutional organisation and diversification of funding sources. The evaluation of tender applications is conducted by an independent international panel organised by the FCT. CoLABs must consist of at least one RD&D unit associated with a higher education institution that receives funding from the FCT (which will cover 20% of expenditures for highly qualified human resources) and at least one private company (ANI, 2019c).

The Interface Programme also established a process (run by the ANI) to certify and fund technological interface centres (TICs) that support RD&D co-operation between higher education institutions and private companies. As of 2020, the ANI had certified 31 TICs, 9 of which support co-operation on energy RD&D. From 2018 to 2020, the 31 TICs received a total of EUR 32 million in funding from FITEC to support RD&D training for TIC and industry personnel (especially from small and medium-sized enterprises), enhance links with RD&D entities and facilitate the hiring of highly qualified staff (ANI, 2019d).

Under Resolution of the Council of Ministers No. 25/2018, Portugal adopted the Technological and Business Innovation Strategy 2018-2030 as the main reference for innovation policy in Portugal through 2030. The strategy set the following eight strategic drivers: 1) increased investment in research and development; 2) entrepreneurship; 3) technology valuation and transfer; 4) internationalisation; 5) improving the implementation of European Structural and Investment Funds; 6) reinforcement of TICs; 7) promotion of innovation; and 8) monitoring. The ANI has overall responsibility for co-ordinating this strategy, in particular by promoting collaboration between public RD&D entities and industry and strengthening the participation of public RD&D entities and industry in international programmes (ANI, 2019e).

The FCT has created research infrastructures (RIs) through the National Roadmap of Research Infrastructures. RIs are hubs to promote research excellence and training of researchers, jointly addressing major societal problems and supporting the dissemination of science while increasing efficiency and reducing operating costs for the national RD&D system as a whole. National RIs play a pivotal role in supporting international co-operation on RD&D, including through European RIs, such as those under the European Strategy Forum on Research Infrastructures Roadmap. There are four RIs in the field of energy: 1) the Biomass and Bioenergy Research Infrastructure, integrated into the LNEG; 2) the National Research Infrastructure in Solar Energy Concentration, integrated into the University of Evora and the LNEG; 3) the Research Infrastructure on Integration of Solar Energy Systems in Buildings (NZEB_LAB), integrated into the LNEG; and 4) the Smart Grid and Electric Vehicles Laboratory, integrated into the Institute for Systems and Computer Engineering, Technology and Science (INESC) (FCT, 2020).

RD&D projects

Since the IEA's last energy policy review in 2016, Portugal has completed or started numerous RD&D projects aligned with the country's energy sector decarbonisation goals. Portugal's energy RD&D projects are executed by public and private institutions, funding agencies, large companies, small and medium-sized enterprises, technological centres, and regional energy agencies. Energy RD&D projects covered a wide range of areas with the most funding going to efficiency, renewable energy, cross-cutting technologies and RD&D, and other energy production and storage technologies. Smaller shares of funding also went to projects related to fossil fuels, nuclear fission and fusion, and hydrogen and fuel cells.

Portugal's energy RD&D projects range from fundamental and applied research to pilot and demonstration projects, systemic approaches, and regulatory sandboxes. There have been technology-specific projects on concentrated solar power (CSP), wind (including floating offshore wind), bioenergy, hydrogen, energy storage and a variety of technologies. Projects have also examined market-based solutions, consumer behaviour and other enabling conditions to increase the integration of renewables and the flexibility of the electricity grid. Most RD&D projects in Portugal are structured around international co-operation.

Energy efficiency

Key examples of RD&D activities related to energy efficiency include the User-driven Energy-Matching and Business Prospection Tool for Industrial Excess Heat/Cold Reduction, Recovery and Redistribution (EMBE3RS) project. EMB3Rs promotes best practices in energy management in the industry in relation to heating and cooling networks. ADENE, together with 15 European institutions, is a partner in this project, which will develop a simulation platform for the recovery and reuse of industrial heating and cooling (ADENE, 2019a).

The LNEC has developed RD&D projects related to building energy efficiency for ADENE (a passive thermal comfort indicator for housing, an energy performance simulator for public buildings ECO.AP, building rehabilitation with rule regulation) and urban water cycle energy efficiency (Avaler+, with financial support from the FAI and Sinergea financial support from the ANI). The LNEC also supports industry in the approval of innovative materials and systems.

Portugal was part of the Industrial and Tertiary Product Testing and Application (INTAS) project providing technical, co-operative capacity building support to European market surveillance authorities in charge of enforcing Ecodesign regulations and requirements for large industrial products, specifically transformers and fans. The project also supported industry awareness of obligations under the EU Ecodesign Directive (INTAS, 2021).

Portugal is participating in the EU Heating Appliances Retrofit Planning project, which aims to motivate individuals to replace inefficient heating appliances with more efficient alternatives. The project enables individuals to get a labelling classification of their heating system; an estimation of the total cost of their heating system; an overview of the most efficient alternatives, including the potential of energy and costs savings, reduction of CO_2 emissions, improvement of indoor air quality or noise reduction. The project also lists the incentives and financial support available to replace inefficient heating appliances with a more efficient alternative. The project supports consumers, and also professionals who can be coached to provide more detailed guidance to consumers (ADENE, 2019b).

Portugal is participating in the EU New Label Driving Supply and Demand of Energy Efficient Products (Label 2020) project. Label 2020 supports the adoption of an updated EU system for energy labelling for a wide range of products based on efficiency. The project aims to smooth the market transition towards the new energy labels. The Label 2020 project started in June 2019 and will last until January 2023 (Label 2020, 2021).

Portugal has several RD&D projects aiming to improve energy and water efficiency in buildings. The Urban Data Driven Models for Creative and Resourceful Urban Transitions (SusCity) project is supported by the FCT. It supports building energy efficiency through the proliferation of scalable urban interventions and the development of a multi-dimensional Urban systems Simulator and Dashboard (INESC, 2017). Portugal is participating in the EU Extending the Energy Performance Assessment and Certification Schemes via a Modular Approach (X-Tendo) project. This project supports the development of the next-generation energy performance certification schemes to improve building energy efficiency. It is focused on the X-tendo toolbox, a freely available online hub presenting all of the provided innovative features, from smart solutions and trusted examples or calculations to guidelines and recommendations (ADENE, 2020a).

Portugal is also participating in the EU Individual Building Renovation Roadmaps (iBRoad) project, which aims to design, develop and demonstrate the concept of individual building renovation road maps to drive deep renovations. Representing an evolution of energy performance certifications and energy audit systems, building renovation road maps are a tool for developing customised renovation plans with a long-term horizon for deep step-by-step renovation of individual buildings (iBRoad, 2021). Portugal is also part of the EU Water Efficiency and Water-Energy Nexus in Building Construction and Retrofit (WatterSkills) project. It aims to develop and implement a common qualification framework and accreditation scheme at the European level for training construction and green professionals on water efficiency and water-energy nexus for building construction and retrofit (ADENE, 2020b).

Renewable energy

The government sees a role for Portugal to play in demonstrating the viability of floating offshore wind generation and has approved six sites for floating offshore wind deployment. Portugal's first floating offshore wind project, WindFloat Atlantic, became fully operational in July 2020. This project consists of three floating turbines with a total capacity of 25 megawatts (MW) and was financed by funds from the EU and the Portuguese government (Offshore, 2020). The Offshore Plan project led by the LNEG used EU funding to map Portugal's offshore wind and wave resources; examine the technical, economic and social challenges to deployment; and assess the integration of offshore wind and wave generation in Portugal's electricity grid (Offshore Plan, 2021).

Portugal is also interested in developing wave energy generation and is participating in several projects in this area, including the Wave Energy to Megawatt Levels (MegaRoller) project, which aims to develop and demonstrate a power take-off (PTO) solution for wave energy converters. The proposed PTO technology is a 1 MW oscillating wave surge converters (OWSC) based on multiple hardware and software innovations. MegaRoller aims to generate extensive knowledge in the area of PTO design and control systems and contribute to decreasing the levelised cost of electricity produced thanks to OWSC devices below EUR 150 per megawatt hour (MWh) (SINTEF, 2021). Portugal is also participating in the Surging Wave Energy Absorption Through Increasing Thrust and Efficiency (SEA-TITAN) project, which aims for a step change in wave energy by designing, building, testing and validating an innovative PTO solution to be used with multiple types of wave energy converters (Sea-Titan, 2018).

Portugal is also participating in EU projects aiming to improve wind generation. These include the EU New European Wind Atlas (NEWA) and the EU WindScanner projects. The NEWA project supports the development of an EU-wide wind atlas for standardised site assessment. The new atlas, based on improved modelling competencies on atmospheric flow, together with the guidelines and best practices for the use of data, should become a key tool not only for manufacturers and developers, but also for public authorities and decision makers, by reducing overall uncertainties in determining wind conditions (NEWA, 2021). The Portuguese WindScanner Facility project develops the Portuguese node of the overall EU research infrastructure WindScanner. WindScanner used a new remote sensing wind measurement system to provide detailed maps of wind and turbulence conditions around either a single wind turbine or across a large wind farm (EERA, 2020).

Research has confirmed that Portugal has one of the best CSP resources in Europe and Portugal is participating in several RD&D programmes examining the performance of CSP technologies through pilot projects and modelling. Projects include the European Solar Research Infrastructure for Concentrated Solar Power, the Scientific and Technological Alliance for Guaranteeing the European Excellence in Concentrating Solar Thermal Energy, the Integrating National Research Agendas on Solar Heat for Industrial Processes, and the New Storage Latent and Sensible Concept for High Efficient CSP Plants. CSP RD&D is also supported through Portugal's national research infrastructure on solar energy concentration (LNEG, 2021b).

Portugal's solar energy RD&D has also focused on exploiting local mineral recourses. The FCT-supported LocalEnergy project aims to valorise Portugal's solar and mineral resources through the development of energy-harvesting applications based on the tetrahedrite mineral, which is abundant in Portugal. LocalEnergy is focused on materials research and the development of thermoelectric and solar energy technologies based on tetrahedrites (LNEG, 2021c).

Portugal has participated in several bioenergy-related RD&D projects, including the EU Direct Ethanol from MicroAlgae research consortium, which aimed to develop, demonstrate and licence a completely economically competitive technology for the direct production of bioethanol from microalgae (CORDIS, 2017a). Portugal also participated in the Modular Small-Scale Integrated Biorefineries project, which aimed to develop small-scale integrated biorefinery units that can process a variety of biomass locally sourced from a short distance in rural and small urban areas, both in Europe and in the Community of Latin American and Caribbean States (SMIBIO, 2021).

Portugal also participated in the Promotion of Energy Production through Optimisation of the Use of Biomass project. The objective of this project is to characterise domestic biomass resources, including the technical potential for energy production; to increase diversified use of biomass; and to define guidelines for supporting policies. The project supported the development of a technical-scientific guide, with recommendations for the efficient use of biomass, with a view to reducing energy dependence (DGEG, 2018a).

The CONVERTE project led by the LNEG and funded by POSEUR assessed Portugal's biomasses resources. The LNEG does significant work on bioenergy conducted mainly through EU-funded RD&D projects focused on international co-operation, including developing advanced biofuel production with energy system integration (AMBITION), large and sustainable deployment of second-generation biofuels in rural areas (BABET-REAL5), the research infrastructure for biofuels (BRISK2), and the biomass and bioenergy research infrastructure.

Portugal also supports RD&D to increase the efficient use of its large hydropower resources. The HYdropower plants PERformance and flexiBle Operation towards Lean integration of new renewable Energies (HYPERBOLE) examined options for enhancing hydropower plant value by extending the flexibility of operating range and improving long-term availability. To support this, the project studied the hydraulic, mechanical and electrical dynamics of several hydraulic machine configurations, including fresh water and seawater turbines and reversible pump-turbines, under an extended range of operations (CORDIS, 2017b).

Portugal supports RD&D on geothermal energy as well, through its participation in the EU Geoatlantic project. Geoatlantic aims to promote increased use of geothermal energy by increasing consumer knowledge and energy service providers' capacity in relation to geothermal energy. The project also supports pilot and demonstration projects, technology transfer, and policy development to increase the deployment of geothermal energy (GeoAtlantic, 2021).

The EN-H2 sets numerous goals for renewable gases to replace fossil fuels and support the decarbonisation of the economy. In line with this, Portugal is supporting and co-operating on RD&D related to hydrogen and renewable gases.

The DGEG assessment of the Potential and Impact of Hydrogen in Portugal – Strategy for Sustainability project assessed the potential and impacts of hydrogen in Portugal, taking into account the country's resources and the characteristics of the national energy system. The results for this project were used to inform policy on hydrogen, including the development of the EN-H2 (DGEG, 2018b). POSEUR issued public call for proposals aimed at projects for production, distribution and consumption of energy from renewable gases, including green hydrogen, for a total amount of around EUR 40 million.

The LNEG is also conducting hydrogen RD&D to support electrolysis deployment in Portugal. Areas of research include assessment of water resources (cost, transport, reliability, environmental constraints), gap analysis of technical standards and the permitting process, and technical and economic analysis of electrolyser operations (LNEG, 2021d).

A private consortium including some of Portugal's largest energy companies is working on developing hydrogen production at the Sines industrial complex, aiming for quick deployment of a 10 MW electrolyser pilot project and 1.0-1.5 gigawatts (GW) of electrolyser capacity by 2030 (Djunisic, 2020). In July 2020, the government selected 37 hydrogen plus renewable energy projects, including the Sines Project, for its application to the EU's Important Project of Common European Interest scheme for hydrogen (Goncalves, 2020).

The LNEC developed RD&D projects related to renewable energy, including geothermal energy, wave energy, floating photovoltaic (PV) systems and innovative materials (Biobuild, Gelclad).

Grid flexibility, market design and renewables integration

Portugal has numerous RD&D projects examining various technical and market-based options to increase grid flexibility and the integration of renewables.

In 2018, the Regulatory Entity for Energy Services (ERSE) started developing rules (including regulatory sandboxes) for two pilot projects examining demand response by industrial consumers. The first one was completed in May 2019 and examined changes to the time-of-use structure of network tariffs to promote demand response and encourage efficiency. It attracted the participation of 82 industrial consumers connected at medium and high voltage. The pilot tested the introduction of locational time signals through regional time-of-use schedules and the definition of a super peak period, corresponding to approximately one-third of the current peak period.

The first pilot project found an incremental demand response of 2% during the super peak period, leading to an overall positive assessment. The ERSE's final report will be presented as part of the tariff code review before the next regulatory period, beginning in 2022. The second project, completed September 2020, validated the interest and ability of large industrial consumers (demand of more than 1 MW) to participate (individually or aggregated) in the replacement reserve market (INESCTEC, 2021a). Based on the results of these pilot projects, the ERSE will conduct a cost-benefit analysis to determine options and next steps for implementing dynamic tariffs and allowing demand response participation in the replacement reserve market.

Under the Code on Services for Intelligent Electricity Distribution Networks, low-voltage network operators must propose pilot projects to the ERSE regarding the availability and use of smart meter data. In April 2020, the ERSE approved a one-year pilot project involving 21 000 low-voltage customers in which the main electricity distribution system operator will examine what type of smart meter data should be collected and how it can be used to improve continuity of service at the low-voltage level (ERSE, 2020a).

Under the Electric Mobility Code, which calls for pilot projects to stimulate innovation supporting electric mobility, Eletricidade dos Açores (EDA) is conducting a vehicle-to-grid pilot project. With the support of Nissan, Magnun Cap, Nuvve and the Regional Directorate of Energy of the autonomous region of the Azores, the pilot project will use ten electric vehicles (EVs) from the EDA fleet to examine how vehicle-to-grid can contribute to the management of the Azores' isolated electricity network. Results of the project are expected by June 2021 (ERSE, 2020b).

There are numerous other projects examining how renewable electricity can be more effectively integrated from both a technical and market perspective, many of which are international projects organised and funded through the EU. The InovGrid project is an innovative programme designed to support the evolution to smarter grids that can support the increasing number of distributed energy resources, provide detailed information to consumers to promote their active involvement and integrate EV infrastructure (S3C, 2021).

The PVP4Grid RD&D project aims to increase the market share and market value of PV by enabling consumers to become PV prosumers in a system-friendly manner (PVP4Grid, 2021) and the LiSCool project demonstrates how air conditioning systems with cold storage can support system flexibility and renewable integration by acting as automated demand-side response assets or virtual power plants (Marques et al., 2019).

The Sysflex project aims to develop new types of services that meet the needs of an electricity system with a renewable energy share over 50% through the right combination of flexibility and system services to support secure and resilient transmission system operations (EU-SysFlex, 2021). The LNEG co-ordinated the EU-funded international Tools for the Design and Modelling of New Markets and Negotiation Mechanisms for a 100% Renewable European Power System project, which develops and tests innovative electricity market design that can support a near 100% renewable electricity system (TradeRES, 2021). The LNEG also co-ordinated the FCT-funded Optigrid project, which aims to develop a methodology and tool to allow dynamic line rating to support optimised operation of Portugal's transmission system, allowing increased renewables integration and more efficient operation of the Iberian wholesale electricity market (LNEG, 2021e).

With EU support, the EDP is participating in the Positive Energy CITY transformation Framework (POCITYF) project. This is a smart city-oriented project with the goal of developing positive energy blocks (limited geographic areas where the average local renewable generation is greater than local electricity demand) in several European cities, including Evora in Portugal (EDP, 2021). The EDP is also participating in the EU InteGrid project, whose aim is to demonstrate intelligent grid technologies for renewables integration and interactive consumer participation enabling interoperable market solutions and interconnected stakeholders (InteGrid, 2021).

Portugal's autonomous island region of Madeira is participating in the EU Smart Island Energy System Project, which aims to support increased system flexibility and integration of renewables on several remote European islands. The Madeira project will test an intelligent control and automation system to provide better management of the distribution network. The project will make use of data from an ongoing roll out of smart metering and will also test demand-side management techniques (including market mechanisms such as dynamic pricing) and battery storage to support secure gird operations and facilitate additional solar and other renewable generation (SMILE project, 2021).

The Laboratory of Smart Grids and Electric Vehicles at the INESC undertakes and co-operates on a wide range of RD&D projects related to grid flexibility, market design, EVs and renewables integration (INESCTEC, 2021b).

Carbon capture utilisation and storage

Portugal's RNC2050 indicated that CCUS is one potential solution to achieve carbon neutrality and Portugal's industry sector is participating in various CCUS pilot projects including the EU STRATEGY CCUS.

STRATEGY CCUS is an ambitious three-year project funded by the EU to support the development of low-carbon energy and industry in southern and eastern Europe. The project started in May 2019 and will run through April 2022. Scientists from ten European countries (including Portugal) are working to accelerate CCUS technology development, to deliver significant emissions reductions from the industrial and electricity sectors. The project focuses on eight regions promising for CCUS development, including Portugal's Lusitanian basin. The project aims to encourage and support initiatives within each region by producing local development plans and business models tailored to industry's needs (STRATEGY CCUS, 2021).

Assessment

While energy RD&D is given a significant role in Portugal's overall RD&D policy, there is not a dedicated policy framework guiding it. It is unclear if existing processes for designing, implementing and monitoring energy RD&D policy account for or support the achievement of the energy and climate priorities set in the NECP, RNC2050 and EN-H2. In addition, funding for energy RD&D comes from a variety of national and EU programmes that set their own priorities and in most cases require energy RD&D proposals to compete with proposals from all other fields of research. Most of these mechanisms do not consider aligning Portugal's energy sector goals as a metric when selecting which projects to fund. As a result, the annual funding levels for energy RD&D and the type of research conducted can vary notably depending on the number, quality and subject of energy RD&D proposals that Portugal's RD&D entities decide to submit for funding in a given year.

Increased policy co-ordination on energy RD&D at the ministerial level is needed to ensure that the numerous RD&D entities, strategies and support measures are aligned with Portugal's ambitious decarbonisation goals. RD&D entities in Portugal have called for increased policy co-ordination and streamlining of various processes for setting, implementing and funding energy RD&D. In particular, the tenders issued through Portugal's various support programmes need to reflect the priorities of the NECP, the RNC2050, the EN-H2 and the thematic agendas relevant for energy.

Energy RD&D efforts are especially critical in relation to hard-to-decarbonise sectors and end uses where new technologies and cost reductions are needed. It is also critical to establish clear policy and funding support for products and services developed through

RD&D to reach commercial deployment. To guarantee efficient and effective drafting of policies and the implementation of programmes and monitoring of results, co-ordination at a high administrative level is necessary. The IEA recommends that the DGEG take on this co-ordinating responsibility, as it plays a key role in developing Portugal's energy sector policy and targets.

There is a need to clarify and co-ordinate the work of the numerous RD&D entities to avoid duplication and ensure optimal use of the existing resources (human, infrastructures, equipment). This could be supported through better links between public and private RD&D and greater efforts to raise awareness of ongoing work and the results of public RD&D among industry. Portugal is taking steps to address these challenges through the Interface Programme, which since 2017 has supported the creation of 31 interface centres and 28 CoLABs that foster public-private collaboration on RD&D and technology transfer from public RD&D to industry.

There is a need to improve the monitoring and evaluation process for RD&D projects. Portugal is working to address this too and the DGEG has been assigned responsibility for monitoring and reporting on funding, implementation, and results of energy RD&D. In addition, there is no dedicated policy framework for energy RD&D. To help address this and support potential work on developing a more coherent approach to energy RD&D, the DGEG is developing an energy-oriented overview of Portugal's RD&D ecosystem. It will assess the complexity of the policy framework, identify key actors that design and implement policies, as well as silos, gaps and opportunities for co-operation to increase scale and impact. It will also examine methodologies to align energy RD&D with government priorities.

Participation in EU RD&D programmes is a key priority for Portugal to increase the funding available for Portuguese RD&D entities and international co-operation. Portugal was particularly successful in raising funds in the challenging and competitive Horizon 2020 EU framework programme, which awarded EUR 1.1 billion for RD&D in Portugal, including EUR 225 million for energy RD&D. Under new EU framework programme (Horizon Europe), Portugal is aiming to win EUR 2 billion in RD&D funding.

To support this goal, Portugal established PERIN in 2017. PERIN is composed of seven of Portugal's main RD&D entities and works to increase the share of EU RD&D funding to Portugal and to foster co-operation between Portugal's science and technology community and other European research entities. Through PERIN, Portugal has the opportunity to strongly engage in Horizon Europe, particularly in new types of co-operation, including HEU partnerships. Given the goals to increase funding for RD&D projects and increase the participation of Portugal in international RD&D collaboration, the government should establish a one-stop shop to help Portugal's public and private RD&D entities to identify and apply for funding. PERIN provides an excellent platform to establish such a shop.

Recommendations

The government of Portugal should:

- Develop a dedicated strategy for energy research, development and demonstration that aligns policy design, implementation and funding with the achievement of Portugal's 2030 energy sector targets and 2050 decarbonisation goals, including support for commercial deployment of new energy technologies, products and services.
- Establish the DGEG as the national focal point for co-ordination on energy RD&D policy design, implementation and funding.
- Develop a one-stop shop that provides public and private RD&D entities with clear information and guidance on all instruments that support energy-related RD&D.
- Increase Portugal's involvement within the framework of Horizon Europe.

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7. Electricity

Key data (2019)

Electricity generation: 51.7 TWh (natural gas 33.4%, wind 26.6%, hydro 16.9%, coal 10.8%, bioenergy and waste 7.0%, oil 2.3%, others 3.0%), +4% since 2009

Electricity net imports: 3.4 TWh (imports 8.1 TWh, exports 4.7 TWh)

Electricity consumption: 48.8 TWh (services/other 35.8%, industry 34.2%, residential 27.1%, energy 1.9%, transport 1.0%)

Overview

In 2019, Portugal's electricity supply was split between renewables (53%) – mostly wind and hydro – and fossil fuels (47%) – mostly natural gas and coal. The Portuguese electricity sector is liberalised, with consumers free to choose their electricity supplier; however, regulated tariffs are still in place for a small share of consumers and the deadline to end regulated tariffs has been extended numerous times. Portugal and Spain have a common wholesale electricity market (MIBEL). The market shares of wholesale and retail electricity suppliers operating in Portugal, and the ownership of Portugal's generation capacity, are highly concentrated among a few private companies.

Portugal's energy policy places a strong focus on achieving economy-wide decarbonisation through broad electrification combined with rapid expansion of renewable electricity generation, all the while maintaining affordable electricity prices. Portugal has goals for electricity to cover 32-33% total energy demand in 2030 and 66-68% in 2050 (electricity covered 25% of total final energy demand in 2019), and for renewables to cover 80% of electricity generation in 2030 and 100% in 2050 (renewables accounted for 53% of generation in 2019). Thanks in part to expanding renewable generation, Portugal became a net electricity exporter for the first time in 2016 and maintained this position until 2019, when it once again became a net importer of electricity. The government has goals to increase renewable electricity exports and is working to increase the electrical interconnection capacity with Spain and between the Iberian peninsula and the rest of Europe.

Decarbonisation of electricity generation is supported mainly through annual auctions for solar photovoltaics (PV) and feed-in tariffs (FIT) for renewable electricity generation. There is also support for electrification of demand, especially for electric vehicles (EVs). In response to policy and market pressures, the private operators of Portugal's two coal-fired power plants announced in 2020 that both plants will permanently close in 2021. The 1.3 gigawatt (GW) Sines coal-fired power plant closed in January 2021. The 0.6 GW Pego coal-fired power plant will close in November 2021 (Simon, 2021). The government indicates that natural gas electricity generation will be maintained until at least 2040.

Electricity capacity, generation and trade

From 2009 to 2019, generation capacity in Portugal increased from 17.4 GW to 21.6 GW, driven mainly by growth in the capacity of hydropower with pumped storage and onshore wind (Table 7.1). Hydropower represents by far the largest share of Portugal's installed capacity (34% in 2019). The significant pumped hydro capacity plays a key role in balancing electricity supply and demand, especially in relation to increasing variable renewable energy (VRE) generation from wind and solar PV. From 2009 to 2019, Portugal's peak electricity demand fell slightly from 9.0 GW to 8.65 GW.

Table 7.1 Generation capacity by type and peak demand, 2009 and 2019

Type (GW)	**2009**	**2019**	**Change 2009-19**
Hydro (total)	5.1	7.3	+2.2
– Hydro with pumped storage	1.0	2.8	*+1.7*
Wind (onshore)	3.3	5.2	+1.9
Bioenergy* (total)	0.4	0.7	+0.3
– Bioenergy with co-generation*	0.2	0.4	*+0.2*
Solar PV	0.1	0.9	+0.8
Geothermal**	0.025	0.029	+0.004
Natural gas	3.6	4.6	+1.0
– Combined cycle gas turbines (CCGT)	3.1	3.9	*+0.8*
– Natural gas with co-generation	*0.6*	*0.9*	*+0.3*
Coal	1.8	1.8	0
Oil***	3.1	1.1	-2.0
Total capacity (GW)	**17.4**	**21.6**	**+4.2**
Peak demand (GW)	**9.0**	**8.65**	**-0.4**

* Includes solid biomass, biogas and municipal waste.
** All geothermal capacity is in the autonomous island region of the Azores.
*** All large-scale oil-fired generation is in the autonomous island regions of the Azores and Madeira.
Notes: Values in table are the maximum electricity generation capacity for each technology. Co-generation refers to the combined production of heat and power.

The majority of Portugal's installed capacity consists of large-scale (100+ megawatts [MW]) generation assets connected to the electricity transmission system. However, there is a growing capacity of generation connected to the electricity distribution system. In 2019, 5.3 GW of generation capacity was connected at the distribution level, equal to about one-fourth of Portugal's total installed capacity. Of this, 4.7 GW was renewable generation (54% wind, 19% hydro, 14% solar PV and 13% biomass), with the remaining 0.6 GW primarily natural gas co-generation.[1]

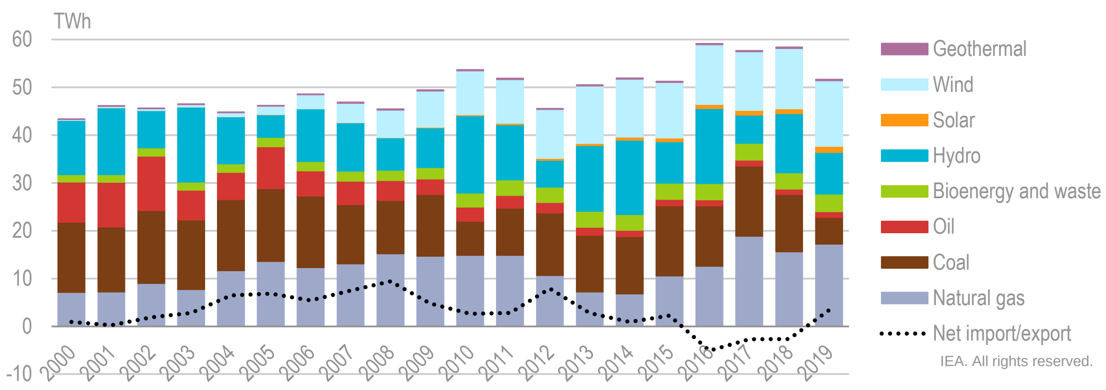
The low-voltage distribution grid has also seen an increasing connection of small-scale (less than 250 kilowatts) distributed generation and generation intended for self-consumption (both primarily solar PV). From 2015 to 2019, total installed capacity of small-scale distributed generation increased from 0.6 MW to 44.8 MW, and 0.2% of total

[1] Co-generation refers to the combined production of heat and power.

generation capacity. From 2015 to 2019, total installed capacity of self-consumption generation increased from 6.4 MW to 215.7 MW, and 1.0% of total generation capacity.

From 2009 to 2019, Portugal's annual electricity generation increased from 49.5 terawatt hours (TWh) to 51.7 TWh, with notable annual variations driven by changing levels of hydro generation, economic activity and electricity trade (Figure 7.1). Because of notable changes in annual rainfall that are typical for Portugal's climate, the large hydropower capacity has a major impact on the annual mix of electricity generation. From 2009 to 2019, hydropower generation fluctuated between 5.6 TWh and 16.2 TWh.

Figure 7.1 Electricity generation in Portugal by source, 2000-19



Variations in Portugal's hydropower generation have a large impact on the generation mix. Wind power experienced large growth from 2004 to 2013, but has since been stable.

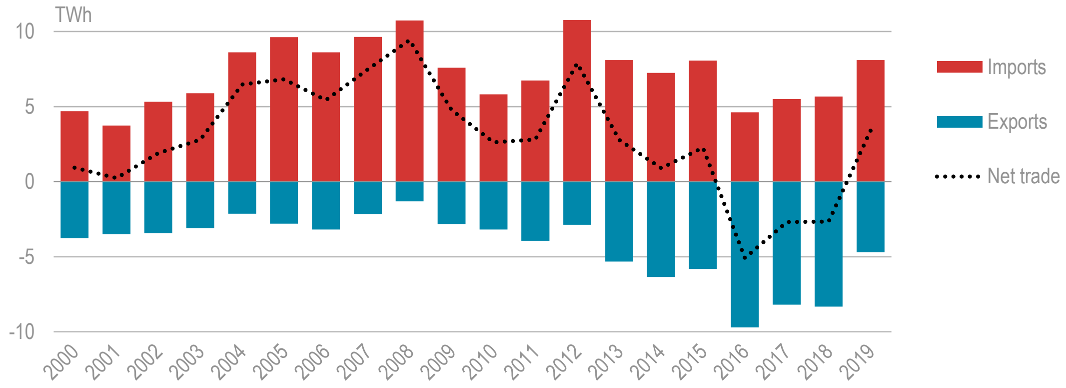
Note: TWh = terawatt hour.
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Portugal has also seen growing VRE generation, mainly onshore wind, but also solar PV. From 2004 to 2013, an FIT for renewable generation drove a strong increase in wind generation, which expanded from 0.8 TWh to 12.0 TWh. Portugal eliminated this FIT for projects commissioned after November 2012. Since the end of this FIT, wind project deployment has continued, but at a slower pace. From 2013 to 2019, wind generation increased from 12.0 TWh to 13.7 TWh. Generation from solar PV is relatively small (1.3 TWh in 2019), but is expected to grow rapidly starting in 2020 with the commissioning of solar PV projects that were awarded network connections in solar PV auctions in 2019 and 2020.

Natural gas and coal-fired power plants are the main assets used to compensate for the seasonal fluctuations in hydropower and increasing VRE generation. As a consequence, the combined generation of natural gas and coal-fired power plants experiences strong variations, ranging from 18.8 TWh to 33.6 TWh between 2009 and 2019. The relative level of natural gas and coal-fired generation also varied notably over this same period, driven mainly by changes in the prices for natural gas and coal. In 2016, the government established an official policy to phase out coal-fired generation and in 2018 introduced measures pushing for the phase-out. As result of these measures and market forces, coal-fired generation dropped significantly in 2019, and Portugal's largest coal-fired power plant closed in January 2021. The one remaining coal-fired power plant will close in November 2021.

Portugal is only electrically interconnected with Spain. Historically, Portugal has been a net importer of electricity, but it became a net exporter of electricity for the first time from 2016 to 2018 (Figure 7.2). However, in 2019, Portugal was once again a net importer of electricity, with 3.4 TWh of net imports (8.1 TWh of imports and 4.7 TWh of exports). The net trade in electricity is driven by the evolution of the Portuguese and Spanish electricity systems configurations, especially expanding VRE capacity and new demand requirements, coupled with the different fuel prices and fiscal issues affecting the competitiveness of the electricity market.

Figure 7.2 Portugal's electricity trade with Spain, 2000-19



Because of expanding domestic renewable generation and rising electricity demand in Spain, Portugal became a net exporter of electricity for the first time in 2016.

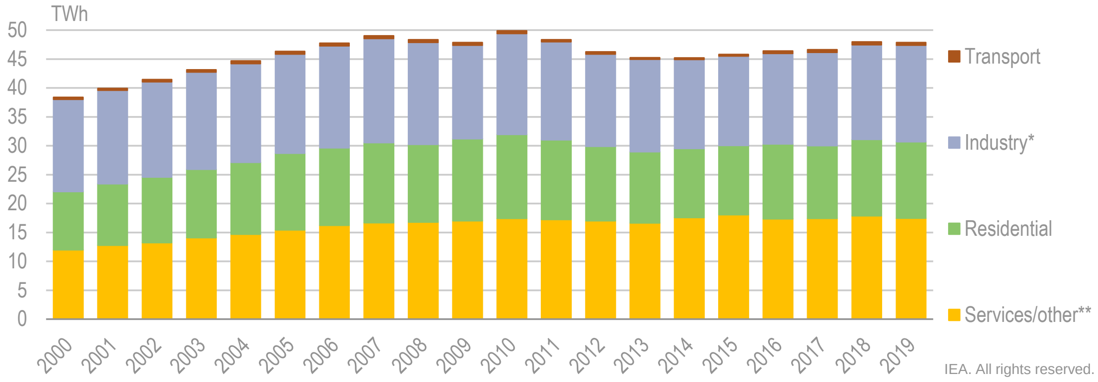
Note: TWh = terawatt hour.

Source: IEA (2020b), *Electricity Information 2020* (database), www.iea.org/statistics.

Electricity demand

Portugal's annual electricity demand peaked at 50.6 TWh in 2010, decreased until 2014 and has since been increasing, reaching 48.8 TWh in 2019 (Figure 7.3). The recent increase was mainly driven by the growth in electricity demand from the residential and industry sectors, along with the increased exports from 2016 to 2018. In 2019, the services/other sector accounted for the largest share of electricity demand (36% and 17.5 TWh), followed by industry (34% and 16.7 TWh), residential (27% and 13.2 TWh) and a small demand from transport (1% and 0.5 TWh), which came mostly from rail and a small but growing number of EVs.

Figure 7.3 Electricity demand in Portugal by sector, 2000-19

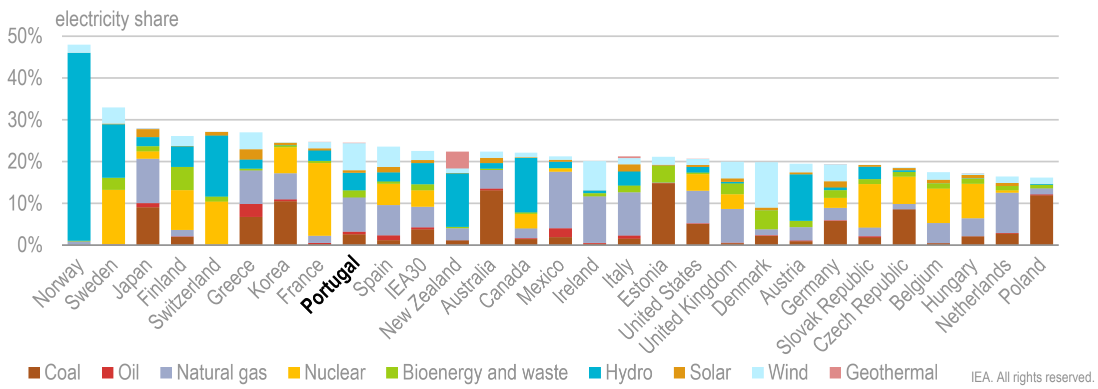


Electricity demand peaked in 2010, but has been growing again since 2014.

* *Industry* includes energy industry demand (petroleum refineries, coke ovens, gas works, etc.).
** *Services/other* includes commercial and public services, agriculture, forestry, and fishing.
Note: TWh = terawatt hour.
Source: IEA (2020b), *Electricity Information 2020* (database), www.iea.org/statistics.

Electricity covers a significant share of Portugal's total energy demand and there is a high level of electrification in all sectors, especially in buildings. In 2019, electricity covered 25% of Portugal's total energy demand, the seventh-highest share among IEA member countries and slightly above the IEA average of 22% (Figure 7.4). By sector, the share of energy demand covered by electricity was 54% for services/other (IEA average 53%), 39% for residential (IEA average 37%), 31% for industry (IEA average 32%) and 0.7% for transport (IEA average 0.8%).

Figure 7.4 Share of electricity in total energy demand in IEA countries, 2019



In 2019, electricity covered 25% of Portugal's total energy demand, the seventh-highest share among IEA member countries and slightly above the IEA average of 22%.

Source: IEA (2020b), *Electricity Information 2020* (database), www.iea.org/statistics.

Institutions

The Directorate-General for Energy and Geology (DGEG) has a number of responsibilities related to the electricity sector, including issuing licences and concessions for the operation of the electricity transmission and distribution systems, and licences for trading and supply of electricity. The Energy Services Regulatory Authority (ERSE) is the independent regulator for the electricity sector and sets network tariffs, grid connection costs and the regulated tariff for electricity. The ERSE and the DGEG are both involved in the approval process for infrastructure plans submitted by electricity system operators. The ERSE performs wholesale and retail market supervision in co-operation with the Portuguese Competition Authority (AdC), which is responsible for the prevention and sanctions of anticompetitive or abusive market practices.

The National Entity for the Energy Sector (ENSE) is a public corporation with responsibility for supervising energy sector facilities, infrastructures and activities, including electricity generation, transmission, distribution and sale. The Logistics Operator for Switching Suppliers (OLMC) manages the process for consumer switching between retail suppliers of electricity and gas. It also supports the automated process that provides the social tariffs for electricity and gas to qualifying consumers. The OLMC is overseen by the Portuguese Energy Agency (ADENE).

Redes Energéticas Nacionais (REN) is a 100% privately owned corporation that plays a major role in Portugal's electricity and gas sectors. REN owns REN Rede Elétrica Nacional, Portugal's electricity transmission system operator (TSO), which is certified as a full ownership unbundled TSO and holds the concession for operation of the national transmission grid and cross-border interconnections. REN Trading is the second-largest wholesale electricity supplier. REN also owns Portugal's natural gas TSO, the second-largest gas distribution system operator (DSO), and the operators of both Portugal's liquefied natural gas (LNG) terminal and largest gas storage facility (REN, 2021). The ERSE has imposed several measures to reinforce the separation of REN Trading from REN's role as the TSO, forbidding members of supervisory and administrative boards of REN Trading from being members of the supervisory and administrative boards of the TSO and from having any contract with or providing any type of service to the TSO.

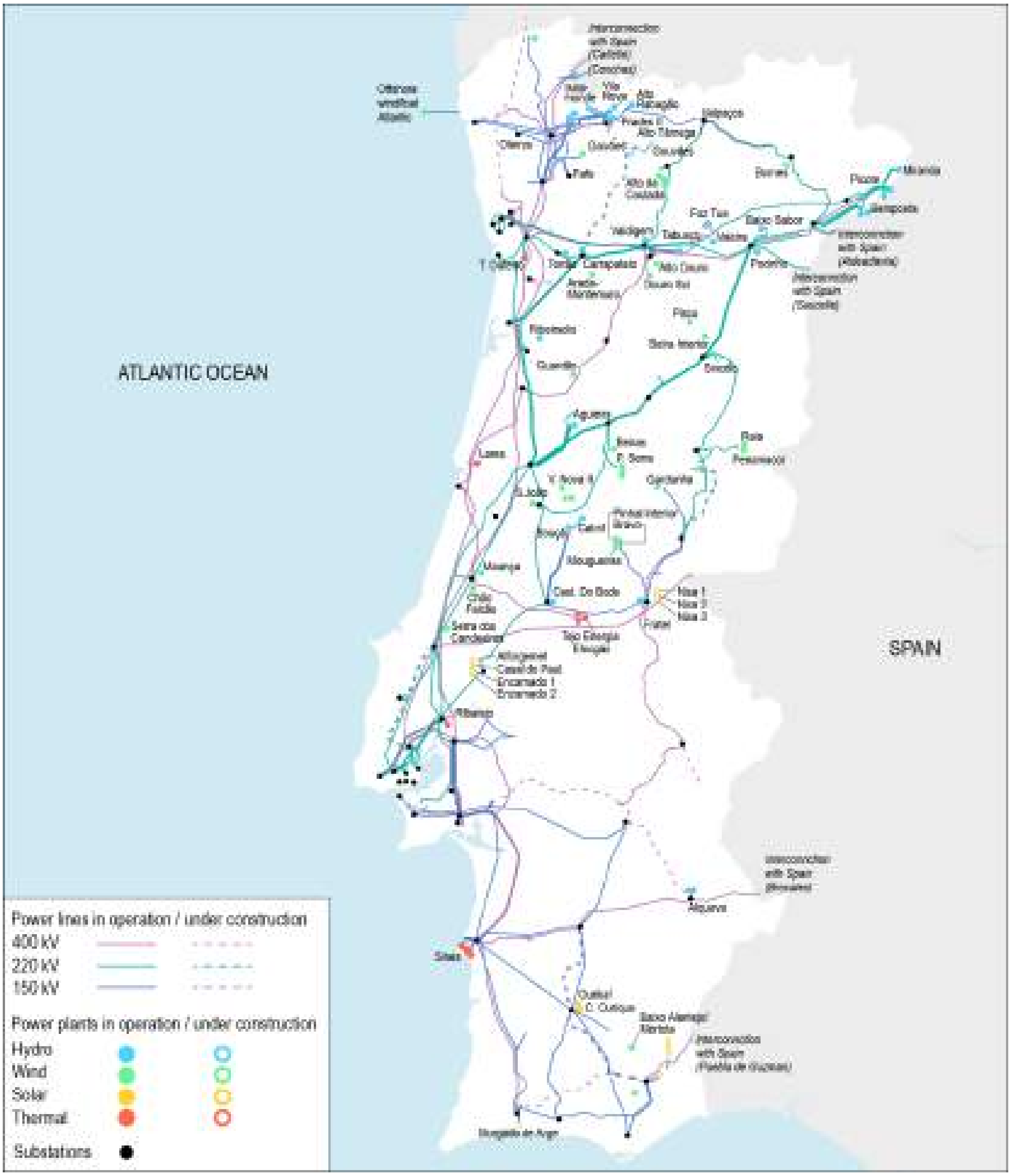
Energias de Portugal (EDP) is another 100% privately owned corporation that plays a major role in Portugal's electricity and gas sectors. It owns E-REDES, which is the only DSO for the high- and medium-voltage distribution system and holds concessions or licences for operation of most of the low-voltage distribution systems. In 2020, the ERSE required that E-REDES be rebranded to comply with brand separation and unbundling requirements. The ERSE approved the new brand name (E-REDES) and logo in August 2020 and these changes were fully implemented in January 2021 (ERSE, 2020a).

EDP Produção owns a large share of Portugal's hydropower thermal generation capacity. EDP Renováveis owns a large share of Portugal's wind and solar PV generation. EDP Comercial is the largest electricity supplier at the wholesale and retail levels and is also a major supplier in Portugal's natural gas wholesale and retail markets (EDP, 2018). SU Eletricidade (formerly EDP Serviço Universal) is the main last-resort supplier responsible for offering the regulated electricity tariff. In 2020, the ERSE required EDP Serviço Universal to be rebranded as SU Eletricidade to comply with brand separation and unbundling requirements (SU Eletricidade, 2020).

Infrastructure

In 2020, Portugal's electricity system consisted of a transmission system composed of 8 907 km of very high-voltage lines linked to Spain via nine cross-border electrical interconnections (Figure 7.5), and a distribution system composed of 226 530 km of high-, medium- and low-voltage lines and cables.

Figure 7.5 Active electricity suppliers in Portugal, 2020



Source: REN (2020), *National Transport Grid Map 2020*, www.ren.pt/en-GB/media/publicacoes.

Interconnections

As of 2020, there are nine interconnections linking Portugal and Spain, all very high-voltage above-ground power lines (six 400 kilovolts [kV] and three 220 kV). An additional 400 kV interconnection between the Minho region in Portugal and Galicia in northwest Spain is planned to start operation in 2022 or 2023. Portugal's TSO (REN) co-operates with Spain's TSO, Red Eléctrica de España (REE), on the operation of cross-border interconnections. In 2020, Portugal had an annual average import capacity of 2.93 GW and an annual average export capacity of 2.97 GW. In comparison, Portugal's maximum generation capacity in 2019 was 21.6 GW and peak demand was around 8.65 GW. Due to seasonal changes which impact power system operations and other factors, interconnection capacity varies throughout the year, with higher capacity in the winter and lower capacity in the summer.

Transmission

At the end of 2020, the national transmission network comprised 9 036 km of lines, of which 2 711 km were at 400 kV, 3 780 km at 220 kV and 2 545 km at 150 kV. The network had an installed transformer capacity of 38 463 mega-volt amperes. The backbone of the national transmission network is the 400 kV line running from the Alto Lindoso generation plant and the interconnections with Spain in the north to Sines in the south. The majority of electricity supplied by the transmission network is delivered to the distribution grid. However, in 2020, the transmission network included 83 very high-voltage connection points supplying electricity to large industrial consumers that accounted for around 5% of total electricity demand.

From 2014 to 2020, Portugal added around 600 km of new lines to the electricity transmission system, including several major projects to support the integration of increasing renewable generation. In 2015, a new 400 kV line started operation in the Minho region to support the integration of 1.1 GW of new hydropower capacity. In 2014, a new 220 kV line started operation in the Douro region between the new 190 MW Baixo Sabor hydropower plant and the Pocinho substation. In 2016, a new 400 kV line between the Pedralva substation and Ponte de Lima started operation to support the integration of 1.16 GW of new hydropower capacity being installed at Alto Tâmega and the planned additional 400 kV interconnection with Spain. A new 400 kV is planned to start construction in 2021 to deliver expanding solar PV generation in the south of the country to major demand centres.

Distribution

At the end of 2020, Portugal's high-voltage and medium-voltage distribution system consisted of 67 451 km of overhead lines, 15 985 km of underground cables, 423 substations and 25 338 consumer connections. The low-voltage distribution system consisted of 109 725 km of overhead lines and 33 715 underground cables, 69 000 secondary substations and 6.3 million consumer connections. Portugal's 308 municipalities own the section of the low-voltage distribution grid contained within their physical territory. Each municipality can directly operate its section of the low-voltage distribution grid or transfer operation to a third party through an exclusive 20-year concession. Historically, all municipalities in mainland Portugal have opted to transfer the operation of their low-voltage grid to a private DSO.

In 2020, 11 DSOs were operating in mainland Portugal. E-REDES is the only DSO for high- and medium-voltage distribution systems. It also operates the low-voltage distribution systems for 278 of Portugal's 308 municipalities, accounting for 99.5% of consumers connected at low voltage. Ten other small-scale DSOs operate the remaining 30 low-voltage networks that supply 0.5% of consumers connected at low voltage.

Most of the concessions for operation of the low-voltage grid have expired or will expire before the end of 2021. Law No. 31/2017 updated the process for awarding concessions. Municipalities are still free to choose direct operation of their networks, but when transferring operation to a private DSO, a competitive public tender is now required. To win a concession, private companies must meet requirements for economic and energy efficiency, and territorial cohesion for both operations and tariff uniformity.

Under Council of Ministers Decree No.5/2018, the ERSE has the responsibility to define territorial areas for low-voltage grid where a single DSO can operate the grid in that entire territory. The ERSE has proposed a geographic division of the low-voltage grid into three territories (north, central and south). The ERSE also has responsibility for reviewing results of the public tenders for DSO concessions (de Athayde Tavares and Campelo, 2019). Under Decree No. 11814/2020, a working group was created in November 2020 to set the terms of the low-voltage network concession tenders by March 2021. Until the new concession is established under tenders, current concession holders (mainly E-REDES) will continue to operate the low-voltage distribution grids.

Infrastructure planning and investment

The TSO is required to develop a ten-year development plan for the transmission network (PDIRT-E). Each DSO is required to develop a five-year infrastructure development plan for their section of the distribution network (PDIRD-E). Development plans for the transmission and distribution systems are updated every two years. The ERSE is responsible for evaluating the plans (including potential impacts on tariffs) and giving an opinion on all of the proposed projects to the DGEG, the TSO and the DSOs. The ERSE recommends which proposed investments are needed to meet reasonable demand projections and/or to safeguard energy security. It also evaluates the plans regarding operation of infrastructure and security of supply, and submits the final version of the plans (and its opinion) to the Secretary of State for Energy who has the authority to approve the plans, after an opinion from the Portuguese parliament.

The latest development plan for the transmission system is the PDIRT-E 2019 covering 2020-29. It proposes a total of EUR 743 million of investments in the transmission system, including several major projects for new 400 kV lines for the integration of renewable generation. This plan is currently in the review and approval process, with the ERSE issuing its opinion in May 2020. The latest development plan for the distribution system, the PDIRD-E 2020 covering the period 2021-26 was submitted to the DGEG in February 2021 to start the review and approval process.

From 2014 to 2019, EUR 2.4 billion was invested in Portugal's transmission and distribution network (Table 7.2). At the transmission level, this spending primarily supported the refurbishment of existing assets reaching their end of life, and new lines and transformation capacity to integrate new renewable capacity from hydro, wind and solar PV. At the distribution level, most investments were related to ensuring quality of service, with some investments aiming to increase security of supply and reduce losses. Over the last few years, new types of investments have supported improved data management, system flexibility and cybersecurity.

Table 7.2 Investment in electricity transmission and distribution in Portugal, 2014-19

Network	Voltage	Investments (EUR million)					
		2014	2015	2016	2017	2018	2019
Transmission	**Very high**	137	148	158	135	86	141
Distribution	**High**	32	43	31	18	12	9
	Medium	163	148	127	130	90	107
	Low	109	114	118	144	145	151
Total		**441**	**453**	**434**	**427**	**333**	**408**

Policy

Portugal's energy policy places a strong focus on achieving economy-wide decarbonisation through broad electrification combined with rapid expansion of renewable electricity generation, all the while maintaining affordable electricity prices. Portugal's National Energy and Climate Plan (NECP) sets a 2030 target for 80% of electricity generation to come from renewables. The Roadmap for Carbon Neutrality (RNC2050) sets a goal for 2050 for 100% of electricity generation to come from renewables and for the transport sector to be fully decarbonised, primarily through electrification. The RNC2050 also indicates that electricity should cover 32-33% total energy demand in 2030 and 66-68% in 2050. In 2019, renewable energy accounted for 53% of electricity generation and electricity covered 25% of total energy demand.

Increased renewable generation

The NECP indicates that to meet the 2030 targets, Portugal's installed capacity of renewable electricity generation needs to grow from 14.0 GW in 2018 to 27.4 GW by 2030. Most of this growth is expected come from a near tenfold increase in solar PV capacity, followed by a near doubling of wind capacity (including some floating offshore wind) and a notable expansion of hydropower capacity (especially for pumped hydro). Large-scale renewable energy projects commissioned before 2012, primarily onshore wind projects, receive an FIT for 15 years from the start of operations. In 2014, a new FIT was introduced supporting renewable generation from small-scale and self-consumption projects. In 2019, the government established annual auctions for large-scale (great than 1 MW) solar PV projects. Auctions held in 2019 and 2020 awarded network capacity of 1.85 GW of PV projects. Also in 2019, a new legal framework was approved to promote energy communities and self-consumption of distributed renewable generation (see Chapter 5).

The government does not provide financial incentives for large hydropower projects, but has approved numerous hydro projects in recent years. In 2018, it approved the construction of three new hydropower dams with 1.16 GW of capacity, of which 0.88 GW will be pumped hydro. Two of the dams are expected to start operating in 2021, and the full project to be operating in 2023 (Iberdrola, 2021). Several major transmission system projects supporting the integration of increased hydropower have been completed since

2016 and a major increase in transmission capacity to integrate solar PV generation is planned to begin construction in 2021.

Government policy for onshore wind is focused on repowering existing wind farms. The NECP notes that Portugal has significant onshore wind generation potential that has yet to be explored. The government is also pushing for Portugal to become a leader in floating offshore wind generation and has approved six sites for floating offshore wind deployment. The NECP indicates that floating offshore wind capacity should reach 0.3 GW by 2030. Portugal's first floating offshore wind project, WindFloat Atlantic, became fully operational in July 2020, with a total capacity of 25 MW (Offshore, 2020).

Coal phase-out and continued use of natural gas

Coal accounted for a major share of Portugal's electricity generation for decades. In line with policy goals for decarbonisation and reducing energy import dependency, the government announced in 2016 that coal-fired generation would be phased out by 2030. In 2018, Portugal introduced a progressive elimination of tax exemptions on coal consumption by coal-fired generation plants. In 2019, the government indicated in the NECP that coal-fired generation would be phased out by 2023.

Since 2018, the competitive position of coal-fired generation in Portugal has been significantly eroded by the reduced tax exemption, higher carbon prices in the European Union's Emission Trading System, low natural gas prices and increasing generation from low-cost renewables. As a result, the private operators of Portugal's two coal-fired power plants announced in 2020 that both plants will permanently close in 2021. The 1.3 GW Sines coal-fired power plant closed in January 2021 and the 0.6 GW Pego coal-fired power plant will close in November 2021.

The NECP notes that the government is examining the possibility of reusing equipment from the two coal-fired power plants to support increased renewable generation. Potential options include the installation of solar thermal collectors with storage to produce steam that can directly feed the existing turbines in the power plants, and direct use of hydrogen produced from renewable energy as a fuel for the power plants.

The NECP also indicates that electricity generation from natural gas will be maintained until at least 2040, and that 2030 combined cycle gas turbine (CCGT) capacity could be maintained at the 2019 level of 3.9 GW or drop to 2.8 GW, depending on the development of other flexibility assets such as pumped hydro, battery storage and hydrogen.

Increased exports, security and European market integration

Portugal has goals to increase renewable electricity exports and to improve electricity security and market efficiency through higher electrical interconnection capacity with Spain and between the Iberian peninsula and the rest of Europe. Under the 2015 Madrid Declaration and the 2018 Lisbon Declaration, Portugal, Spain, France and the European Commission committed to building electricity infrastructure that better integrates the Iberian peninsula into the European electricity market. At the 23rd Spain-Portugal summit in October 2020, the governments of Portugal and Spain signed a joint declaration reconfirming their support for increased electrical interconnections (Government of Spain and Government of Portugal, 2020).

Portugal achieved the EU's 10% interconnection target for 2020 (which is determined by the ratio of interconnection import capacity and generation capacity) and is planning to construct additional interconnection capacity to meet the 2030 interconnection target of 15%. The interconnection capacity of the Iberian peninsula with the rest of Europe has also been increasing, with the addition of a 2 GW direct current interconnection between Spain and France in 2017 (Enjuanes, Castejón and Camacho 2017). An additional 2 GW of direct current interconnection between Spain and France is in the permitting process (ENTSO-E, 2020).

Electrification

Portugal is supporting increased use of electricity in all sectors. In line with the NECP, the National Investment Plan 2030 (NIP 2030), which sets infrastructure investment priorities through 2030, includes funding for numerous projects supporting electrification, especially in the transport sector. These include EUR 4.5 billion for a new electric high-speed rail line from Lisbon to Porto, EUR 300 million for an international electric high-speed rail connection, EUR 3.7 billion to expand the electric metro systems in Lisbon and Porto, EUR 450 million to promote electric mobility, EUR 590 million to decarbonise public transportation and EUR 450 million to decarbonise urban logistics (both primarily through electrification) (Government of Portugal, 2020). Portugal also has subsidies and tax benefits for EVs and goals for expanded EV charging infrastructure. The government's energy efficiency policy includes numerous programmes and measures that support the electrification of building and industry energy demand (see Chapter 4).

Hydrogen from renewable electricity

Portugal's National Hydrogen Strategy (EN-H2) sees hydrogen produced from electrolysis using renewable electricity as a key pillar of long-term decarbonisation, especially for hard-to-decarbonise end uses. The EN-H2 indicates that by 2030, hydrogen should cover 1.5-2.0% of Portugal's energy demand, 2-5% of industry energy demand, 3-5% of domestic maritime shipping energy demand, 1-5% of road transport energy demand and 5-10% of the volume of gas delivered by the natural gas network. This would require the deployment of an estimated 2.0-2.5 GW of electrolysis capacity powered by renewable electricity by 2030, along with enabling legislation, regulations and, standards. The EN-H2 also indicates that in the long term, renewable hydrogen could be used directly for electricity generation and energy storage (see Chapter 5).

Storage

The government sees electricity storage as a key pillar of its decarbonisation strategy, especially for VRE integration and system flexibility. The NECP notes that through 2030, the main focus will be increasing the capacity of pumped hydro storage, which is expected to grow from 2.7 GW in 2020 to 3.6 GW by 2030. The NECP also indicates that there will be an increasing focus on battery storage and hydrogen closer to 2030 and that behind-the-meter battery storage should play an important role in supporting demand response. In the 2020 solar PV auction, 72% of the awarded capacity went to projects under a bid option requiring energy storage and should result in the deployment of at least 100 MW of battery storage. The government has indicated that future PV auctions will include bidding options that require storage.

The NECP notes that the government is working on a legal framework and a road map for energy storage. The legal framework is needed to clarify the regulatory and market status of storage systems, especially for batteries. The main objective of the road map is to provide an independent analysis of pathways for storage deployment aligned with targets for renewable energy, decarbonisation, security and cost. The government aims to produce the first storage road map in 2021, with plans to update it at least every five years to reflect the evolution in technology and costs. The storage road map will also be aligned with the EN-H2.

Demand response

The government sees demand response as a key option for increasing the flexibility of the electricity system and VRE integration. In 2018, the ERSE started developing rules (including regulatory sandboxes) for two pilot projects examining demand response by industrial consumers. The first pilot project was completed in May 2019 and examined changes to the time-of-use structure of network tariffs to promote demand response and encourage efficiency. The pilot project attracted the participation of 82 industrial consumers connected at medium and high voltage. It tested the introduction of locational time signals through regional time-of-use schedules and the definition of a super peak period, corresponding to approximately one-third of the current peak period.

The first pilot project found an incremental demand response of 2% during the super peak period, leading to an overall positive assessment. The ERSE's final report will be presented as part of the tariff code review before the next regulatory period, beginning in 2022. The second project, completed in September 2020, validated the interest and ability of large industrial consumers (demand over 1 MW) to participate (individually or aggregated) in the replacement reserve market (INESCTEC, 2021). Based on the results of these pilot projects, the ERSE will conduct a cost-benefit analysis to determine options and next steps for implementing dynamic tariffs and allowing demand response participation in the replacement reserve market.

Smart grids and meters

The government sees smart grids empowered by smart meters as key to increasing VRE integration and system flexibility through greater consumer participation in electricity markets. The August 2019 regulation for smart grid services, published by the ERSE, includes goals to establish minimum standards of service to be provided by a smart grid in relation to metering (15-minute data collection, remote access for network operators, digital platform of consumers with real-time data and consumption alerts, etc.) contracts and billing (maximum demand settings, time-of-use schedules, etc.) and operations (remote connect/disconnect, better real-time load data and predictive load profiles, etc.).

The government is pushing for smart meter deployment. Under Decree-Law No. 64/2020, electricity meters installed after 25 October 2020 must support remote reading if this is technically and economically feasible. Meters already installed that do not support remote reading must be equipped with this capacity or replaced by meters supporting remote reading by 1 January 2027. E-REDES (the main DSO) has a voluntary target for all consumers to have a smart meter by 2025, which would result in a total of around 6.2 million smart meters deployed in mainland Portugal. In 2020, around 2 million smart meters had been deployed and all consumers connected to the distribution grid at high, medium and low voltage above 41.4 kilovolt-amperes (kVA) had smart meters. Together, these consumers accounted for approximately 70% of the total electricity demand.

According to Law No. 12/2008, DSOs cannot charge consumers for the cost of installing, maintaining or operating electricity or gas meters. The law does not allow meters to be included in the regulatory rate of return that the ERSE establishes for distribution system assets. Smart meters had benefited from a special regime allowing a return of 80% of the smart meter's cost, but this regime ended in 2018. The 2019 regulation for smart grid services established an output-based incentive, which aims to encourage low-voltage DSOs to deliver smart grid services to consumers. Under the incentive, low-voltage DSOs receive a fixed annual amount for a fixed number of years per connection point that provides a defined set of smart grid services to consumers.

The level and duration of the incentive is published annually by the ERSE and DSOs receive the incentive base on the year a connection is established. Qualified connections established in 2019, 2020 and 2021 receive the incentive for eight years with the value per connection varying slightly by year: EUR 5.00 in 2019, EUR 5.20 in 2020 and EUR 5.15 in 2021. In 2019, 4 500 connections qualified for the incentive and an estimated 4 400 in 2020.

Social tariff

Portugal has social tariffs for electricity and natural gas that provide discounts on parts of distribution tariffs to reduce the electricity and gas bills of households that meet certain socio-economic requirements. The social tariffs are offered by the last-resort suppliers and all market suppliers. In 2016, the process to apply for social tariffs was amended so that qualifying households are automatically assigned the social tariff. This resulted in an increase in the number of consumers receiving the electricity social tariff from 140 545 in the first quarter of 2016 to 691 860 in June 2016. Since 2016, the number of households receiving the electricity social tariff has continued to grow. In December 2020, 752 956 households (14% of all households) received the electricity social tariff. The electricity social tariff covers electricity used for domestic purposes by private households connected to the low-voltage electricity network with a contract not exceeding 6.9 kVA.

In the spring of 2020, the government initiated a review of the legislative acts regulating the social tariffs for electricity and gas to address the economic impacts of Covid-19 and to ensure that the tariffs were available to the most economically vulnerable consumers. As result of this review, the requirements for the natural gas and electricity social tariffs were amended with the intention for both tariffs to cover an increased share of economically vulnerable households. In March 2020, the eligibility for the social tariff was extended to all situations of unemployment. In November 2020, the government again expanded eligibility requirements for electricity and gas social tariffs.

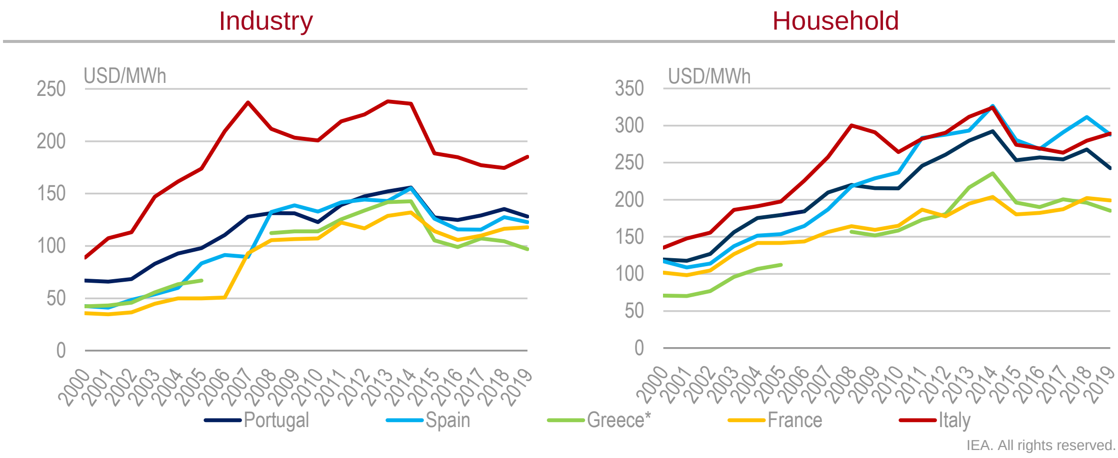
Under the new requirements, households are eligible for the electricity social tariff if their annual income is less than EUR 5 808 plus EUR 2 904 per member of the household that does not have any income, up to a maximum of ten household members. Additionally, households can receive the electricity social tariff if the holder of the electricity contract is a beneficiary of one of the following governmental social programmes: solidarity supplement for the elderly, social income, unemployment benefits, beneficiary of child support or social disability under the special disability protection regime or the complement to the social benefit for inclusion, or social elderly pension (ERSE, 2020b).

The cost reduction provided to households by the electricity social tariff results from a discount on the transitory tariffs on sales to final electricity consumers, excluding value-added tax (VAT), other taxes, contributions and applicable fees. The government and the ERSE evaluate and if necessary update the discount on an annual basis. In 2020, the discount was set at 33.8%. In 2020, the social tariff led to a total cost reduction of around EUR 109 million (including mainland Portugal and the autonomous island regions). The cost of the electricity social tariff is covered by the private companies that operate thermal and large (above 10 MVA) hydro generation in mainland Portugal, with payments proportional to installed generation capacity.

Prices and taxes

Portugal's electricity prices increased notably from 2000 to 2014, but have since fallen following a trend similar to that in other southern European countries (Figure 7.6). Portugal has relatively high retail electricity prices compared to other IEA member countries (Figure 7.7). In 2019, industrial electricity prices ranked seventh-highest (128 USD/MWh), with the third-highest tax component (27%). Household electricity prices ranked the eighth highest (242 USD/MWh), with a high tax component (49%).

Figure 7.6 Electricity prices in selected IEA member countries, 2000-19

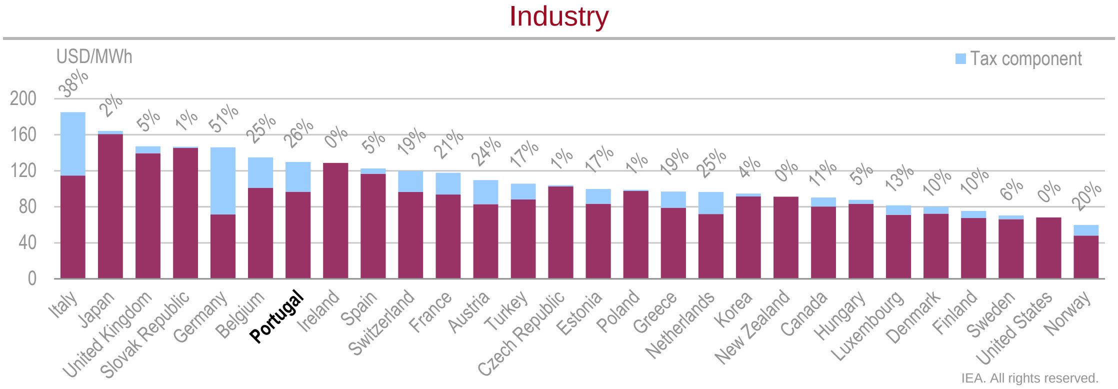


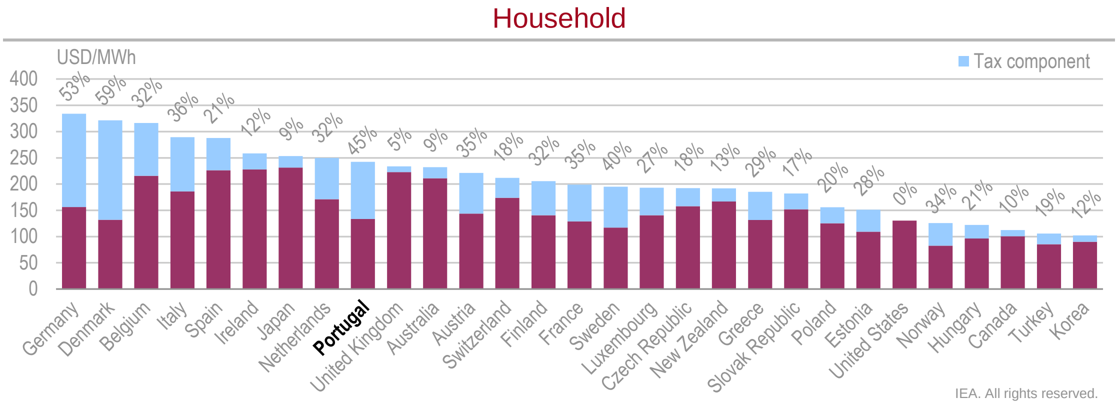
Portugal's electricity prices are more stable compared to Italy's and Spain's, although all southern European countries follow similar price trends.

* Data are not available for Greece for 2006 and 2007.

Source: IEA (2020c), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Figure 7.7 Electricity prices in IEA member countries, 2019





Portugal's electricity prices for industry and households are above the median price for IEA countries, with relatively high tax components.

Notes: Tax Information is not available for the United States. Household price data are not available for Mexico. Industry price data are not available for Australia or Mexico.

Source: IEA (2020c), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Retail electricity prices in Portugal are composed of wholesale electricity costs, tariffs paid to system operators, operating margins of retail suppliers and taxes. The tax component of electricity prices is composed of the tax on energy products (ISP), VAT, and a variety of other taxes and fees (e.g. the audiovisual contribution, which funds public radio and television). The maximum VAT rate of 23% is applied to all electricity sales, but is refunded 100% for industrial consumers. In 2020, only 33% of the average household retail price for electricity was composed of energy costs; the remaining 67% came from tariffs and taxes. For industrial consumers, around 49% of the average retail price for electricity was composed of energy costs, with the remaining 51% coming from tariffs and taxes.

The ISP for electricity is EUR 1.00 per MWh and has been unchanged since it was introduced in 2012. The ISP rate is the same for all consumers regardless of the sector, and rates do not vary with the level of demand. However, since 2013, industrial consumers have a 100% exemption from the ISP for electricity and industrial fuels if they are covered by the EU Emissions Trading System (ETS) scheme or by an energy consumption rationalisation agreement (ARCE). ARCEs are part of a government programme requiring industrial energy efficiency measures (see Chapter 4). In addition, all industrial consumers receive a full refund of the VAT charged on energy products (including electricity). As a result, the taxation on electricity is significantly lower for industrial consumers than it is for residential and commercial consumers.

In 2019 and 2020, Portugal made changes to the VAT charged on electricity and gas demand that reduced taxation of electricity in comparison to gas for many consumers and created VAT rates for electricity that increase with higher levels of demand to encourage efficiency. For consumers connected to the low-voltage electricity network with a contract not exceeding 3.45 kVA and for natural gas consumers connected to the low-pressure gas network with a contract not exceeding 10 000 cubic metres per year, the VAT charged on the fixed component of network access tariffs was lowered from 23% to a "reduced rate" of 6% in mainland Portugal, 4% in the Azores and 5% in Madeira. For electricity consumers with a contract lower than or equal to 6.9 kVA (and those receiving the social tariff), the VAT charged on the entire electricity bill (but not gas bill) was reduced from 23% to an "intermediate rate" of 13% in mainland Portugal, 9% in the Azores and 12% in Madeira. The intermediate rate only applies to the first 100 kWh per 30 days (150 kWh per 30 days for households of more than five persons); above this demand, the 23% rate is applied (ERSE, 2020c).

In January 2021, Portugal experienced record-breaking low temperatures, resulting in large increases in electricity and gas demand. In response, the government provided a temporary discount on the electricity bills of household consumers with a contracted power lower than or equal to 6.9 kVA and on the bills of those consumers receiving the electricity social tariff. This exceptional reduction in electricity bills was financed by the Environmental Fund.

Electricity prices are also indirectly affected by the ISP and the carbon tax charged to operators of natural gas and coal-fired electricity plants. Historically, coal and gas used for electricity generation were exempt from the ISP and carbon tax. However, Portugal has been reducing the tax exemption on fossil fuels used by power plants to support decarbonisation. Starting in April 2020, natural gas used for electricity generation (excluding co-generation)[2], was no longer fully exempt from the ISP or the carbon tax, and operators began to pay 10% of the ISP and 10% of the carbon tax. Both of these percentages will be progressively increased to 40% in 2023. In 2018, Portugal introduced a progressive elimination of the ISP and carbon tax exemptions for coal-fired power plants, with the exemption to be completely eliminated in 2022. The largest coal-fired power plant closed in January 2021 and the last remaining plant will close in November 2021.

Market structure

Portugal has liberalised electricity markets: any supplier can sell electricity at the wholesale and retail levels and consumers have the right to choose and switch suppliers. Portugal and Spain have a common wholesale electricity market (MIBEL) that is part of the European common electricity market. The market shares of wholesale and retail electricity suppliers operating in Portugal and the ownership of Portugal's generation capacity are highly concentrated among a few private companies. The size of the ancillary service market is currently modest and highly concentrated. Electricity prices are determined by market forces; however, in 2020, regulated tariffs were used by 5.1% of consumers and accounted for 15.3% of total retail electricity sale.

[2] Co-generation refers to the combined production of heat and power.

MIBEL wholesale market

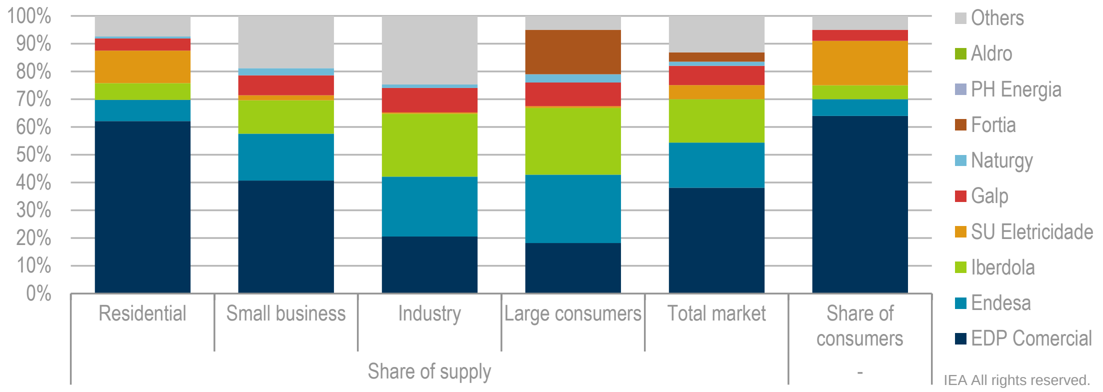
The MIBEL wholesale market uses a market coupling model that produces a single price for Portugal and Spain when there are no constraints on cross-border interconnection capacity. Market splitting (the percentage of hours when the price difference in Portugal and Spain is equal to or greater than EUR 1.00 per MWh) ranged from 2% to 7% between 2014 and 2020 and has been 4% or lower since 2018. The market operator responsible for the management of MIBEL is based on a bipolar interconnected structure with OMIE (Spanish Centre) responsible for day and intraday market management and OMIP (Portuguese Centre) responsible for the management of forward markets. Since May 2014, MIBEL has been coupled with the European common electricity market, where it acts as a single balancing and entry/exit zone (REN, 2014). The ERSE continues to work on deepening the integration of MIBEL and co-ordinates with other national energy regulators to integrate the Portuguese electricity market with other regional and European markets.

EDP owns the majority of Portugal's installed generation capacity. In 2019, it owned 57% of total generation capacity, 100% of large hydro capacity, 66% of coal capacity, 53% of CCGT capacity and 17% of renewable capacity excluding large hydro (mostly onshore wind). EDP is by far the largest supplier of electricity purchased at the wholesale level in Portugal. In 2019, it supplied 46% of the electricity purchased at the wholesale level in Portugal, followed by REN Trading (9%) and Endesa (5%). Numerous renewable energy generators under the FIT regime supplied the remaining 40% (ERSE, 2020d).

Retail market

In 2019, there were 29 suppliers active in Portugal's retail electricity market. EDP Comercial is by far the dominant supplier, accounting for 64% of consumers and 38% of supply, and just four companies (EDP Comercial, Endesa, Iberdrola and Galp) accounted for 77% of retail supply and 80% of consumers (Figure 7.8). In 2019, SU Eletricidade (the main supplier of last resort, which is owned by EDP) had the second-largest share of consumers (15%) and covered 5% of retail electricity supply. Ten small suppliers of last resort, operating exclusively in the household and small business retail segments, supplied less than 0.5% of consumers.

Figure 7.8 Active electricity suppliers in Portugal, by type of consumer, 2019



EDP is by far the dominant retail electricity supplier and just four companies (EDP, Endesa, Iberdrola and Galp) accounted for 77% of retail supply and 80% of consumers in 2019.

Source: ERSE (2020d), *Annual Report Electric Markets and Natural Gas in 2019*, www.erse.pt/media/en0plsfa/relat%C3%B3rio_ce-2019.pdf.

In 2017, the government assigned the management of the procedure for switching retail electricity suppliers to OLMC. Prior to this, the DSO managed the switching procedure. In 2018, the ERSE approved common switching procedures for electricity and gas consumers. Under these procedures, switching retail electricity suppliers is free of charge, there is no limit to the number of times a consumer can switch and switching requests must be executed within three weeks or less. In 2019, the annual switching rate was 11.9%, a slight reduction from 2018 (12.4%), but still relatively high in comparison to other EU countries (ACER, 2020).

Regulated tariffs

When Portugal started the process of market liberalisation in 2010, the government aimed to end regulated retail electricity tariffs by 2015. However, in 2013, a transitory regime was established that extended regulated tariffs through 2020. In 2017, consumers connected to the low-voltage grid were given the option to switch from the liberalised market back to the regulated tariff. In April 2020, the Portuguese government again extended regulated tariffs until 31 December 2021 for consumers connected at medium voltage, until 31 December 2022 for consumers connected at low voltage with a contract greater than 41.4 kVA, and until 31 December 2025 for consumers connected at low voltage with a contract equal to or less than 41.4 kVA.

In 2016, regulated tariffs accounted for 8% of the total retail electricity supply and 23% of consumers. This dropped to 5.5% of supply and 16.5% of consumers in 2019, but the rate of consumers moving away from the regulated tariff has slowed. Since 2017, consumers connected at low voltage are allowed to switch back to the regulated tariff. The majority of consumers remaining under the regulated tariff are private households. Almost all industrial and commercial consumers purchase electricity from the liberalised market. Regulated tariffs are set annually by the ERSE based on MIBEL prices from the previous year, but can be adjusted quarterly if wholesale prices go outside minimum or maximum values set by the ERSE. SU Eletricidade (owned by EPD) has been designated by the ERSE as the electricity supplier of last resort that provides the regulated tariff. All retail electricity suppliers are free to offer their consumers a tariff equivalent to the regulated tariff.

Electricity security

Portugal has an extensive and well-maintained electricity system that provides a high level of security of supply. In 2019, Portugal's generation capacity (21.6 GW) greatly exceeded peak demand (8.65 GW). In addition, the majority of generation capacity is composed of highly responsive generation assets, with 7.3 GW of hydro (including 2.8 GW of pumped hydro) and 3.9 GW of CCGTs. Portugal's nine cross-border interconnections and strong market integration with Spain through MIBEL also support security of supply by allowing Spain's significant generation capacity (104 GW in 2019) to easily supply electricity demand in Portugal. In 2019, Portugal's interconnections provided an average import capacity of 2.62 GW, meeting the EU target for 10% interconnection capacity. An additional 400 kV interconnection will be constructed in 2021 and more interconnection capacity is planned to support the achievement of the EU's 2030 target for 15% interconnection capacity. The Iberian peninsula is also fully integrated into the European electricity system, providing additional security of supply. Portugal and Spain are working to increase the electrical interconnection capacity of the Iberian peninsula with the rest of Europe.

In 2021, 1.8 GW of coal-fired generation capacity will be permanently shut down; however, the government has conducted studies showing that existing CCGT and hydropower plants provide more than sufficient capacity to allow the coal-fired plants to be closed without creating adequacy issues. In addition, from 2021 to 2023, 1.16 GW of new hydropower capacity (including 0.88 GW of pumped hydro) will come online, further strengthening system security.

Portugal is an international leader with respect to VRE integration. The combined share of wind and solar PV generation has exceeded 22% of generation every year since 2012 and reached 29.1% of generation in 2019 (26.6% wind and 2.5% solar PV). Portugal is pushing for a major expansion for VRE generation from 2019 to 2030, with the NECP indicating that solar PV capacity should expand from 0.4 GW to 9.0 GW, while wind capacity should grow from 5.2 GW to 9.3 GW. Portugal is taking clear steps to ensure that expanded VRE generation can be securely integrated, including an update to the process for connecting to the electricity grid in 2019, which requires electricity generation projects to be granted a network capacity reserve title before they can start construction.

The solar PV auction system that Portugal established in 2019 gives preference to solar PV deployment in areas where the TSO and DSO have determined there is sufficient grid capacity. In the 2020 edition of the auction, 72% of the awarded capacity (483 MW) went to projects under a PV plus battery storage option, greatly increasing the ease of integration. The government has indicated that future auctions will contain a PV plus storage option. The government also approved transmission projects that will start construction in 2021 to support the integration of solar PV generation.

Portugal has a comprehensive electricity security framework to manage system disruptions. The TSO (REN) has duplicate control rooms in Lisbon and Porto and maintains a System Defence Plan defining the responses to disruptions and a System Restoration Plan, defining responses to restore electricity supply if a blackout occurs. The main DSO (E-REDES) has several contingency plans to respond to system disruptions, including an Operational Plan to Act in Crisis, which is activated when a predefined number of assets or consumers face disruptions. The Security of Supply Monitoring Report (RMSA) is published annually by the DGEG and covers electricity system adequacy, taking into account current and projected demand, and generation, network and interconnector capacity. The RMSA is taken into consideration when defining response measures for major disruptions to the electricity system.

In the case of major disruptions, the DGEG, REN and E-REDES co-operate through legislatively established procedures designed to ensure security of supply or restore normal operations. The main emergency measure is a load shedding scheme that aims to minimise overall disruptions while maintaining the supply of electricity to as many consumers as possible. For electricity consumers connected at ultra-high, high and medium voltage, there is a demand response scheme allowing the TSO to establish interruptible contracts providing remuneration for reducing demand. Presently, the TSO has 50 interruptible contracts with large industrial consumers intended for use in emergencies. The contracts have two different options allowing for interruption of a total demand of either 688.9 MW or 693.4 MW. None of these contracts have been used in the last 15 years.

All electricity supply disruptions are analysed by the TSO and E-REDES to determine the underlying causes and improve response procedures and upgrade infrastructure as needed. The TSO performs emergency response training exercises twice a year with the participation of all operators of both control rooms. The trainings are based on scenarios including total blackouts with top-down and bottom-up restoration, regional blackouts, and other major disruptions. Portugal's TSO also regularly holds joint training exercises with Spain's TSO on co-ordinating responses to major disruptions.

System performance

The Portuguese Quality of Service Regulation establishes the following metrics to assess the performance of the transmission and distribution networks:

- Energy not supplied (ENS): MWh of electricity demand requested by not supplied per year
- System average interruption frequency index (SAIFI): average number of unplanned power system outages per year
- System average interruption duration index (SAIDI): average number of minutes of unplanned power system outages per year.

The performance of Portugal's electricity transmission and distribution systems has improved in recent years to reach levels for the ENS, SAIDI and SAIFI that are close to the averages for Europe and above some southern European countries (Tables 7.3 and 7.4). However, Portugal's electricity system faces growing threats from wildfires and storms, which have caused increasing disruptions. In addition, there are issues related to electricity theft and fraud at the distribution level that DSOs are still working to address.

In 2017 and 2018, two wildfires and six storms caused major disruptions to the electricity system. One fire in 2017 affecting the transmission system caused the interruption of electricity supply to 92 586 customers. A fire in 2018 caused an interruption lasting 43 minutes and resulting in an ENS of 74.1 MWh. In 2017, the distribution network had three major disruptions (events resulting in an ENS of over 50 MWh). Two disruptions were caused by wildfires, which together interrupted supply to 905 612 customers. The other disruption was caused by a major storm that interrupted supply to 243 760 customers.

In 2018, transmission losses were 790 gigawatt hours (GWh), equal to 1.84% of total injections, a slight increase from 1.71% in 2019 and 1.66% in 2018. Transmission losses in EU countries ranged from 0.5% to 3.0% in 2018. Losses in the distribution network peaked at 11.22% in 2013 and declined notably to 9.77% in 2015. Since 2015, distribution losses have remained above 9.48% and were 9.58% in 2019, largely because of continued high levels of non-technical losses resulting from electricity fraud and theft.

Table 7.3 Portugal's transmission system's key performance metrics, 2016-18

Metric	2016		2017		2018		2019	
	Non-exceptional	Exceptional	Non-exceptional	Exceptional	Non-exceptional	Exceptional	Non-exceptional	Exceptional
ENS (MWh)	11	20.8	9.1	1.4	2.5	76.6	67.5	0
SAIFI (interruptions)	0.03	0.01	0.04	0.05	0.02	0.02	0.06	0
SAIDI	0.11	0.17	0.13	2.65	0.13	0.6	0.46	0

Notes: ENS = energy not supplied: MWh of electricity demand requested by not supplied per year. SAIFI = System average interruption frequency index: average number of unplanned power system outages per year. SAIDI = System average interruption duration index: average number of minutes of unplanned power system outages per year.

Table 7.4 Portugal's distribution system's key performance metrics, 2016-18

Voltage	Metric	2016		2017		2018		2019	
		Non-exceptional	Exceptional	Non-exceptional	Exceptional	Non-exceptional	Exceptional	Non-exceptional	Exceptional
High	SAIFI	0.27	0.02	0.16	0.06	0.19	0.08	0.2	0.14
	SAIDI	109.7	3.67	35.09	40.27	44.4	1542	22.97	89.17
Medium	ENS	3 416	657	3 488	3 536	3 900	5 435	3439	4348.17
	SAIFI	1.68	0.26	1.55	0.66	1.77	0.46	1.74	0.94
	SAIDI	71.2	16.45	71.38	55.32	84.95	146.1	72.13	109.88
Low	SAIFI	1.45	0.19	1.4	0.51	1.55	0.35	1.49	0.71
	SAIDI	64.08	11.66	66.57	41.3	80.98	119.7	68.57	82.98

Notes: ENS = energy not supplied: MWh of electricity demand requested by not supplied per year. SAIFI = System average interruption frequency index: average number of unplanned power system outages per year. SAIDI = System average interruption duration index: average number of minutes of unplanned power system outages per year. According to the Quality of Service Regulation approved by the ERSE, calculation of the ENS is only mandatory for the medium-voltage network and not available for the high- or low-voltage networks.

E-REDES has taken sustained efforts to reduce distribution losses, with the deployment of smart meters supporting proactive maintenance and better operational practices. The deployment of smart meters and the resulting increase in electricity data has also allowed a more detailed analysis of consumption patterns through a new supervision centre, which has improved the detection of fraud and theft. Operations in the field to detect electricity fraud and theft have also been increased. There is a need for new legislation regarding the way fraud and energy theft are treated. Under current law, consumers caught for electricity fraud or theft are only required to pay the cost of unbilled electricity demand, but no additional fines or penalties can be levied.

Assessment

Portugal's energy policy places a strong focus on achieving economy-wide decarbonisation through broad electrification combined with rapid expansion of renewable electricity generation, all the while maintaining affordable electricity prices. While natural gas will continue to play a role in electricity generation, coal-fired electricity will exit the market in 2021, which will considerably reduce the emission intensity of electricity generation.

Portugal is to be commended on its progress in connecting renewable energy sources to the grid, with renewables reaching 53.1% of electricity generation in 2019. This augurs well for the electricity sector to play a leading role in decarbonising the economy. Portugal ranks third in Europe in terms of share of wind energy in electricity generation (26.6% in 2019) and has developed its significant hydropower capacity, including valuable pumped storage capacity. The addition of new hydropower plants and a major build out of solar PV by 2030 and the coal phase-out will help put Portugal on track to achieve the 2030 target for 80% of electricity generation from renewables and the 2050 target for 100% of electricity generation from renewables. However, reaching these targets require a rapid increase in the deployment of renewables that will need to be sustained over the coming decades.

A clear market framework is needed to incentivise the flexibility of the electricity system, increase competition, drive down costs for consumers and support the integration of renewable generation. Well-functioning and open energy and flexibility markets should guide investment decisions. The size of the ancillary service market is currently modest and highly concentrated; in 2018, it was valued at a weighted average cost of EUR 1.56/MWh, compared with an average wholesale price of EUR 57.6/MWh.

In line with other countries with high levels of renewables on the grid, Portugal should develop an ancillary service market that rewards flexibility, incentivises new products and brings in new market players. Ramping products, fast frequency response, voltage support and local flexibility products should be evaluated and developed according to system needs. Demand-side response, aggregators, storage and also variable renewable energy sources will all have a role to play. The recent pilot project to allow participation of demand response in the Portuguese balancing market is a welcome step in the right direction, but all possible sources should be allowed to provide demand response. The commitment in the NECP to develop a policy road map for storage needs to support markets for flexibility and set out the long-term role of storage in integrating renewable energy.

Portugal has undertaken or is planning significant upgrades to the electricity transmission and distribution network to accommodate new renewable capacity additions. Grid development will need to be co-ordinated with the renewable deployment goals set in the NECP to ensure that the required reinforcements are made in time and grid congestion is minimised. Speedy approval of network development plans by the government is important to support necessary investments. The new approach to allocate grid connection capacity started in 2019, which requires new generation project developers to pay for network reinforcements to accommodate their projects or compete in an auction for capacity rights. Recent auctions for solar PV have been very successful in this regard and may be a model for other countries to follow.

Equally, the distribution network has a major role to play in accommodating new renewable capacity and transitioning to a more flexible system. Decentralised connected renewable generation (including solar PV) is expected to increase rapidly in the coming years. E-REDES has an important role to play in enabling smart grid services, self-consumption, the roll out of smart meters and carrying out the necessary investments required to expand the EV charging network. It is important that the ERSE provides the necessary regulatory framework and incentives to facilitate this.

The rapid roll out of smart meters is a key enabler and should be prioritised. The government is pushing for smart meter deployment. The 2019 regulation for smart grid services established an output-based incentive, which aims to encourage low-voltage DSOs to deliver smart grid enabled services that add value to consumers. Under the incentive, low-voltage DSOs receive a fixed annual amount for each supply point that provides a defined set of smart grid services to consumers. Since October 2020, meters must support remote reading. Increasing variable and distributed renewable generation, and the goals for improved demand-side response, require effective co-ordination on network operation and planning between the TSO and all of the DSOs.

Under Portugal's legal framework, municipalities are the owners of the low-voltage electricity networks and are free to allocate operation of their networks to a third party. Most municipalities opted to give the concession for low-voltage network operations to E-REDES, the DSO for the high- and medium-voltage distribution system. In 2020, the process for awarding the concession for the low-voltage networks was amended to require competitive tenders. The rules for the tenders are expected to be published in March 2021. E-REDES also operates most of the low-voltage distribution networks. As such, the tender process could result in low-voltage distribution operations being separate from medium-voltage distribution operations in a significant part of the country.

Portugal has some experience with this situation: ten small-scale DSOs covering 0.5% of electricity supply operate low-voltage networks independent from E-REDES' operation of the medium-voltage system. However, the IEA recommends that the DGEG and the ERSE examine existing regulations to ensure that the roles and responsibilities for operation of the various levels of the distribution system are clear and support secure and efficient operations in case a notable share of electricity supply was to be delivered by low-voltage DSOs operating separately from the high- and medium-voltage DSO.

The wholesale market in Portugal is well integrated with Spain through MIBEL, with strong price convergence and liquidity in the spot market (day-ahead and intraday markets with regional auctions and continuous pan-European cross-border coupling). Increasing electricity interconnection capacity between Portugal and Spain and between the Iberian peninsula and France will be important to build on the success of MIBEL and foster the coupling of the Iberian market with the rest of Europe. A major step forward in cross-border balancing took place in 2020 with the Portuguese TSO joining the Trans European Replacement Reserves Exchange project. The TSO already participates in a variety of other projects under the EU electricity balancing guideline.

There is a transparent forward market on the OMIP platform with multiannual offerings and new products to match variable renewable profiles. However, several market participants have indicated that liquidity on the forward markets is below the level needed for a well-functioning wholesale electricity market. According to market participants, the lack of liquidity partly results from financial regulations that place capital requirements similar to those required for investment firms on companies that trade energy derivatives on the forward market. This requirement has a notable impact on the participation of Portuguese and Spanish companies, many of which lack the level of credit to meet requirements for participating in the forward market.

The MIBEL Council of Regulators launched a public consultation on measures to promote the liquidity of the MIBEL forward market. This consultation aims to examine the impact of bilateral contracting in vertically integrated companies, the role and importance of market makers, the contribution of renewables for market liquidity, and the participation of smaller agents.

The market shares of wholesale and retail electricity suppliers operating in Portugal, and the ownership of Portugal's generation capacity, are highly concentrated among a few private companies, with EDP, the historic incumbent, maintaining a dominant position. The ancillary services market in particular shows very high levels of concentration. A recent successful antitrust case taken by the AdC, following a notification from the ERSE, against a market participant for anticompetitive behaviour in the ancillary services market highlights the urgent need for market reform. The ERSE is working to develop updated market rules for ancillary services in line with EU Regulation 2017/2195 establishing a guideline on electricity balancing. The Entry of 1.2 GW of new hydro capacity owned by the Iberdrola Group over the period 2021-23 is to be welcomed in this respect.

Portugal has high retail electricity prices compared to other IEA member countries, both at the industrial and household level, mainly explained by the significant tariff and tax component of the price. In addition, the liberalised retail market is highly concentrated among just four companies. In 2019, EDP Comercial, Endesa, Iberdrola and Galp together accounted for 78% of retail supply and 79% of consumers. EDP Comercial alone accounted for 66% of consumers and 39% of supply. The industry segment is the most competitive, while the residential segment is the most concentrated, but barriers need to be eliminated in all segments to allow the entry of new players. Retail competition should be further enhanced with an assessment of the existing barriers for new suppliers to enter the market and grow their market share, while ensuring the integrity and security of retail market functioning. Development of new products such as time-of-use tariffs should be prioritised.

There have been some cases of bankruptcies of new retail market entrants, which have caused aggregate losses to the system (e.g. through failure to pay grid access tariffs), and led to a negative perception of new market entrants among consumers. Legislation has recently been revised to address these issues and improve the integrity and security of the functioning of the retail market through the inclusion of integrated risk management and verification of the record of shareholders or administrators of new entrants in the electricity sector.

The end of regulated tariffs has been extended numerous times and they will remain in place for low-voltage consumers until 2025. The continuation of the regulated tariff, which in 2019 covered 16.5% of customers, is detrimental to competition and should be phased out. Switching rates are high compared to other European countries. In 2019, 15.5% of electricity consumers switched supplier. Of those, 47% switched between market suppliers, 30% switched from the regulated tariff to market suppliers. Switching from the market back to the regulated tariff has been allowed since 2017, but is almost non-existent.

The social electricity tariff is intended to protect vulnerable customers and in September 2020 covered 749 355 households. In 2020, the rules for the social tariff were expanded with the intention to cover an increased share of economically vulnerable households to help address the impacts of the Covid-19 pandemic. The social tariff in electricity is designed as a discount on the transitory tariffs and allows market suppliers to compete for consumers that qualify for the social tariff. While poverty reduction measures for low-income households is an important government priority, energy poverty issues would be more efficiently addressed through dedicated fiscal and social policy, especially support for energy efficiency measures. The government should ensure that dedicated fiscal and social policy and energy efficiency related measures are considered during the development of the National Long-Term Strategy to Tackle Energy Poverty and the National Strategy to Combat Poverty and that measures addressing energy poverty support the achievement of Portugal's decarbonisation goals.

The Portuguese electricity system delivers a high level of security of supply. However, susceptibility to climate change impacts is emerging as a significant risk. Portugal's transmission and distribution infrastructure faces a growing threat from extreme weather events and wildfires, both of which are likely to increase in frequency and severity because of climate change. Also, climate change impacts on rainfall pose a notable threat to Portugal's hydropower generation, which is critical to support secure grid operations and to meet energy sector targets on decarbonisation, electrification and reducing energy import dependency. It is recommended Portugal include potential climate change impacts on the electricity system as part of the RMSA and in the planning for climate adaptation.

Portugal's electricity sector has a high level of market concentration for generation and wholesale and retail supply. In addition, the TSO and main DSO are part of private companies that have dominant electricity market positions. Strong regulatory supervision is critical to ensure that the different players fulfil their legal and contractual obligations in the areas of generation, transmission, distribution, trading and supply to preserve the public interest, ensure quality of service and security of infrastructure, and maintain free and healthy competition. In this context, the National Entity for the Energy Sector has been developing a set of inspection actions covering electric generation, transmission, distribution, and EV charging and other electricity infrastructures.

Recommendations

The government of Portugal should:

- ☐ Foster competitive markets that properly value and incentivise flexibility in supply and demand to drive investment and innovation.
- ☐ Review network development plans to ensure that they facilitate the integration of variable renewables in line with 2030 targets and support smart grids, including electric vehicle charging and smart meters.
- ☐ Ensure that the MIBEL wholesale market is further developed to increase competition and maximise the integration of renewables.
- ☐ Continue to work with Spain on increasing electricity interconnection capacity between Portugal and Spain and between the Iberian peninsula and the rest of Europe.

- Enhance electricity retail market competition by removing barriers to entry for new players and facilitate market innovation to incentivise demand response, distributed renewables and increased electrification while ensuring market integrity and security.
- Assess and monitor climate impacts on security of supply, including the volatility of hydro generation and vulnerability of infrastructure to extreme weather and fires, as part of the annual Security of Supply Monitoring Report.

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8. Natural gas

Key data (2019)

Share of gas: 0% of domestic energy production, 24% of total energy supply, 11% of total final consumption, 33% of electricity generation

Gas demand: 6.1 bcm, heat and electricity 59.6%, industry 23.8%, residential 5.4%, services/other 4.8%, transport 0.3%

Net gas imports: 6.1 bcm (6.1 bcm imports, 0 bcm exports)

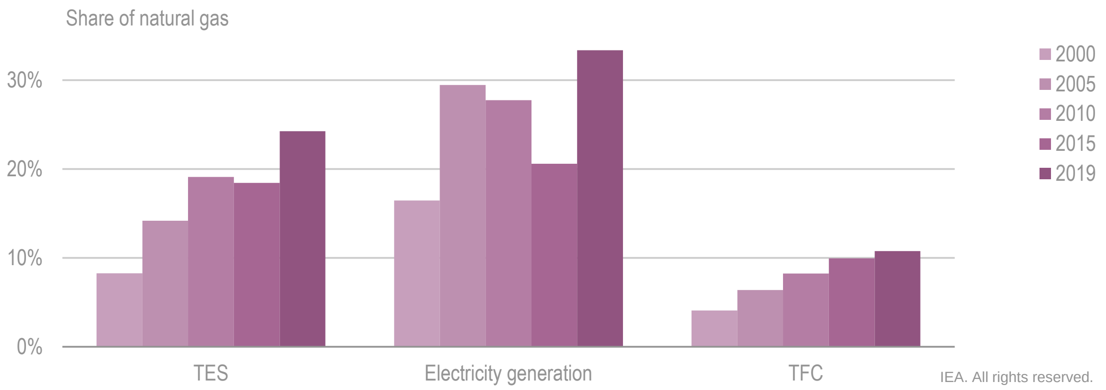
Overview

Natural gas was introduced in Portugal in 1997 and has since become a key energy source. From 2000 to 2019, Portugal's natural gas supply and demand notably increased (Figure 8.1). The share of gas-fired electricity generation experiences notable year-on-year changes related to normal variations in generation from Portugal's large hydropower fleet. In 2019, natural gas accounted for 24% of total energy supply (TES), 11% of total final consumption (TFC) and was the largest source of electricity with 33% of generation.

Portugal has no natural gas production and 100% of the gas supply is imported. There is a high concentration of market share at both the wholesale and retail levels. Most of the gas supply comes from four long-term contracts controlled by Galp, the historic incumbent, which also dominates retail gas supply. In March 2021, Portugal was integrated into a common wholesale natural gas market with Spain through Iberian gas market (MIBGAS). Despite market liberalisation in 2010, Portugal still has regulated tariffs in some segments of the retail gas market and has extended the deadline to end regulated tariffs several times. In April 2020, regulated tariffs were again extended to 2022 or 2025 depending on the market segment.

Portugal has a mixed policy on natural gas. The government sees a role for natural gas in its energy transition and is pushing for more efficient gas markets and increased gas import and export capacity. However, there are also clear goals to significantly reduce natural gas demand through increased electrification, energy efficiency and the deployment of renewable energy, including biomethane and hydrogen produced from renewable energy.

Figure 8.1 Share of natural gas in the Portuguese energy system, 2000-19



Gas was introduced in Portugal in 1997 and has become a key energy source. Electricity generation is the largest source of gas demand, but varies greatly from year to year.

Notes: TES = total energy supply. TFC = total final consumption.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Supply and demand

Supply

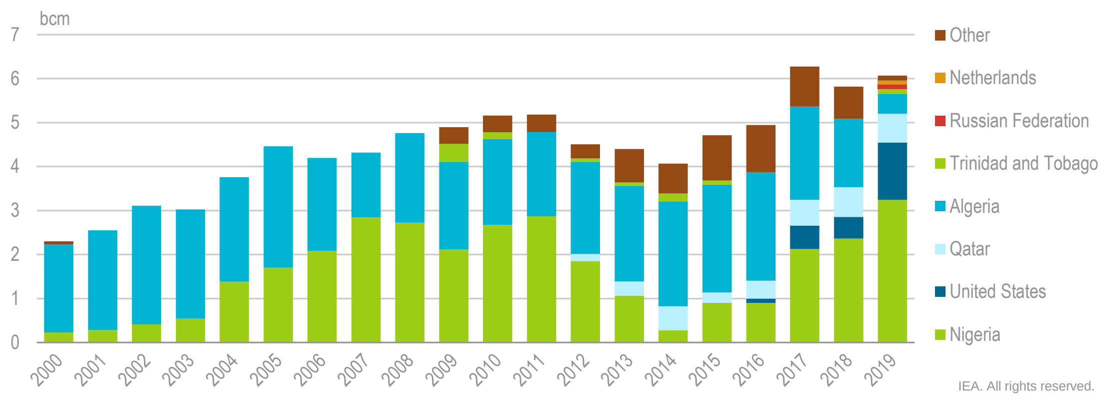
Portugal has no domestic natural gas production and no proven natural gas reserves. All of its gas supply is imported through three entry points: the Sines liquefied natural gas (LNG) terminal and two cross-border gas pipeline interconnections with Spain. Oil and gas exploration has taken place in Portugal on a small scale. In 2015, there were 15 contracts allowing gas and oil exploration and exploitation, but as of 2020, all of them were either relinquished by the concession holder or terminated by the government, and no exploration or exploitation activities are taking place. In September 2020, the Ministry of Environment and Climate Action announced that no more contracts will be awarded for natural gas or oil exploration and exploitation (Cabrita-Mendes, 2020).

Trade

Historically, the majority of Portugal's natural gas imports came from Algeria (via pipeline) and Nigeria (via LNG) (Figures 8.3). Portugal's cross-border gas pipeline interconnections to Spain allow imports of gas arriving via Spain's LNG terminals and pipeline interconnectors with Europe, Algeria and Morocco. However, almost all of Portugal's pipeline imports originate from Algeria under a long-term contract that was recently extended to 2029. LNG imports are also dominated by a long-term contract with a supplier in Nigeria, but there has been more diversity of LNG imports, with the United States becoming a major supplier in recent years. The share of supply from pipeline and LNG is affected by the relative prices of these import options. In recent years, falling LNG prices have led to a strong preference for LNG, which covered a record 92% of Portugal's gas imports in 2019.

On 31 October 2018, Portugal registered the first day of net gas exports through the main interconnection point with Spain (Campo Maior). Low temperatures occurred earlier than predicted on the Iberian peninsula and Portugal delivered 12.8 gigawatt hours (GWh) of gas (around 0.1 billion cubic metres [bcm] and 16% of total daily export capacity) to help meet heating demand in Spain.

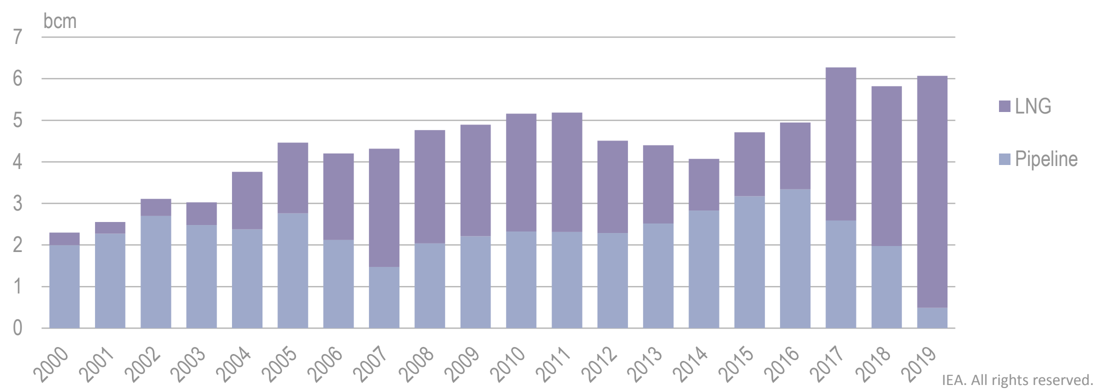
Figure 8.2 Portugal's natural gas imports by country, 2000-19



Imports cover 100% of Portugal gas supply. Although gas imports have become more diversified, most imports still come from long-term contracts with Nigeria and Algeria.

Note: bcm = billion cubic metres.
Source: IEA (2021), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 8.3 Portugal's natural gas imports, liquefied natural gas versus pipeline, 2000-19



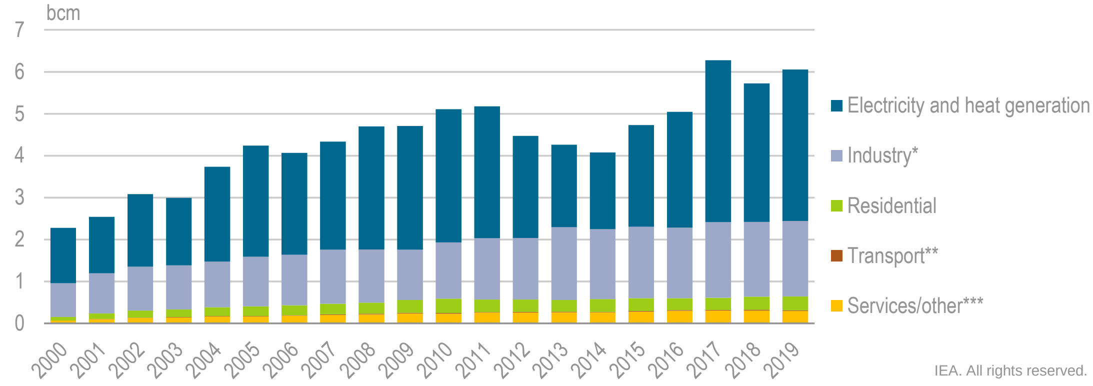
Since completion of the Sines LNG terminal in 2003, LNG has accounted for 30-92% of imports. Since 2016, falling global LNG prices led to a strong market preference for LNG imports.

Notes: bcm = billion cubic metres. LNG = liquefied natural gas.
Source: IEA (2020a), *Monthly Natural Gas Statistics* (database), www.iea.org/statistics.

Demand

From 2008 to 2019, Portugal experienced an overall increase in natural gas demand, which grew from 4.7 bcm to 6.1 bcm, but with significant annual variation in demand, from 4.1 bcm in 2014 to an all-time peak of 6.3 bcm in 2017 (Figure 8.4). Electricity generation has been the largest source of gas demand in Portugal since gas was introduced in 1997. From 2008 to 2018, electricity generation accounted for 44-62% of total gas demand. The variations in gas demand for electricity generation are driven by a number of factors, including notable year-on-year changes in the level of hydropower generation, the rapid growth in wind generation, competition between gas and coal-fired generation, and the reduction and rebound of overall electricity demand caused by the 2008 financial crisis and subsequent recovery (see Chapter 7).

Figure 8.4 Natural gas demand in Portugal by sector, 2000-19



Natural gas demand in Portugal increased from 2000 to 2019, but with notable annual variations, driven mainly by changing demand for gas-fired electricity generation.

* *Industry* includes energy demand from oil refineries and non-energy demand from all industries.

** *Transport* gas demand was 0.014 bcm in 2009 and 0.020 bcm in 2019.

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

Note: bcm = billion cubic metres.

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

The industry sector has consistently been the second-largest source of gas demand in Portugal, accounting for 25-41% of total demand from 2009 to 2019. Industrial gas demand grew from 1.2 bcm in 2009 to 1.7 bcm in 2013, but has since been stable between 1.7 bcm and 1.8 bcm. In 2019, the non-metallic minerals subsector (cement, glass, ceramics) accounted for the largest share of industrial demand (0.5 bcm), followed by chemical and petrochemical industry (0.2 bcm). The industry demand includes natural gas used for steam methane reforming hydrogen production, which represented about 4% of Portugal's natural gas demand (0.2 bcm) in 2018.

From 2009 to 2019, gas demand in the residential sector and the services/other sector both ranged from around 5-7% of total gas demand. From 2008 to 2018, gas demand in the residential sector was up overall (from 0.30 bcm to 0.33 bcm), but with notable year-to-year fluctuations. Gas demand in the services/other sector experienced more steady growth, from 0.24 bcm to 0.29 bcm. The shares of gas in the total energy demand of Portugal's residential sector (11% in 2019) and services/other sector (10%) are relatively low in comparison to many IEA countries. This reflects the relatively recent introduction of gas; the comparatively lower heating demand; and the high shares of heating and cooking covered by electricity, biomass, liquefied petroleum gas (LPG) and diesel. In 2018, less than 40% of Portuguese households had a gas connection.

There is a very small demand for compressed natural gas in transport (mainly for public buses, but also through 12 compressed natural gas refuelling stations for private vehicles), which grew from 0.014 bcm to 0.020 bcm (0.3% of gas demand) from 2009 to 2019. LNG demand from LNG powered ships in the mainland and Madeira is small, but has been rising since 2017.

Institutions

The Directorate-General for Energy and Geology (DGEG), within the Ministry of Environment and Climate Action, has a number of responsibilities related to the gas sector, including the issuing of licences and concessions for the LNG terminal, gas storage, transport, distribution, trading and supply, and approving infrastructure projects. The DGEG collects annual, quarterly, monthly and weekly energy prices (including for gas); sends this information to the IEA, Eurostat and the European Commission (EC); and publishes it on its website. The Portuguese natural gas sector is regulated by the Energy Services Regulatory Authority (ERSE), which has responsibility to ensure the fair and transparent operation of the market. The ERSE is responsible for advising the government on the infrastructure plans submitted by gas network operators. It also sets network tariffs, grid connection costs, and the regulated and social tariffs for natural gas and electricity and ensures third-party access to natural gas infrastructure. The ERSE performs wholesale and retail market supervision in co-operation with the Portuguese Competition Authority (AdC). The AdC is responsible for the prevention and sanctions of anticompetitive or abusive market practices.

The National Entity for the Energy Sector (ENSE) is a public corporation that supervises and monitors the energy sector, including for natural gas, electricity and oil. It has responsibility for evaluating the causes of energy sector accidents and monitoring compliance with licensing obligations by concession holders (ENSE, 2020). The National Energy Agency (ADENE) is a government agency that supports the efficient use of all energy sources. It manages the OLMC platform, which supports consumer switching between retail gas and electricity suppliers (OLMC, 2020).

Redes Energéticas Nacionais (REN) is a 100% privately owned corporation that plays a major role in Portugal's gas and electricity sectors. REN Gasodutos is the gas transmission system operator (TSO), certified by the ERSE under the full ownership unbundling model, and holds a concession for the technical management of the National Natural Gas System (SNGN) with responsibility for guaranteeing the continuity and security of gas supply and for maintenance and development of the National Natural Gas System. In 2018, REN acquired REN Portgás Distribuição, the second-largest gas distribution system operator (DSO). REN Atlântico holds the concession for the operation of the Sines LNG terminal and REN Armazenagem holds the concession for the only large-scale underground natural gas storage facility. REN Rede Elétrica Nacional is the electricity TSO.

Galp Energia is the main gas supplier in Portugal at both the wholesale and retail level. Galp Energia is 100% controlled by the Galp Group, which is 92.52% privately owned and 7.48% owned by Portuguese state. Galp Gás Natural Distribuição (GGND) owns or holds controlling shares in 9 of Portugal's 11 gas DSOs, which together hold concessions or licences for the operation of the majority of Portugal's gas distribution network. In October 2020, Galp accepted a proposal from the private company Allianz to purchase a 75% stake in GGND from the Galp Group (Allianz SE, 2020). The acquisition is expected to be completed in the first quarter of 2021, once the ERSE grants regulatory approval. Energias de Portugal (EDP) is a private utility that is a major importer of natural gas (to supply its natural gas power plants) and is also one of the largest retail suppliers of natural gas, especially in the residential and small business market segments.

Policy

Portugal has a mixed policy on natural gas. The government sees a role for natural gas in its energy transition and is pushing for more efficient gas markets and increased gas import and export capacity. However, there are also clear goals to significantly reduce natural gas demand through increased electrification, energy efficiency and the deployment of renewable energy, including biomethane and electrolysis-based hydrogen produced with renewable electricity.

Portugal's National Energy and Climate Plan (NECP) indicates that natural gas will play an important role in the transition to an energy system mainly based on renewables, allowing time for the development of technological solutions, with a special emphasis on storage, which will give the system the necessary resilience to guarantee adequate levels of supplies. The NECP indicates that electricity generation from natural gas will be maintained until at least 2040, and that 2030 capacity for combined cycle gas turbines (CCGT) could be at the 2019 level of 3.8 gigawatts (GW) or drop to 2.8 GW, depending on the development of other flexibility assets such as pumped hydro storage, battery storage and hydrogen.

The National Strategy for Hydrogen (EN-H2), approved in August 2020, notes a role for natural gas in covering most demand from heavy industry and other hard-to-decarbonise sectors through at least 2030, but that by 2050 most demand for gas will be covered by renewable gases. The 2017 National Action Framework for the creation of infrastructure for alternative fuels details measures supporting natural gas in road and maritime transport, including funding from the Operational Programme for Sustainability and Efficient Use of Resources (POSEUR) to support the purchase of natural gas buses.

The government has approved network development plans resulting in notable investment to expand the gas transmission and distribution system and the number of connected consumers, and also supports increasing Portugal's gas import and export capacity. In June 2018, the Prime Minister indicated support for a project to increase the capacity of the Sines LNG terminal (PortsEurope, 2018).

The government is promoting the construction of a third gas pipeline interconnection to Spain. However, this project requires completion of a proposed gas interconnection between France and Spain. In 2019, French and Spanish regulators announced opposition to the Spain to France gas interconnection. In addition, the Spain to France interconnection and Portugal and Spain interconnection did not appear in the European Commission's (EU) proposal for the fourth list of EU Projects of Common Interest. Despite this opposition, the government continues to support the development of both projects.

The government is also clearly aiming to reduce natural gas demand, especially towards 2050. The Roadmap to Climate Neutrality 2050 (RNC2050) indicates that primary energy consumption of natural gas should fall from 147 petajoules (PJ) in 2020 to 124-133 PJ in 2030 and to 30-34 PJ in 2050. In addition, 100% of the gas supply is imported and the government has placed a strong priority on reducing energy import dependency. The

RNC2050 indicates that energy import dependency should drop from 80% in 2020 to 57-58% in 2030 and 15-19% in 2050.

Most energy sector targets, support measures and programmes are aimed at increasing renewable energy and reducing energy demand and greenhouse gas emissions. Many of these measures would reduce gas demand, especially from electricity generation and the built environment. In addition, the EN-H2 aims to rapidly develop hydrogen production based on renewable electricity, which would create an alternative to natural gas in industry and other hard-to-decarbonise end uses.

Under the NECP and the EN-H2, the government has set goals for using natural gas infrastructure to support the energy transition through grid injection of renewable gases. The NECP notes that gas infrastructure can play an important role in supporting the production, distribution and consumption of renewable gases, particularly biomethane and hydrogen. The EN-H2 sets a 2030 goal for 10-15% of the volume of gas in the natural gas network to be covered by hydrogen produced from renewable energy. The strategy also sets a 2030 goal for biomethane to cover 4.5% of total energy demand (primarily through injection into the natural gas grid).

Decree-Law No. 62/2020 allows grid injection of renewable gases (biomethane and hydrogen) and defines a new market actor, the gas producer, that clarifies the status and role of renewable gas producers in market regulations. The TSO is still in the process of developing regulations to define technical, quality and security requirements for renewable gases (including for grid injection), which will need approval from the ERSE and the DGEG. In tandem, the DGEG is developing the licensing procedures for renewable gas producers.

Regulated tariffs

Portugal has a liberalised natural gas market. All consumers are free to select the gas supplier of their choice. Portugal initially aimed to end regulated tariffs in 2015. However, in 2013, a transitory regime was established that extended regulated tariffs until 31 December 2020. In 2017, consumers were given the option to switch back from the liberalised market to the regulated tariff. In April 2020, the government again extended regulated tariffs until the end of 2021 for consumers connected to the low-pressure gas system with demand greater than 10 000 cubic metres per year (cm/y) and until the end of 2025 with demand less than 10 000 cm/y. Regulated tariffs are set annually by the ERSE based on historic prices in Portugal's wholesale gas market, but can be adjusted on a quarterly basis if the wholesale cost of gas goes outside of minimum or maximum values set by the ERSE. Regulated tariffs are available from 11 suppliers of last resort, with one supplier for each of Portugal's 11 gas distribution networks. There is also one wholesale level supplier of last resort that sells gas to the distribution level suppliers of last resort. All suppliers of last resort are designated by the ERSE.

Social tariffs

Portugal has social tariffs for natural gas and electricity that provide discounts on parts of distribution tariffs to reduce the electricity and gas bills of households that meet certain socio-economic requirements. The social tariffs are offered by the last-resort suppliers and market suppliers. In 2016, the process to apply for social tariffs was amended so that qualifying households are automatically assigned the social tariff. This led to an increase in the number of consumers receiving the natural gas social tariff, from 14 103 in the first quarter of 2016 to 34 935 in June 2016. From 2016 until 2019, the number of households on the social tariff has been relatively stable, with 34 239 households (2.6% of all households connected to the gas network) receiving the tariff in September 2019.

In November 2020, eligibility requirements for the natural gas and electricity social tariffs were extended to cover all types of unemployment and disability pensions. This was done to address concerns related to the economic impacts of the Covid-19 pandemic and to ensure that the social tariffs were available to the most economically vulnerable consumers. Under the new requirements, households qualify for the gas social tariff if the holder of the natural gas contract is a beneficiary of one of the following governmental social programmes: solidarity supplement for the elderly, social income, unemployment benefits, beneficiary of child support or social disability pension. The gas social tariff is only available to private households served by the low-pressure gas network with an annual consumption not exceeding 500 cm/y and exclusively for domestic use at the residence.

The price reduction offered through the social tariff is the result of a discount on the low-pressure network access tariff. The level of discount is set by the government and corresponds to a 31.2% reduction on the end user tariff in the gas year 2020-21. The gas social tariff supported a cost reduction of around EUR 1.6 million in the 2020-21 gas year, equal to an average cost reduction of around EUR 43 per consumer receiving the social tariff. The financing of the social tariff is covered by the gas network operators and suppliers, with the share of contribution proportional to the volume of gas delivered (for network operators) or sold (for suppliers) in the previous year.

Prices and taxation

Retail natural gas prices in Portugal are composed of wholesale gas costs, network tariffs, operating costs and taxes. In 2020, only around 30% of the average retail price was composed of energy costs, with 70% coming from tariffs and taxes. The tax component of natural gas prices is composed of the tax on energy products (ISP), the carbon tax and the value-added tax (VAT), with the maximum rate of 23%. For the ISP and the carbon tax, there are two tax categories for natural gas: one for gas used in the residential, commercial and industry sectors and one for gas used in the transport sector. Because of a steady ISP rate and a higher carbon tax, the total tax rate for gas used in the residential, commercial and industry sectors increased notably, from EUR 0.38 per gigajoule (GJ) in 2018 to EUR 1.33 per GJ in 2020. Natural gas used for road transportation is also assigned a road service contribution tax and pays a higher overall tax of EUR 2.44 per GJ in 2020.

The ISP and carbon tax rates for all energy products are the same for all consumers. There are not different rates for households or industrial consumers and rates do not vary with the level of demand. However, industrial consumers have a 100% exemption from the ISP and the carbon tax for industrial fuels (including gas) and electricity if they are covered by the EU Emissions Trading System regime or an energy consumption rationalisation agreement (ARCE). ARCE is part of the Portuguese programme requiring industry energy efficiency measures. In addition, all industrial consumers receive a full refund of the VAT charged on energy products. As a result, the level of taxation on natural gas use is significantly lower for industrial consumers than it is for residential and commercial consumers.

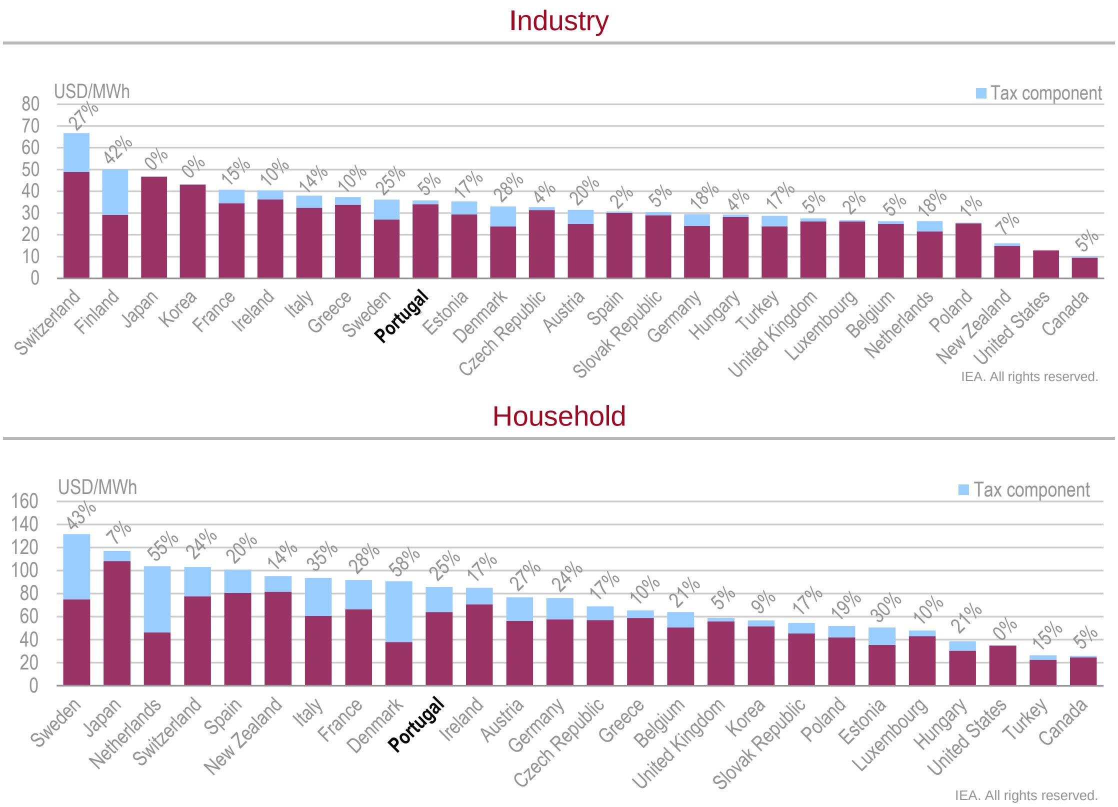
In 2019 and 2020, Portugal made changes to the VAT charged on electricity and gas demand that reduced taxation of electricity in comparison to gas for many consumers and created VAT rates for electricity that increase with higher levels of demand to encourage efficiency. For consumers connected to the low-voltage electricity network with a contract not exceeding 3.45 kilovolt-amperes (kVA) and for natural gas consumers connected to the low-pressure gas network with a contract not exceeding 10 000 cm/y, the VAT charged on the fixed component of network access tariffs was lowered from 23% to a "reduced rate" of 6% in mainland Portugal, 4% in the Azores and 5% in Madeira. For electricity consumers with a contract lower than or equal to 6.9 kVA (and those receiving the social tariff), the VAT charged on the entire electricity bill (but not the gas bill) was reduced from 23% to an "intermediate rate" of 13% in mainland Portugal, 9% in the Azores and 12% in Madeira. The intermediate rate only applies to the first 100 kWh per 30 days (150 kWh per 30 days for households of more than 5 persons); above this demand, the 23% rate is applied (ERSE, 2020a).

Starting in April 2020, natural gas used for electricity generation (excluding co-generation)[1], was no longer fully exempt from the ISP or the carbon tax, and was subject to 10% of the ISP and 10% of the carbon tax. Both of these percentages will be progressively increased to reach 40% in 2023. This change is intended to support Portugal's energy transition by giving preferential tax treatment to electricity generation from renewable energy. In the State Budget for 2021, the government proposed to progressively eliminate the carbon tax exemption on energy products (including gas) that is used by industrial installations with an ARCE. If passed, the law would result in those installations paying 5% of the carbon tax in 2021, 10% in 2022, 30% in 2023, 65% in 2024 and 100% from 2025 onwards.

In 2019, retail gas prices in Portugal for both industry and households were close to the IEA median (Figure 8.5). Industrial consumers paid 35 USD/MWh with a tax share of just 2%, the tenth-highest price but one of the lowest tax shares among IEA member countries In 2019, the household gas price was 86 USD/MWh, with a 24% tax share, the tenth -highest price and an average tax share among IEA member countries. Portugal's industry and household gas prices show trends similar to those in other European countries (Figure 8.6). From 2002 to 2014, retail gas prices in Portugal increased notably, by 146% for industry and 182% for households. From 2014 to 2019, Portugal's retail gas prices experienced an overall decline of around 39% for both industry and households.

[1] Co-generation refers to the combined production of heat and power.

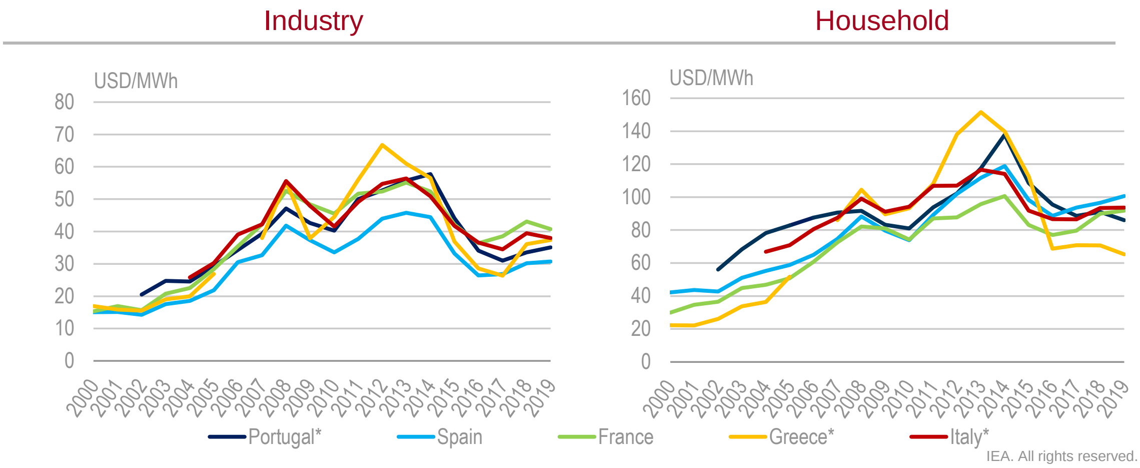
Figure 8.5 Natural gas prices in IEA member countries, 2019



Notes: Industry price data are not available for Australia, Japan, Mexico or Norway. Household data are not available for Australia, Finland, Japan, Mexico, New Zealand or Norway. Tax information is not available for the United States.

Source: IEA (2020b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Figure 8.6 Industrial and household gas prices in select IEA countries, 2000-19



Portugal's industry and household gas prices follow trends similar to those in other southern European countries: a sharp increase from 2002 to 2014 and an overall decline since 2014.

* Data missing for some years for Portugal (2000-01), Italy (2000-03) and Greece (2006).

Source: IEA (2020b), *Energy Prices and Taxes 2020* (database), www.iea.org/statistics.

Market structure

MIBGAS wholesale market

Portugal does not have an organised wholesale gas market. There is no national gas trading platform or price formation, and the wholesale gas supply continues to be purchased primarily through long-term bilateral contracts with limited price transparency. The Portuguese gas transmission system operates as a single balancing/entry-exit zone and suppliers are free to import or export gas through the interconnection points (imports only at the Sines LNG terminal), with physical exchanges of natural gas determined bilaterally through the Portuguese virtual trading point (VTP).

The government supports the ongoing project for a common Iberian wholesale gas market (MIBGAS) covering Portugal and Spain, which would provide Portugal with a fully functioning wholesale market and support further integration into the EU internal gas market. Since 2015, the MIBGAS market has been in operation in Spain and gas suppliers in Portugal can use the two cross-border pipeline interconnection points to access the MIBGAS wholesale market. A major step towards Portugal's integration into MIBGAS was taken in September 2020, when the ERSE approved rules to allow trading on the MIBGAS platform of natural gas products with physical delivery at the Portuguese VTP. In October 2020, MIBGAS, S.A. (market operator) and REN (gas TSO) published a joint calendar for the implementation of the organised natural gas market in Portugal, full integration into MIBGAS was completed on 16 March 2021 as planned (REN, 2020a).

Portugal has implemented the interconnection point allocation mechanisms defined in the European Network Code on Capacity Allocation Mechanisms with regular auctions for interconnection capacity allocation conducted for several time horizons (yearly, quarterly, monthly, daily and intraday). In 2018, five-year auctions were introduced. In line with EU requirements, a certain share of interconnection capacity is set aside for short-term products (at least 10% in products of less than one year and an additional 10% in quarterly or shorter term capacity products). Similar auction mechanisms are used to allocate capacity of Portugal's underground and LNG gas storage capacity. Allocation of capacity at the LNG terminal (regasification and storage) does not offer capacity products beyond the next year.

Portugal has adopted the European Network Code on Gas Balancing, which incentivises market liquidity by obligating suppliers to provide gas that covers demand from their contracted consumers and to perform financial settlements of any imbalances. Currently, gas transactions that support the balancing of the Portuguese gas network are accomplished through bilateral arrangements between traders, while the respective infrastructure operators (gas TSO and/or DSOs) are responsible for the execution of the transactions. These transactions reached 19.4 terawatt hours (TWh) in 2018 (30% of domestic gas demand), an increase of 21% compared to 2017. There are no gas transit contracts in the Portuguese natural gas system. Any transit flows are exceptional and made under technical assistance rules of the interconnection agreement between the Portuguese and Spanish gas TSOs.

Wholesale gas supply

In 2018, there were close to 20 companies registered with the gas TSO as market agents with the ability to execute transactions for wholesale supply. However, four companies with large gas import contracts account for essentially the entire wholesale gas supply. Galp, the historic gas incumbent, is by far the dominant supplier for both LNG and pipeline imports. Galp covered around 70-80% of Portugal's gas supply from 2016 to 2018. Galp's dominant position in wholesale gas supply is based on four large contracts with the gas producers Sonatrach (Algeria) and Nigeria LNG Limited (Table 8.1). Two of the contracts for LNG imports will expire between 2021 and 2023. In 2019, Galp and Sonatrach signed a new contract for pipeline imports through 2029 (Galp Energia, 2019). EDP and Endesa are also notable players at the wholesale level and hold import contracts (mainly for LNG) to fuel their gas-fired power plants in Portugal. Naturgy, a major supplier in the large consumer segment of the gas retail market, is the only other company with a notable share of the wholesale gas supply.

Interconnection capacity is offered through unbundled products on the Portuguese side, which reduces the risk of mismatch between exit capacity from Spain and entry capacity into Portugal. Most interconnection capacity on the Spanish side of the pipeline interconnection points is currently under long-term contracts (93 GWh/d out of 144 GWh/d) that will expire shortly (only 4 GWh/d of capacity will remain under contract after 2020 and none after 2022). From 2020, all interconnection capacity will be offered as bundled products.

Table 8.1 Long-term natural gas supply contracts in Portugal

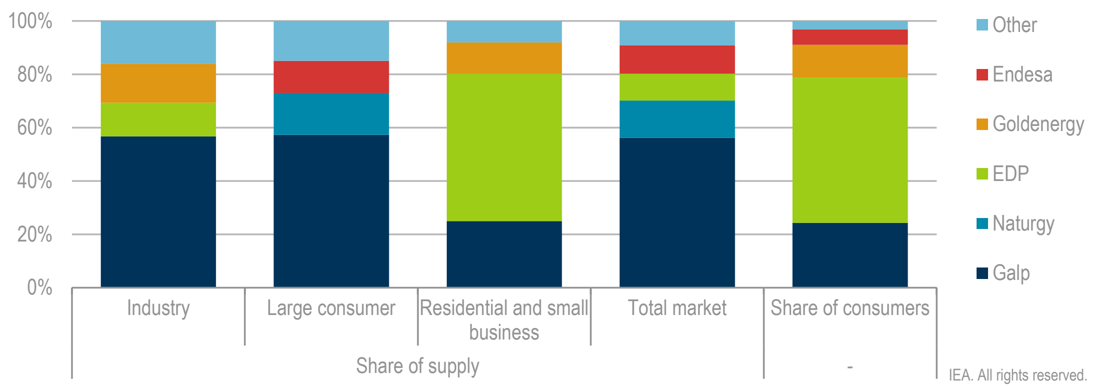
Delivery	Country of origin	Quantity (bcm/year)	Duration (years)	Start year	End year
LNG	Nigeria	0.347	23	1998	2021
LNG	Nigeria	0.995	24	1999	2023
LNG	Nigeria	1.99	25	2002	2027
Pipeline	Algeria	2.4	26	1994	2020
Pipeline	Algeria	2.5	10	2020	2029

Notes: bcm = billion cubic metres. LNG = liquefied natural gas.

Retail market

In 2020, there were around 1 510 000 consumers in Portugal's retail gas market. The majority of consumers (84%), representing 98% of total gas demand, participated in the liberalised retail market. From 2017 to 2020, the share of consumers receiving the regulated tariff dropped from 21% to 16% of total consumers and 2% of gas demand. In October 2020, the liberalised market accounted for the following shares of gas demand by retail market segment: large consumers (100%), industry (95.9%), residential (84.7%) and small businesses (77.4%), with 20 suppliers active in the residential segment, 18 in the small business segment, 15 in the industrial segment and 9 in the large consumer segment. Market shares are highly concentrated among a few suppliers across all segments (Figure 8.7). In October 2020, four companies (Galp, Naturgy, Endesa and EDP) accounted for 93% the retail market gas supply, with Galp alone accounting for 60% of supply. Four companies (EDP, Galp, Goldenergy and Endesa) supplied 97% of consumers, with EDP alone suppling 55% of consumers (ERSE, 2020b).

Figure 8.7 Retail gas market suppliers' market shares in Portugal, 2020



Portugal's gas retail market is dominated by just a few companies, with Galp accounting for 60% of the total supply and EDP 55% of consumers.

Source: ERSE (2019), *Liberalized Market Report 2019,* www.erse.pt/media/ojfc1kdc/201906_ml_gas_resinf_.pdf.

In 2019, there were 11 suppliers of last resort offering the regulated tariff to natural gas consumers. One last-resort supplier is active in each of Portugal's 11 gas distribution networks. Galp owns the three largest suppliers of last resort, which together served over 60% of the consumers receiving the regulated tariff. Galp also owns the wholesale supplier of last resort, which is responsible for purchasing gas on the wholesale market to provide gas to all 11 retail level suppliers of last resort (ERSE, 2020b).

The procedures for switching retail gas and electricity suppliers were published in March 2009. In the absence of legislation defining which entity would act as the switching operator, the ERSE assigned the management of the switching process to the gas TSO. In 2017, legislation was passed assigning management of the switching process to ADENE, the national agency with responsibility for promoting energy efficiency. In 2018, the ERSE approved common switching procedures for electricity and gas consumers. Under these procedures, switching of suppliers is free of charge, there is no limit to the number of times a consumer can switch and switching requests must be executed within three weeks or less.

In September 2019, ADENE completed the transition from the e_Switch platform (previously run by the TSO) to a new platform, the OLMC portal (OLMC, 2020). The OLMC portal is subject to periodic independent audits, the results of which are sent to the ERSE for review and made publicly available. The ERSE publishes a monthly report on its website with switching activity, including retail market shares, total number of switches, consumption and switching rates. In 2019, the annual switching rate was 14.4%. This level of switching is lower than in recent years, but still relatively high in comparison to other EU countries (ACER, 2020).

Infrastructure

Portugal is supplied with natural gas through two pipeline interconnection points with Spain and the Sines LNG terminal. Portugal has two large-scale natural gas storage facilities, the Carriço underground storage facility and LNG storage at the Sines terminal. Portugal's natural gas transmission network is operated by the national gas TSO, REN Gasodutos, and supplies the major population centres, power plants and industrial sites. The gas distribution network is operated by 11 privately owned DSOs under concession or licence agreements; several of the distribution networks are not connected to the gas transmissions system and receive their supply via LNG tanker truck deliveries to satellite regasification plants (Figure 8.8).

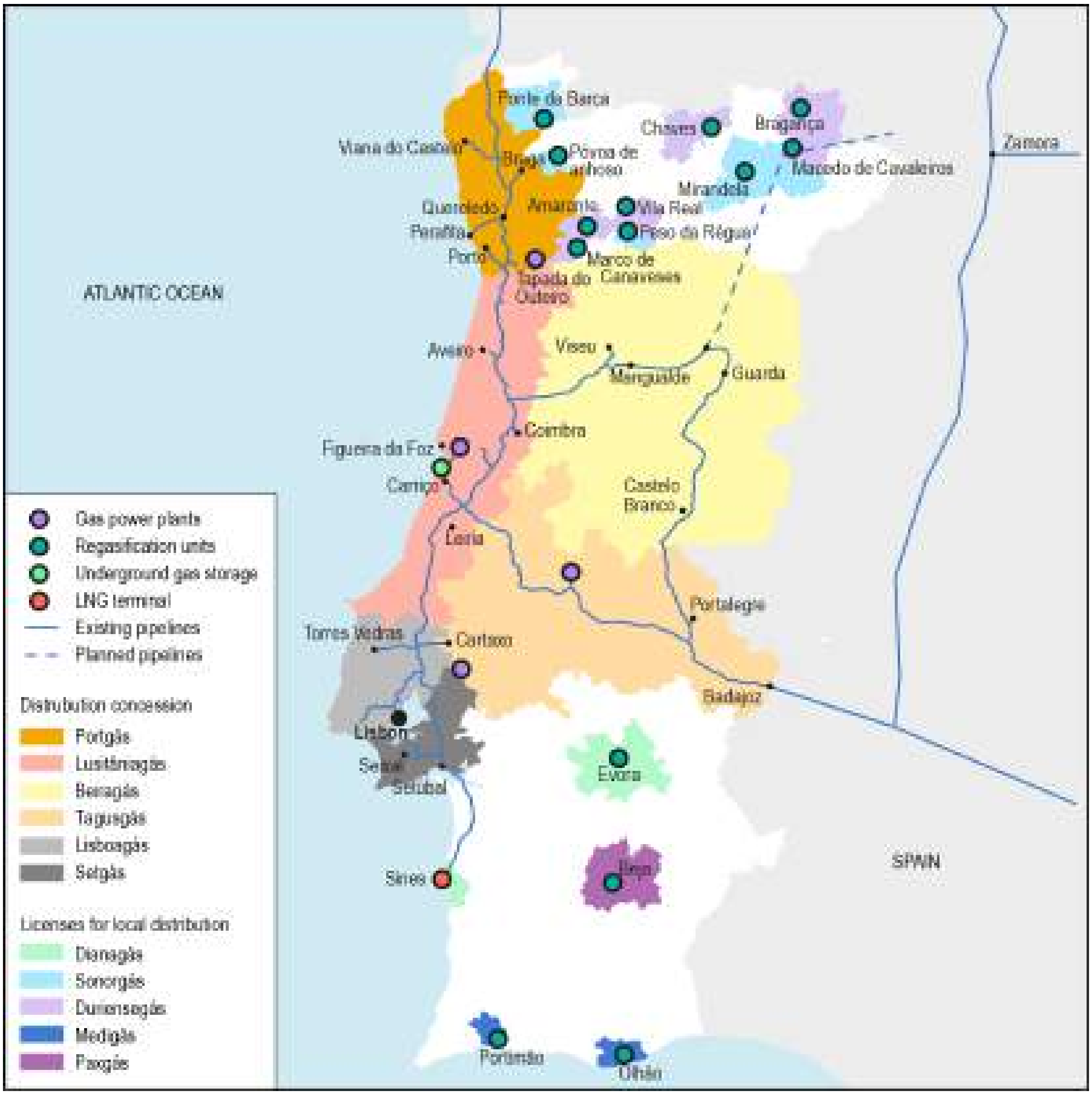
Pipeline interconnections

Portugal's two high-pressure pipeline interconnections have a combined entry and exit capacity of 144 GWh/d import and 80 GWh/d export. Campo Maior is the primary interconnection, with the largest capacity (134 GWh/d import and 55 GWh/d export) and the highest utilisation rate. From 2015 to 2018, Campo Maior accounted for most of the natural gas imported via pipeline. Campo Maior is primarily used to import gas produced in Algeria, which is transported via a subsea pipeline to Spain and then through the Spanish gas transmission network to Portugal. The Valença do Minho interconnection has a smaller capacity (10 GWh/d import and 25 GWh/d export) and links Portugal to the north-west of Spain (Galicia). Recently, Valença do Minho has been used mainly for cross-border system balancing and very small amounts of imports and exports.

Sines LNG terminal

The Sines LNG terminal has a technical import capacity of 229 GWh/d; however, due to the restriction of the injection point into the gas transmission system, the terminal's available capacity was 200 GWh/d in 2020, the highest capacity of the three gas entry points into Portugal. Reception, storage and regasification of LNG are carried out under a 40-year concession contract held by REN Atlântico. The Sines terminal has an unloading capacity of 10 000 cubic metres (cm) per hour and can receive large ships with LNG capacities of 40 000-216 000 cm. The LNG terminal is equipped with five vaporisers that use seawater as the thermal fluid to regasify the LNG into natural gas, which is then compressed to 78 bar and injected into the gas transmission network. The Sines terminal also has the capacity to refuel LNG powered ships (NGV Journal, 2020)

Figure 8.8 Portugal's natural gas import, transmission and storage infrastructure, 2019



Source: REN (2020b), *Technical Data 2019*, https://www.centrodeinformacao.ren.pt/PT/InformacaoTecnica/DadosTecnicos/Dados%20T%C3%A9cnicos%202019.pdf.

Storage

Portugal has two large-scale natural gas storage facilities, the Carriço underground storage facility and LNG storage at the Sines terminal, which together provide a combined maximum technical storage capacity of around 600 million cubic metres (mcm). The Carriço facility is composed of six salt caverns with a combined storage capacity of 320 mcm, a withdrawal capacity of 129 GWh/d and an injection capacity of 24 GWh/d. The facility is connected to the high-pressure gas transmission network near the middle of the main north-south axis that serves the most densely populated section of the country. The facility supports strategic reserves and is used to inject or withdraw gas to balance seasonal and daily fluctuations in demand and supply. The Carriço storage facility is operated by REN Armazenagem based on a public service concession and is subject to regulated third-party access. The LNG storage at the Sines terminal consists of three LNG storage tanks with a combined LNG storage capacity of 390 000 cm, corresponding to around 242 mcm (2.5 TWh) of natural gas. REN Atlântico holds the concession for the operation of the Sines LNG terminal, including the LNG storage.

Transmission network

Portugal's natural gas transmission network is operated by the national gas TSO, REN Gasodutos, and in 2019 had 1 375 km of high-pressure gas pipelines and 203 pipeline stations. The transmission network serves primarily to deliver natural gas to the gas distribution network, which is connected to the majority of final gas consumers. However, several large-scale gas consumers, including gas-fired power plants and large industrial consumers, are directly connected to the gas transmission network. The gas transmission network has two main axes: 1) the north-south axis runs from the Sines LNG terminal to the Valença do Minho interconnection and supplies natural gas to the most densely populated part of the country; 2) the east-west axis primarily delivers gas imported via Campo Maior into the north-south axis.

Distribution network

Portugal's distribution network is composed of 19 100 km of medium- and low-pressure pipelines and supplies gas to consumers in the residential, commercial, and small and medium-sized industrial sectors. The gas distribution network is operated by 11 privately owned DSOs under concession or licence agreements (Table 8.2). GGND owns or holds controlling shares in 9 of Portugal's 11 DSO, which in 2019 accounted for the majority of gas demand and consumers (GGND, 2020). The DSOs are responsible for the gas supply in exclusive geographical areas on the basis of a concession or licence agreement issued by the DGEG.

In 2020, there were 49 satellite LNG regasification plants in mainland Portugal for distribution of gas to areas that are not connected to the gas network. There were also 55 satellite LNG regasification plants used for private consumption. These regasification plants are supplied by LNG tanker trucks. The Sines LNG terminal has the capacity to load 36 LNG tanker trucks per day. In 2020, there were 39 additional satellite LNG regasification plants under construction or planned.

Table 8.2 Key data for Portugal's distribution system operators, 2019

Operator	Market share (% total gas demand)	Consumers (number)	Network (km)	Operating under:	Ownership
Beiragás	3.7	56 163	853	Regional concession	GGND (59.5%)
Lisboagás GDL	35.6	536 517	4 637		GGND (100%)
Lusitaniagás	15.4	232 037	3 576		GGND (97.2%)
REN Portgás	25	377 747	5 177		REN (100%)
Setgás	11.5	173 027	2 246		GGND (99.9%)
Tagusgás	2.7	39 989	947		GGND (99.4%)
Dianagás	0.7	10 322	198	Local licence agreement	GGND (100%)
Duriensegás	2.1	31 103	497		GGND (100%)
Medigás	1.6	24 192	283		GGND (100%)
Paxgás	0.4	6 140	67		GGND (100%)
Sonorgás	1.4	20 936	619		Dourogás (90%)
Total	100	1 508 173	19 100		

Virtual LNG pipeline

Gaslink, a consortium between Grupo Sousa and Galp, operates a virtual pipeline consisting of LNG truck deliveries from Sines to the port of Lisbon, where the LNG tanks are loaded onto ships and delivered to Madeira's LNG regasification plant. The gas supplied via this virtual pipeline supports operation of Madeira's only natural gas power plant.

Infrastructure planning and investment

All investments in the gas and electricity transmission and distribution networks are examined to ensure that they are needed to meet reasonable demand projections or safeguard energy security. The gas TSO is required to develop a ten-year development plan for the transport network, storage infrastructure and LNG terminal (PDIRGN). Each gas DSO is required to develop a five-year infrastructure development plan for their section of the distribution network (PDIRD-GN). Development plans for the transmission and distribution networks are updated every two years. The ERSE is responsible for evaluating the plans (including potential impacts on tariffs) and delivering an opinion on all proposed projects to the DGEG, the TSO and DSOs. The DGEG evaluates the plans regarding the operation of infrastructure and security of supply, and submits the final version of the plans (and its opinion) to the Secretary of State for Energy who has the authority to approve the plans.

In December 2018, the Secretary of State for Energy approved the PDIRGN for 2018-27, which supports investments of EUR 55 million. The approved projects included the designated base projects, required to improve the operation efficiency of the current infrastructures, as well as relevant IT projects. The gas TSO presented the 2019 PDIRGN, covering 2020-29, to the government and the ERSE in July 2019. The plan includes a proposed project for the construction of a new interconnection with Spain that would increase interconnection capacity by 75 GWh/d and is estimated to cost EUR 123 million. The plan also contains a proposed compression station that would increase the maximum technical capacity of the Sines LNG terminal from 229 GWh/d to 321 GWh/d and support an equal level of grid injection capacity (equivalent to 1.125 mcm per hour, with a peak hourly capacity of 1.35 mcm/h). The compressor project is estimated to cost EUR 24 million and would be built from 2025 to 2027. As of 2020, the review of the 2019 PDIRGN was ongoing and no investment decision had been reached on these projects.

From 2014 to 2018, Portugal's gas TSO invested EUR 157 million in the transmission network, while the 11 gas DSOs invested EUR 284 million in the distribution network (Table 8.3). Investments included projects by the TSO for new delivery points and operational upgrades to increase capacity to supply the distribution network, increase operation efficiency and ensure third-party access. REN Armazenagem made notable investments to increase the capacity of the Carriço storage facility, including the commissioning of a new storage cavern (REN C-6). REN Atlântico made small investments that increased the LNG terminal capacity from 193 GWh/d to 200 GWh/d.

Table 8.3 Natural gas network investments in Portugal, 2014-18

Network	Investments (EUR million)				
	2014	2015	2016	2017	2018
Transmission	25.8	91.8	13.8	14.2	11.3
Distribution	55.9	46.3	52.4	56.9	72.2
Total	81.7	138.1	66.2	71.1	83.5

From 2016 to June 2020, the nine DSOs owned by GGND made investments to increase the number of connections from 1 033 867 to 1 112 830 and increase the combined length of their medium- and low-pressure pipeline networks from 11 836 km to 13 226 km. In 2019, GGND also invested in a small pilot project to test gas smart meters with 95 commercial consumers. The other two DSOs (Portgás and Sonorgás) also made investments to increase the length of pipeline networks and the number of consumer connection points.

Emergency response policy

In Portugal, security of supply for gas, oil and electricity is supervised by the DGEG, which assumes the roles and responsibilities of the Portuguese National Emergency Strategy Organisation (NESO). In its role as the NESO, the DGEG collaborates with the gas TSO to publish an annual security of supply monitoring report (RMSA). The RMSA is the national tool for assessing medium- to long-term needs of the natural gas system in relation to the EU Regulation on Security of Gas Supply. The DGEG is also the competent authority concerning security of gas supply. In this role, it conducts a risk assessment every four years, which evaluates, among others, the main risks identified in the common risk assessment carried out with other EU member states within regional risk groups.

The results of the risk assessment are used to update the Preventive Action Plan (focusing on preventive measures to be taken in the short and medium term) and the Emergency Plan (focusing on measures that are deployed if gas supply is disrupted). The Preventive Action Plan and the Emergency Plan are shared with neighbouring EU member states to ensure compatibility and are submitted to the EC. The Minister of Environment and Climate Action defines priority rules for the implementation of emergency response measures, taking into consideration the need to provide a stable gas supply for protected consumers. The ENSE supervises and monitors the natural gas security stocks.

The government considers that current gas infrastructure does not meet the N-1 standard established by EU Regulation 2017/1938, which requires the ability to maintain gas supply in the case of unavailability of the most significant infrastructure in terms of system entry capacity (for Portugal this is the Sines LNG terminal). Portugal's analysis shows that with the expected increase in gas demand resulting from the decommissioning of the two remaining coal-fired power plants in 2021, the N-1 factor ranges from 78% to 93% depending on the stock levels of the Carriço gas storage facility. The expected reductions in gas demand should allow Portugal to achieve the N-1 standard in the long term. In the interim, Portugal is exploring options to comply with the N-1 standard, including using the maximum import capacity of the Valença do Minho interconnection and implementing interruptible service for two CCGT power plants.

Gas reserves

Suppliers of natural gas are required to maintain mandatory gas reserves corresponding to the demand level of protected customers as defined in Article 2(5) of EU Regulation 2017/1938 (primarily households and essential social services) on the assumption that exceptionally high gas demand continues for 30 days. Suppliers are also obliged to maintain gas reserves corresponding to the demand of non-dual fired CCGTs for 30 days of exceptionally high gas demand for electricity generation. The Minister of Environment and Climate Action is responsible for decisions regarding the release of compulsory gas stocks under conditions established by legislation and there are no automatic triggers for emergency stock releases.

Emergency natural gas reserves are commingled with commercial stocks at the Carriço underground storage facility and the LNG storage at the Sines terminal, which together provide a combined maximum technical storage capacity of around 600 mcm. Considering that annual gas consumption was 5.7 bcm in 2018, existing gas storage capacity can cover the equivalent of around 38 days of Portugal's gas demand. The average stock level of mandatory emergency gas reserves in 2018 was 239 mcm, equivalent to 16 days of imports. On top of the mandatory stocks, the volume of commercial stocks depends on decisions of market stakeholders and varied between 172 mcm and 455 mcm in 2018. Unlike many IEA countries, peak gas demand in Portugal is driven by demand from gas-fired electricity generation, not heating demand. As such, peak gas demand does not occur at a consistent time of the year, but is dependent on market-related conditions for gas-fired electricity generation, which is primarily driven by the availability of hydropower generation. In 2018, peak demand occurred on 8 January and was 261 GWh/d. In comparison, maximum import capacity is 344 GWh/d (LNG terminal: 200 GWh/d, pipeline: 144 GWh/d), while the Carriço storage facility has a maximum withdrawal capacity of 85.7 GWh/d.

Assessment

Natural gas is a key energy source, accounting for 24% of Portugal's total energy supply in 2019. Portugal has no domestic natural gas production and relies on imports. From 2009 to 2019, natural gas demand increased significantly, from 4.8 bcm to 6.1 bcm. There are large year-to-year variations as gas demand is driven primarily by changes in the demand for electricity from gas-fired power plants, which ranged from 1.83 bcm in 2014 to an all-time peak of 3.86 bcm in 2017. The industry sector has consistently been the second-largest source of gas demand in Portugal, with relatively consistent growth, from 1.2 bcm in 2009 to 1.8 bcm in 2019. The level of gas demand in Portugal's residential sector (0.33 bcm in 2019) and services/other sector (0.29 bcm) is low in comparison to many IEA countries. This reflects the relatively recent introduction of gas. In 2018, less than 40% of Portuguese households had a gas connection. The number of consumers connected to the gas grid has steadily increased since gas was introduced in Portugal and reached 1 508 173 consumers in 2019.

The government is aiming to reduce natural gas demand, especially towards 2050. The RNC2050 indicates that primary energy consumption of natural gas should fall from 147 PJ in 2020 to less than 133 PJ in 2030 and less than 34 PJ in 2050. However, the government has indicated that natural gas has a role to play in the energy transition, especially to provide security of supply for electricity generation and to cover demand from industry and other hard-to-decarbonise sectors. The phase-out of coal-fired generation in 2021 and the expected increase in shares of generation from variable solar PV and wind could give natural gas power plants an increased role in balancing Portugal's electricity demand and supply. However, the government is also exploring the development of flexibility assets such as pumped hydro and battery storage that could limit the need for natural gas electricity generation.

The government is preparing measures to support domestic production of renewable gases, such as biomethane and renewable hydrogen, including options for injection into the natural gas grid and use in industry and other hard-to-decarbonise sectors. Although there are no renewable hydrogen production facilities in Portugal as of 2020, the EN-H2 sets a 2030 goal for 10-15% of the volume of gas in the natural gas network to be covered by hydrogen produced from renewable energy. The strategy also sets a 2030 goal for biomethane to cover 4.5% of total energy demand (primarily through injection into the natural gas grid).

The Portuguese natural gas market was liberalised in 2010, allowing any supplier to sell gas at wholesale and retail levels and giving consumers the right to choose and switch suppliers. Regulated tariffs were maintained under a transitory regime that initially aimed to end regulated tariffs by 2015. The share of consumers using regulated tariffs has declined notably since 2010. In 2020, 2% of gas demand and 17% of consumers were contracted under the regulated tariff. However, regulated tariffs have been extended several times since 2010. In April 2020, the regulated tariff was again extended to between 2020 and 2025 depending on the level of gas demand. In 2011, Portugal established a social tariff for natural gas, applicable to customers in a situation of socio-economic need. The difference of the social tariff with market prices is financed by gas network operators and suppliers. In 2019, around 35 000 households (2.5% of households or 6.3% of households with a gas connection) benefited from the gas social tariff. In 2020, eligibility requirements for the gas social tariff were expanded to include more situations of social and economic vulnerability.

A major step towards Portugal's integration into the MIBGAS wholesale market was taken on 19 September 2020, when the ERSE approved rules to allow trading on the MIBGAS platform of natural gas products with physical delivery at the Portuguese VTP. The ERSE should use its role as market regulator to ensure that the new rules are effectively implemented and lead to increases in traded volumes and the number of market participants in MIBGAS. In October 2020, MIBGAS and REN (the gas TSO) published a joint calendar aiming to complete full integration into MIBGAS, which too place as planned on 16 March 2021. There are still regulatory and legal issues that need to be resolved for Portugal to be fully integrated into MIBGAS.

Interconnection tariffs still apply for cross-border gas flows between Spain and Portugal and could be progressively reduced, eliminated or simplified to improve market function, while ensuring compliance with EU rules. In 2019, the combined exit/entry tariffs for gas traded from Spain to Portugal were EUR 0.99 per MWh for annual, EUR 1.46 per MWh for monthly and EUR 2.66 per MWh for daily contracts. However, for gas traded from Portugal to Spain, the tariffs were EUR 0.36 per MWh for annual, EUR 0.52 per MWh monthly and EUR 1.08 per MWh for daily contracts.

The supply of gas in Portugal is highly concentrated among a few companies at the wholesale and retail levels. Galp, the historic gas incumbent, is by far the dominant supplier at the wholesale level, accounting for around 70-80% of Portugal's gas supply from 2016 to 2018. In 2019, four companies (Galp, Naturgy, Endesa and EDP) accounted for 95% of the retail market gas supply, with Galp alone accounting for 60% of supply. From 2021 to 2023, contracts covering a notable share of gas supply and interconnection capacity will expire, opening the possibility of a reworking of Portugal's gas market. However, in 2019, Galp and Sonatrach signed a new contract until 2029, which could easily cover the volume of gas delivered to Portugal via pipeline in recent years. The recent reductions in global LNG prices and increased imports through the LNG terminal support a better environment for new market entrants as LNG ship deliveries at Sines can be split between numerous suppliers. However, Galp has a contract through 2027 that allows purchasing enough LNG to account for most of the Sines LNG terminal's import capacity.

The AdC proposed several measures to increase competition on the wholesale and retail markets. Its report on natural gas from November 2017 noted, among others: high market concentration, import dominance by the incumbent (Galp), pancaking (double network tariff for cross-border gas transmission), and significant access costs to the LNG terminal for small operators. The report made two recommendations to improve competition in the natural gas market: 1) impose on Galp an obligation to auction part of the LNG imports from its contracts; and 2) impose on Galp an obligation to accept swaps between the LNG terminal and the interconnection pipelines (AdC, 2017). The AdC also called for continued work on MIBGAS integration to improve competition. The AdC's recommendations should be effectively implemented by the government.

Recommendations

The government of Portugal should:

- Clarify the future role of natural gas and gas infrastructure in Portugal, taking into account the expected drop in gas demand and decarbonisation of the gas supply, to provide certainty to all market participants and avoid stranded assets.
- Enhance gas market integration with Spain to create a larger, more efficient market by concluding an international agreement to simplify capacity booking and tariff-setting mechanisms, and to merge the national virtual balancing points.
- Encourage the regulator to design and implement measures to increase traded volumes and the number of market participants in MIBGAS, and to enhance competition on the wholesale market.
- Follow up on the recommendations of the Portuguesee competition authority to increase competition on the wholesale and retail markets.
- Abolish regulated tariffs for gas before 2025 in order to promote consumer choice, facilitate retail price formation in the liberalised market as well as promote decarbonisation of residential energy demand in cases where electrification from renewable sources is competitive.

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REN (2020b), Technical Data 2019, www.centrodeinformacao.ren.pt/PT/InformacaoTecnica/DadosTecnicos/Dados%20T%C3%A9cnicos%202019.pdf

9. Oil

Key data (2019)

Domestic oil production: Portugal has no domestic oil production

Net imports of crude oil: 252.4 kb/d, +11% since 2009

Domestic oil products production: 269.6 kb/d, +12% since 2009

Net exports of oil products: 21.6 kb/d (imports: 77.9 kb/d, exports 99.5 kb/d) -77% since 2008

Share of oil: 49% of total supply,* 49% of total final consumption

Oil consumption by sector: 241.4 kb/d (domestic transport 122.8 kb/d, international bunkering 48.5 kb/d, industry 38.3 kb/d, services/other** 12.5 kb/d, residential 11.4 kb/d, electricity and heating 4.7 kb/d, other energy 3.2 kb/d).

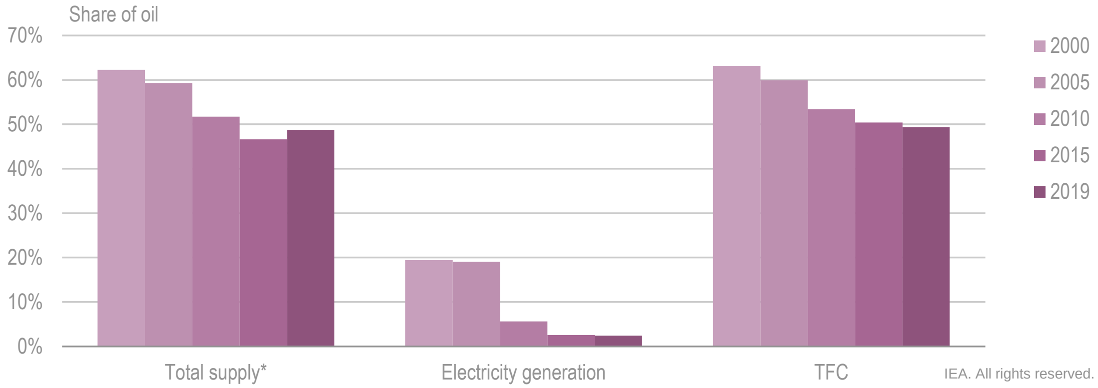
* Total energy supply + international bunkering fuel.

** Commercial and public services, agriculture, forestry, and fishing.

Overview

Oil was the largest energy source in Portugal in 2019; oil demand peaked in 2002 and has since experienced a notable decline (Figure 9.1). From 2000 to 2019, the combined share of oil in Portugal's total energy supply (TES) including international bunkers declined from 62% to 49% and the share of oil in total final consumption (TFC) declined from 63% to 49%. The decline in oil demand was initially driven by strong reductions in industry and transport oil demand that resulted from the 2008 financial crisis. Since 2012, increased economic activity has led to a slow growth in Portugal's oil demand, with a continued decline in industrial oil demand offset by a steady increase in transport oil demand. Portugal's energy policy is focused on significantly reducing oil demand to lower greenhouse gas (GHG) emissions and import dependency, while ensuring security of oil supply and the efficient functioning of downstream oil markets.

Figure 9.1 Share of oil in total supply, electricity generation and total final consumption, Portugal, 2000-19



The share of oil in total energy supply, electricity generation and TFC has declined in recent decades. Only the autonomous island regions have large-scale oil-fired electricity generation.

* *Total supply* includes total domestic oil supply and international bunker fuels.

Note: TFC = total final supply.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Supply and demand

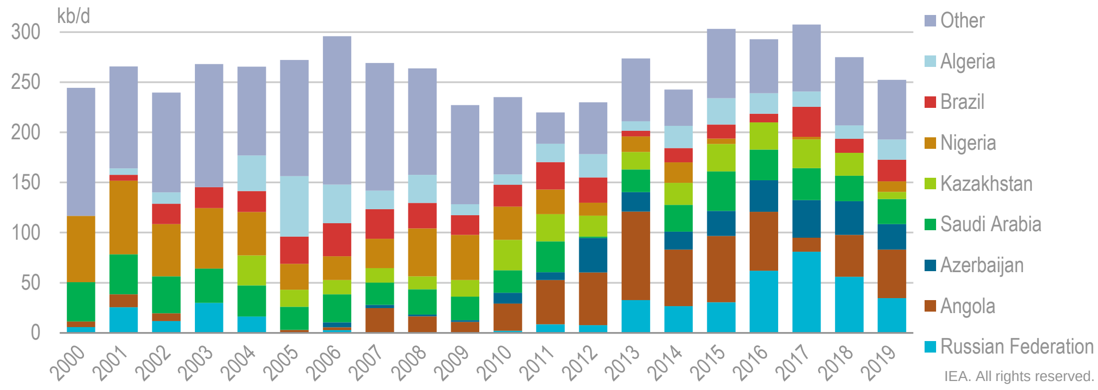
Crude oil imports

Portugal has no domestic crude oil production, no proven oil reserves and relies entirely on imports for its crude oil supply. In 2019, Portugal's net crude oil imports were 252.4 tousand barrels per day (kb/d), with 255.3 kb/d imports and 2.9 kb/d exports (Figure 9.2). Portugal's oil imports come from a diversified range of countries. The Russian Federation recently became a major oil supplier to Portugal, accounting for 14% of imports in 2019, while 19% of imports came from Angola.

Oil products supply and trade

There are two oil refineries in Portugal. In 2019, the combined crude processing capacity of the two refineries was 270 kb/d (Figure 9.3). The 2008 financial crisis drove down international and domestic oil products demand, resulting in a notable drop in Portugal's refinery output from 2008 to 2011. From 2012 to 2017, rising international oil products demand led to an overall increase in the output of Portugal's refineries; however, output has declined since 2017. Domestic oil products demand has been flat since 2012. As a result, Portugal's refinery output has exceeded domestic demand for many oil products and the country has been a net oil products exporter since 2012 (Figure 9.4). Net exports reached an all-time high of 83.0 kb/d (141.6 kb/d exports and 58.6 kb/d imports) in 2017, but dropped notably in 2018-19 to 49.3 kb/d (99.5 kb/d exports and 77.8 kb/d imports).

Figure 9.2 Portugal's crude oil imports by country, 2000-19

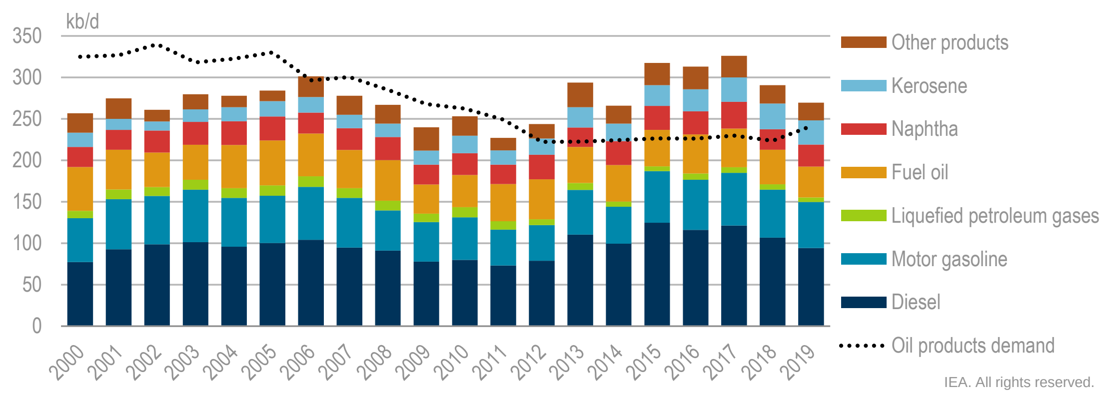


Portugal relies entirely on imports for its crude oil supply, but has maintained diversified sources of crude oil imports.

Note: kb/d = thousand barrels per day.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 9.3 Portugal's oil products production and demand, 2000-19

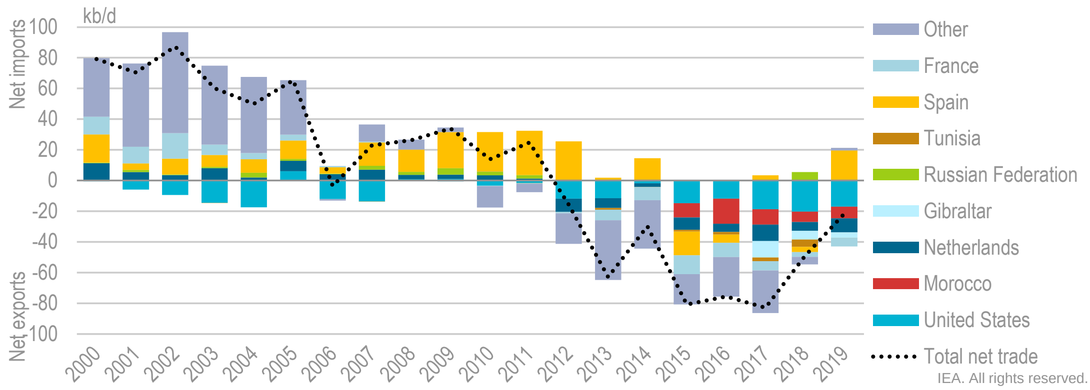


Portugal's oil products production experienced an overall increase from 2008 to 2019, but with notable annual variations. Domestic demand has significantly dropped since 2008.

Notes: kb/d = thousand barrels per day. Oil products demand in this figure is from annual data, different from monthly data used for Figure 9.4. *Kerosene type jet fuel, motor gasoline, gas/diesel oil* exclude biofuels.

Sources: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics; IEA (2020b), *Oil Information 2020* (database), www.iea.org/statistics.

Figure 9.4 Portugal's oil products net trade by country and total, 2000-19



Portugal has been a net exporter of oil products since 2012. In 2019, the largest share of Portugal's oil product exports went to the United States, Morocco and the Netherlands.

Note: kb/d = thousand barrels per day.
Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Oil products demand

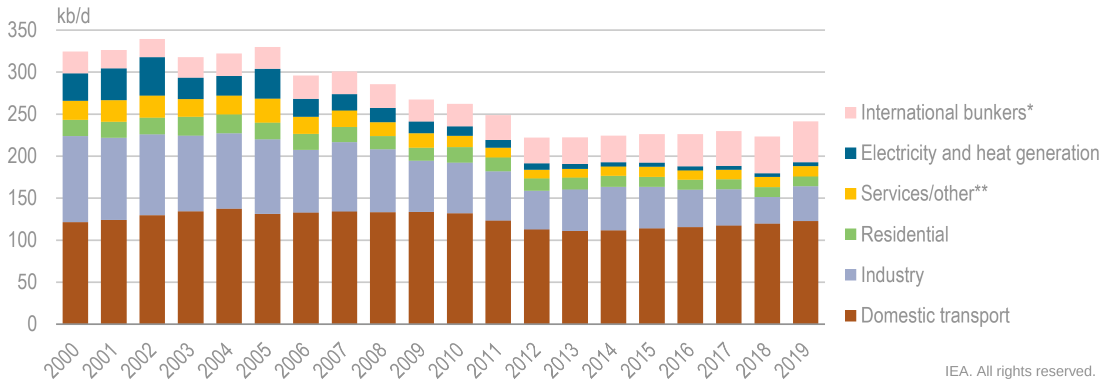
Portugal's oil products demand peaked in 2002, experienced a significant decline through 2012 and grew slowly until 2017, when demand began to fall again (Figure 9.5). The 2008 financial crisis drove a large drop in oil products demand. Since 2012, increased economic activity has led to slow growth in oil products demand, with a continued decline in industry demand offset by a steady increase in transport demand. However, in 2019 oil products demand dropped by 7.1 kb/d, driven primarily by a sharp drop in industry demand.

In 2019, domestic transport accounted for 51% of oil products demand, followed by international bunker fuels (20%), industry (16%), services/other (5%), residential (5%), and heat and electricity generation (2%). The domestic transport sector has consistently been the largest source of oil products demand in Portugal, accounting for around 50% of total oil products demand from 2009 to 2019. Oil products are the dominant fuel for transport in Portugal, accounting for 94% of domestic transport demand in 2019, with 5% of demand covered by biofuels blended into diesel and gasoline, and 1% by electricity.

From 2009 to 2019, demand for international bunker fuels increased from 26.0 kb/d to 48.5 kb/d, to overtake industry as the second-largest source of oil products demand. In 2019, aviation bunkers accounted for 63% of total bunker fuels and marine bunkers 37%. From 2009 to 2019, industry oil products demand fell 31% from 55 kb/d to 38 kb/d. Oil demand in the residential and services/other sectors comes from oil-fired heating of buildings. From 2009 to 2019, residential sector oil demand declined from 15 kb/d to 11 kb/d and services/other sector demand fell from 17 kb/d to 13 kb/d. Only the autonomous island regions of the Azores and Madeira have large-scale electricity generation based on oil (primarily diesel). From 2009 to 2019, oil demand for electricity generation fell by 66% to 4.7 kb/d as a result of a transition to renewable electricity and reduced electricity demand in the autonomous island regions.

Road transportation fuels have consistently accounted for the majority of Portugal's oil products demand. In 2019, diesel accounted for the largest share (50%), while gasoline accounted for 10% (Figure 9.6). Jet and kerosene, used primarily for international aviation bunkers, accounted for the second-largest share of oil products demand (16% in 2019). Portugal also has a notable demand for liquefied petroleum gas (LPG) (8% of oil products demand in 2019). Most of this demand comes from heating and cooking by households that are not connected to the natural gas grid, with a large share of low-income households relying on LPG for heating and cooking. Total demand for LPG in 2019 was 25.4 kb/d, with residential sector demand accounting for 10.4 kb/d, followed by industry (1.7 kb/d) and transport (1.2 kb/d).

Figure 9.5 Oil products demand in Portugal, by sector, 2000-19



Oil demand significantly dropped following the 2008 crisis. Since 2012 oil demand has been relatively flat. Transport has consistently accounted for the largest share of oil demand.

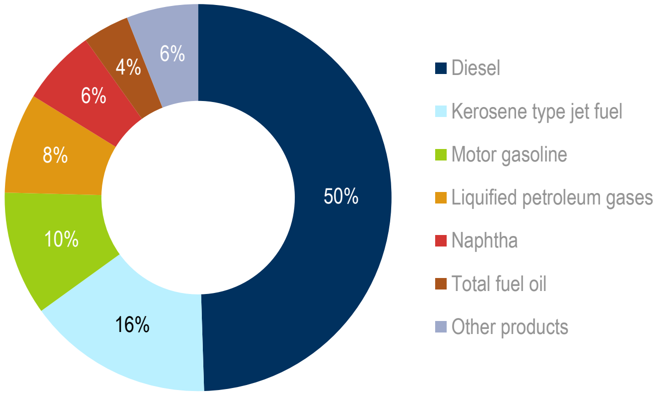
* *International bunkers* includes bunker fuels for international aviation and navigation.

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

Note: kb/d = thousand barrels per day.

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Figure 9.6 Oil products demand in Portugal, by type, 2019



In 2019, diesel (primarily used for road transport) accounted for the largest share of oil products demand (50%), followed by kerosene (16%), primarily for aviation bunkers, and gasoline (10%).

Source: IEA (2020a), *IEA World Energy Statistics and Balances* (database), www.iea.org/statistics.

Institutions

Decree-Law No. 57-A/2018 and Decree-Law No. 69/2018 redefined the regulatory structure of Portugal's oil sector in 2018. The Energy Services Regulatory Authority (ERSE), the independent regulator for electricity and natural gas, had its role extended to cover the downstream oil sector, including markets for transportation fuels, heating oil, LPG, and assuring third-party access to oil and gas storage, and transportation infrastructure. Under the new structure, the Directorate-General for Energy and Geology (DGEG), with the Ministry of Environment and Climate Action, became responsible for the upstream oil sector, and certification and registration of all oil sector companies. This includes issuing licences for oil refining, storage, transportation, trading and supply. The DGEG continues to be responsible for collecting annual, quarterly, monthly and weekly data on prices, supply and demand for crude oil and oil products. The DGEG publishes these data on its website and reports them to the IEA and the European Commission.

Under the new regulatory structure, the National Entity for Fuel Markets (ENMC), which was previously responsible for upstream and downstream oil sector activities, was renamed the National Entity for the Energy Sector (ENSE) and restructured as a public corporation with horizontal supervising authority for the entire energy sector, especially for oil. The ENSE is responsible for evaluating the causes of energy sector accidents, monitoring fuel quality and compliance with licence obligations by energy sector concession holders. It is also the central stockholding entity in Portugal, responsible for the acquisition, maintenance, management and deployment of national reserves for crude oil and oil products (ENSE, 2020).

The Competition Authority (AdC) is an independent public body that promotes competition and ensures compliance with competition laws in Portugal. In its role overseeing competition in the oil sector, it has issued numerous opinions and recommendations on legislation, regulation and calls for legal actions.

The Galp Group plays major a role in Portugal's energy sector, especially in relation to oil and natural gas. The Galp Group is 92.52% privately owned and 7.48% owned by the Portuguese state. The Galp Group consists of more than 100 companies, which are consolidated under Galp Energia, SGPS, S.A. Galp owns Petrogal S.A., which owns and operates Portugal's two oil refineries. Galp owns most of Portugal's oil storage capacity and the only large-scale oil pipeline, and has a dominant position in the retail market for oil products. Galp is also the main natural gas supplier in Portugal at both the wholesale and retail level (Galp Energia, 2018). The Portuguese Association of Petroleum Companies (APETRO) is an industry association representing the interest of companies in the Portuguese oil sector. Its membership is composed of the major companies active in oil procurement, refining, logistics and retail sales (APETRO, 2020).

Oil policy

Portugal's energy policy is focused on reducing oil demand to lower GHG emissions and import dependency, while ensuring security of oil supply and the efficient functioning of downstream oil markets. Many of the measures that will drive lower oil demand are connected to other policy goals, including increasing energy efficiency and the use of renewable energy. The implementation of all measures stipulated in Portugal's National Energy and Climate Plan (NECP) would lead to a substantial drop in oil demand by 2030 and the Roadmap for Carbon Neutrality 2050 (RNC2050) sets strong carbon neutrality targets that would almost eliminate oil demand in Portugal by 2050. The RNC2050 indicates that oil will continue to be needed for certain hard-to-decarbonise applications including transport (heavy road, aviation and shipping), industry and the military, but that primary energy consumption of oil should fall from 376 petajoules (PJ) in 2020 to around 240 PJ in 2030 and less than 57 PJ in 2050.

The government supports maintaining a competitive position of the Portuguese refining sector and is examining options for refineries to support the energy transition. The National Plan for the Promotion of Biorefineries, approved by Resolution of the Council of Ministers No. 163/2017, promotes the production of advanced biofuels and the emergence of new bioenergy value chains and a circular economy.

The domestic transport sector accounts for the largest share of Portugal's oil demand (53.5% in 2018). The government has introduced several measures specifically aiming to reduce transport oil demand, including purchase subsidies and tax benefits for electric vehicles (EVs). The RNC2050 indicates that by 2030, 36% of passenger car mobility demand should be covered by electricity. Portugal's overall vehicle taxation system results in lower taxes for more efficient vehicles. Portugal also has a biofuels blending mandate that directly reduces diesel and gasoline demand by requiring fuel suppliers to cover a progressively increasing share of fuel sales with biofuels (10% by energy content in 2020). Portugal also has energy efficiency and renewable energy targets and measures that will reduce oil demand in buildings, industry and electricity generation (see Chapters 4 and 5).

Decree-Law No. 243/2008 led to the creation of a website that provides consumers with up-to-date information about fuel prices and aims to encourage competition between retailers. The law requires all fuel retailers in mainland Portugal to report fuel prices, business hours, location and services provided. Under Law No. 6/2015, all public service stations must sell versions of diesel and gasoline without supplementary additives. Additional recent changes affecting the oil sector include Law No. 71/2018, which approved the State Budget for 2019 and mandated that the ERSE should perform a cost-benefit analysis for the construction of any new infrastructures, including oil pipelines.

Prices and taxation

The oil products markets in mainland Portugal have been liberalised since 2004 with prices determined by market forces. The governments of the autonomous island regions of the Azores and Madeira continue to regulate retail oil products prices for many fuels. Retail fuel prices in mainland Portugal consist of the wholesale price, logistics and retail costs, supplier margin, and a tax component. The tax component is composed of the tax on energy products (ISP), the carbon tax and the value-added tax (VAT), with the maximum 23% rate applied for all oil products. Road transportation fuels (automotive diesel, gasoline and LPG) are also assigned a road service contribution tax, which is used to cover road infrastructure maintenance costs.

The ISP and carbon tax rates for each energy product (including all oil products) are the same for all consumers regardless of sector and rates do not vary with the level of demand. However, industrial consumers have a 100% exemption from the ISP and the carbon tax for industrial fuels (including oil and oil products) and electricity if they are covered by the EU Emission Trading System regime or by an energy consumption rationalisation agreement (ARCE). ARCEs are part of a government programme requiring industrial energy efficiency measures (see Chapter 4). As a result, the taxation on oil and electricity is significantly lower for industrial consumers than it is for residential and commercial consumers. The 2021 State Budget, approved in November 2020, includes a provision that will progressively eliminate the carbon tax exemption on energy products (including oil) used by industrial installations with an ARCE, which will pay 5% of the carbon tax in 2021, 10% in 2022, 30% in 2023, 65% in 2024 and 100% from 2025 onwards.

Starting in April 2020, oil used for electricity generation (including co-generation)[1], which previously was exempt from the ISP and the carbon tax, began to pay 25% of the ISP and 25% of the carbon tax (this change excludes the autonomous island regions where almost all oil-fired electricity generation takes place). Both of these percentages will be progressively increased to 100% in 2023.

Figure 9.7 Price comparison for automotive diesel in the IEA, 1Q 2020

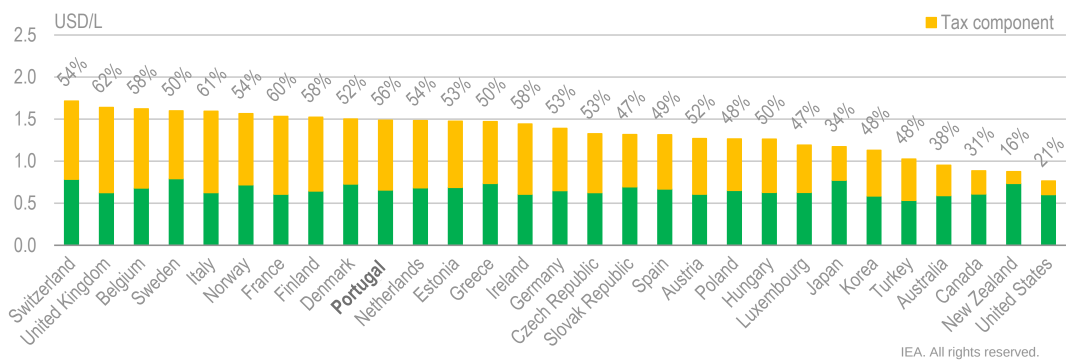
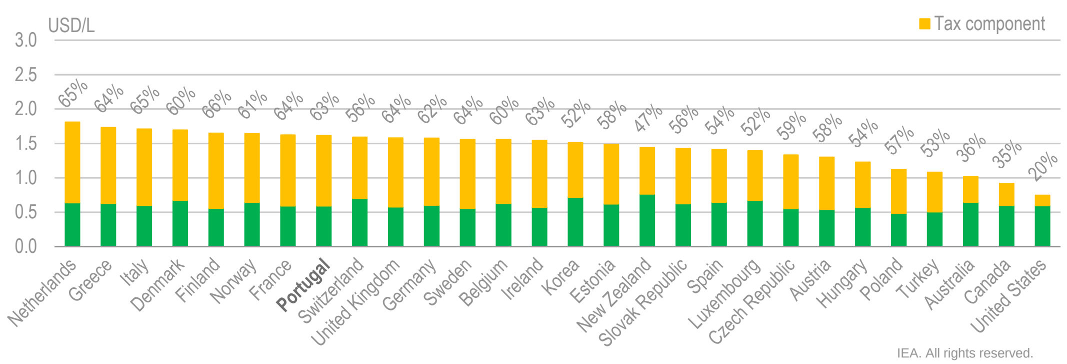


Figure 9.8 Price comparison for unleaded gasoline (95 RON) in the IEA, 1Q 2020



In the first quarter of 2020, prices for diesel and gasoline in Portugal were slightly above IEA median prices, while prices for light fuel oil were the third-highest among IEA member countries.

Notes: Automotive diesel data are not available for Mexico; gasoline data are not available for Japan or Mexico; light fuel oil data are not available for Australia, Ireland, Mexico, New Zealand, Norway, the Slovak Republic or Sweden.
Source: IEA (2020c), *Energy Prices and Taxes* (database), www.iea.org/statistics.

[1] Co-generation refers to the combined production of heat and power.

In the first quarter of 2020, prices for automotive diesel and unleaded gasoline in Portugal were slightly above IEA median prices. Portugal's automotive diesel price was the tenth-highest, at USD 1.48/L (of which 56% is tax) (Figure 9.7). For unleaded gasoline, Portugal ranked the eighth highest, at USD 1.62/L, 63% of which was tax (Figure 9.8). LPG prices in Portugal peaked in 2012 at 0.81 USD per litre (USD/L), before declining to 0.55 USD/L in 2016 and rising again to 0.68 USD/L in 2020. The introduction of the carbon tax in 2014 led to a sharp increase in the tax share of LPG prices.

In 2018, the government started developing a programme in co-operation with municipalities and LPG suppliers to provide low-income households with a reduced price on bottled LPG (LPG social tariff). However, there was limited interest and in February 2021 the government cancelled the LPG social tariff pilot project. Instead, the government aims to implement a programme that will support households in transitioning from LPG heating and cooking to electric heating and cooling (Silva, 2021).

Like many EU member states, Portugal has seen a significant increase in the share of diesel vehicles in its passenger car fleet over recent decades. In 2018, there were approximately 5 283 000 passenger vehicles registered in Portugal, with diesel vehicles representing 55.9%, gasoline vehicles 42.0% and small shares of vehicles powered by LPG, natural gas and electricity. In line with environmental and public health goals, the government has been aiming to lower the share of diesel vehicles in the passenger vehicle fleet and has been reducing the tax advantage of automotive diesel versus gasoline. From 2015 to 2018, the difference in taxation on diesel versus gasoline dropped from EUR 216 per 1 000 litres to EUR 155 per 1 000 litres. In addition, the annual vehicle registration fee includes a surcharge for diesel vehicles based on engine size, which starts at EUR 5.02 per year and increases to EUR 68.85 per year for engines above 2 500 cubic centimetres.

The reduced tax advantage for diesel seems to be driving the desired change in consumer preference. In 2019, the share of diesel vehicles in new vehicle sales dropped below that of gasoline vehicles for the first time since 2003. The government is also providing subsidies and tax incentives for EVs, which are taking a small but growing share of market (see Chapter 4).

The government also has several measures that reduce diesel taxes for certain sectors and end uses. There is a substantially lower tax on coloured diesel used for agriculture, forestry and stationary generators (EUR 165.96 per 1 000 litres for coloured diesel versus EUR 343.15 per 1 000 litres for automotive diesel in 2020). In 2016, the government created a diesel excise duty refund for transportation companies. The rebate applies to category D heavy goods vehicles with a weight of 35 tonnes or higher that are registered in the EU. The refund is EUR 182.6 per 1 000 litres and is limited to 35 000 litres of diesel per vehicle per year (BELIM, 2020).

Market structure

Upstream

Currently, Portugal has no proven oil or natural gas reserves. Oil and gas exploration has taken place in Portugal on a small scale. In 2015, there were 15 contracts allowing oil and gas exploration and exploitation, but as of 2020, all of them were either relinquished by the concession holder or terminated by the government, and no exploration or exploitation activities are taking place. In September 2020, the Ministry of Environment and Climate Action announced that no more contracts will be awarded for oil or gas exploration and exploitation (Cabrita-Mendes, 2020).

Downstream

Galp Energia is the most important player in the Portuguese downstream oil sector. It is the only operator with domestic refining capacity and is active in every downstream sector (procurement, refining, logistics and retail). The remaining major operators (BP Portugal S.A., Repsol Portuguesa S.A., Cepsa Portuguesa Petróleos S.A. and Prio Supply S.A) are active in procurement, logistics and retail.

Wholesale market

From 2018 to 2020, four operators (Galp, Repsol, BP and Cepsa) dominated the wholesale market, accounting for over 87% of diesel sales and over 85% of gasoline sales. These four operators own the refineries and the largest oil storage facilities on the Iberian peninsula. Galp, the only operator that owns refining capacity in Portugal, has the largest shares of the wholesale markets for diesel (38% in 2019) and for gasoline (39%). The wholesale market for bottled LPG is highly also concentrated. From 2018 to 2020, three operators (Galp, Rubis and Repsol) accounted for over 75% of bottled propane sales and over 85% of bottled butane sales; Galp's market share was over 40% for both fuels. These three operators are also owners of the three largest LPG storage facilities in Portugal: CLC, Pergás and Sigás (ERSE, 2020a). Since the 1990s, there has been only one new entrant to the bottled LPG wholesale market, Prio in 2014 (OECD, 2018).

Retail market

In 2018, mainland Portugal had around 3 100 retail service stations selling transportation fuels, an increase of around 7% compared to 2014. All stations sell diesel and gasoline, while around 350 also sell automotive LPG. Retail prices for automotive diesel and gasoline show good correlation with international prices; however, there is a high level of market concentration and some signs of limited competition, including price convergence across retail stations owned by the major operators and at retail stations along highways (ERSE, 2020b).

The ownership of stations and the share of retail fuel sales are highly concentrated among a few companies, with Galp controlling the largest market share. In 2018, the four largest operators (Galp, Repsol, Cepsa and BP) owned 62% of retail service stations in Portugal, down just 1.3% from 2014. Small independent players owned 29% of stations and supermarkets owned 9%. In 2018, Galp maintained its dominant place in the retail market with a 30.4% market share; other large players together had a market share of 35.6%, followed by supermarket chains (19%) and small independent players (15%). In 2018, 65% of road fuels sales came from stations owned by companies that were members of the Portuguese Association of Petroleum Companies.

In 2018, there were 34 retail companies operating LPG pipeline distribution networks providing LPG (propane) directly to end users. Bottled LPG is available at all retail service stations selling transportation fuels. The high level of concentration seen in the LPG wholesale market is also reflected in the retail market, with three large operators (Galp, Rubis and Repsol) owning the majority of retail suppliers. The average retail prices for propane and butane have been stable in recent years and were not responsive to a notable decrease in the cost of LPG production and imports. There is price convergence among the retailers owned by the three largest LPG suppliers, and retail margins on bottled LPG have been stable in recent years and were notably higher (40-60% in 2020) than margins for diesel (14%) and gasoline (16%) (ERSE, 2020b).

Infrastructure

Portugal has two major ports for oil imports, each of which is linked to a refinery. There are also smaller ports that handle only oil products. The majority of the country's 43.5 million barrels (mb) of oil storage capacity is located at the refineries. Portugal has one major oil product pipeline and no cross-border oil pipelines (Figure 9.9).

Figure 9.9 Oil infrastructure in Portugal, 2020

Ports

All crude oil imports and the majority of oil products imports pass through two ports, Sines and Leixões, each of which are directly connected to a refinery. The oil terminal at Sines operates year-round, is able to accommodate very large crude carriers and is directly connected the Sines refinery. The port of Leixões, although susceptible to difficult winter conditions, can operate year-round thanks to a single-point mooring buoy, connected to the Matosinhos refinery by a 3.0 km subsea pipeline. In 2012, both ports were significantly improved in terms of capacity and accessibility. Portugal also has several smaller ports importing and exporting oil products located at Aveiro, Lisbon and Setubal, and in the autonomous island regions of the Azores and Madeira.

Refining

There are two refineries in Portugal, Sines and Matosinhos, which jointly provide a crude processing capacity of 330 kb/d and together represent around 20% of refining capacity on the Iberian peninsula. The Sines refinery is located in the country's largest port and industry complex and has a capacity of 220 kb/d (81.1 mb/y). Sines accounts for almost 70% of Portugal's refining capacity and is one of the largest refineries on the Iberian peninsula. The Matosinhos refinery, located at a large industry site on the north-west coast, is a hydro-skimming refinery with vacuum distillation and has a capacity of 110 kb/d (40.5 mb/y). Although the two refineries operate independently, they exchange feedstocks and semi-finished products to optimise capacity utilisation. The Sines and Matosinhos refineries are owned by the Galp subsidiary, Petrogal.

From 2014 to 2018, around EUR 120 million was invested in both refineries for energy efficiency programmes to reduce their carbon footprint and to improve overall process efficiency and conversion rates. From 2018 to 2019, Petrogal also made upgrades to both refineries to comply with the International Maritime Organisation (IMO) regulation, IMO 2020. Under IMO 2020, which entered into force on 1 January 2020, ships operating outside designated emission control areas must use fuels with sulphur content below 0.5%, a significant reduction from the previous 3.5% limit (IMO, 2020). Both refineries in Portugal can produce very low sulphur fuel oil (VLSFO) and the fuel has been available for sale at all Portuguese ports since 15 November 2019.

Pipelines

Portugal has two pipelines for domestic transportation of oil products and no cross-border oil pipelines. To distribute oil products to the central part of the country, CLC (a Portuguese fuel logistics company) operates a 147 km-long pipeline connecting the Sines refinery to a tank farm at Aveiras (located 45 km north of Lisbon). CLC is owned and operated by a consortium composed of the following enterprises: Petrogal (65%), BP (15%), Repsol (15%) and Rubis (5%), but under Portuguese law allows third-party access. The CLC pipeline is a multi-product pipeline, with an annual capacity of 29.5 mb (80-110 kb/d of seven different products, in sequence and by cycles). In 2018, a total of 2.9 million countrnes (21.4 mb) of products (diesel, gasolines and jet fuel) were transported via the CLC pipeline and distributed by truck to the Portuguese market (a 6.2% increase from 2017).

There is a 4 km jet fuel pipeline from the Matosinhos refinery to the Porto international airport. The pipeline has a capacity of 17 kb/d and is operated by Petrogal. Portugal's main international airport in Lisbon is currently supplied with jet fuel only by truck. In April 2019, strikes by fuel truck drivers disrupted airport operations. In response, the government announced in May 2019 that a jet fuel pipeline will be built to supply the Lisbon airport, with an expected cost around EUR 40 million. Portugal also has numerous small-scale pipeline systems for distribution of LPG.

Storage

Portugal's total oil storage capacity is approximately 43.5 mb, with around 70% of the total capacity located at the Sines (18.65 mb) and Matosinhos (11.57 mb) refineries and the remaining capacity spread across numerous smaller sites on the mainland and in the autonomous island regions of the Azores and Madeira. From 2016 to 2018, total mainland oil storage capacity increased by around 0.7 mb. In 2020, all of Portugal's oil storage capacity was composed of above-ground tanks, except for one small underground cavern for propane at the Sines refinery. The ENSE is studying the possibility of storing oil products in salt caverns. In 2018, more than 90% of total oil storage was owned by the three largest oil sector operators and 100% of crude oil storage capacity was owned by Galp Energia (AdC, 2018).

Emergency response policy

Portugal's oil emergency response policy is aligned with EU Directive 119/2009/EC on Oil Stocks. The Minister of Environment and Climate Action has the competence to authorise the use of oil security reserves in case of a severe supply disruption and to impose restrictions on demand, particularly for prioritising oil products allocation. During a supply crisis, the minister has the power to order the release of compulsory oil stocks to safeguard the national economy or to participate in IEA collective actions.

The ENSE is the Portuguese central stockholding entity operating under the supervision of the government with responsibility to purchase and manage strategic oil reserves of crude oil and oil processed products. The Emergency Plan for the Mobilization of Oil Reserves and Petroleum Products (also called the Plan for Intervention and Use of Security Reserves) was elaborated by the ENSE in 2019. The ENSE ensures the operation of the plan in the case of an event causing a serious disruption by mobilising emergency reserves in an effective and efficient manner. For local supply disruptions, the government maintains a list of strategic retail fuel stations, the Strategic Network of Supply Stations, that can be used to supply emergency response services and other priority users. These stations are obliged to reserve a certain amount of diesel, gasoline and LPG for the exclusive use of the priority users. The selection of the stations was based on their location, type of products sold, accessibility and storage capacity to ensure adequate geographic coverage (Jornal Económico, 2019).

In early 2019, Portugal experienced a notable disruption to oil product supplies resulting from strikes by fuel truck drivers. As a result of the strikes, flights at the main international airport in Lisbon were disrupted, around 40% of retail fuel stations in the country either shut down or ran out of fuel, and some public transportation services were suspended (Tvi24, 2019). In response, volume restrictions were placed on the sales of road transportation fuels and the government used the national police for some fuel deliveries and issued an emergency decree allowing the strikers to be prosecuted and face up to two years in prison (BBC, 2019).

Assessment

Portugal has no oil resources and is entirely dependent on oil imports. However, Portugal imports crude oil and oil products from a diverse range of sources, reflecting the country's well-developed port infrastructure on the Atlantic seaboard with ready access to global maritime trade. Portugal's refining sector is relatively well matched to national demand in terms of overall capacity and product mix. The only significant net import requirements are for diesel (gasoil), jet (kerosene) and LPG, with LPG having the highest import dependency. This balanced position is the result of Petrogal investing significantly over the past decade to ensure that supplies reflect demand and to meet energy efficiency targets.

Oil products cover the largest share of Portugal's energy demand (49% of TFC in 2019). However, the RNC2050 aims for a 36% decrease in oil products demand by 2030, through a combination of energy efficiency and increased use of electricity, bioenergy and low-carbon hydrogen. The government has targets to increase the share of renewable energy in transport to 10% by 2020 and 20% by 2030, and a target for hydrogen to cover 1-5% of road transport energy demand and 3-5% of domestic shipping energy demand by 2030. These goals present notable challenges for the oil sector, both in terms of absolute demand and in the changing balance of products, and could hamper the economic case for current refining and infrastructure capacity.

Portugal's oil industry will need to transform to align with the RNC2050, and its business will need to be more diversified, including investments in biorefining and low-carbon hydrogen. In addition, Portugal's refining sector was hit hard in 2020 by the Covid-19 pandemic, which led to the biggest reduction ever in global oil demand. Demand, particularly for jet fuel, is expected to remain below pre-COVID levels until 2022 at the earliest, unless there is a faster than expected solution to the pandemic. This will have a significant impact on the revenues for the whole downstream oil sector and the availability of capital for future investments; the scale of this impact on the oil sector both globally and in Portugal is not yet clear. To effectively deal with fallout of Covid-19 and support the RNC2050's carbon neutrality goals, Portugal's oil industry would benefit from more clarity in terms of the expected decarbonisation and demand trajectory in the oil-consuming sectors, notably for transport, and the IEA recommends that the Portuguese government maintain open consultations on energy and transport policy with the downstream oil industry.

The AdC's report on the road fuels market from May 2018 examined the impacts of market concentration, noting that more than 90% of oil storage capacity is owned by the three largest oil sector operators, industry gross margins are relatively stable and there is a high concentration of ownership of retail fuel stations on highways (AdC, 2018). The report made four recommendations to improve competition in the market for road fuels: 1) promote access to oil storage and transport facilities; 2) promote market-based competition for the licensing of retail fuel stations on highways; 3) promote a consumer transparency policy; and 4) promote impact assessments of public policies on competition. The AdC's recommendations need to be effectively implemented by the government and there is concern that competition at wholesale and retail levels is still very low. The Portuguese government is to be commended for having the ERSE take a specific role in regulating oil markets to help promote efficient markets and competition.

Road transport demand is dominated by diesel. The government has taken steps to reduce the share of diesel vehicles in the passenger vehicles fleet, lowering the tax advantage for diesel versus gasoline, which has resulted in gasoline-powered vehicles gaining market share. However, the government has also taken steps to limit the impact of increased diesel taxes on freight transportation through a tax rebate programme. In 2018, freight trucks, which use almost exclusively diesel, accounted for 41% of road transport fuel demand.

The proposed carbon tax is a welcome addition to the government's policy toolbox. It will give a value to the external costs of fossil fuels across all economic sectors. But when applying the carbon tax to transport fuels, the level of carbon taxation should be calibrated with the excise duties to avoid a sudden increase in fuel prices, which would risk public support for the carbon tax.

Portugal has notable demand for LPG, which accounted for 8% of oil product demand in 2019, and was driven by use of bottled LPG and LPG pipeline networks to cover heating and cooking demand in a large share of Portuguese households. In 2019, around 41% of total LPG demand came from the residential sector. The majority of LPG is imported and domestic LPG production will likely decrease in the coming decades if refinery throughput is reduced in line with the RNC2050's goals.

Most LPG demand comes from heating and cooking by households that are not connected to the natural gas grid. In addition, many households with high LPG use live in buildings that require notable investments to support electrical heating and cooking. A large share of low-income households rely on LPG for heating and cooking. The government had planned a pilot project for 2021 to examine a potential LPG social tariff (below market price) to address issues of fuel poverty and determine how such a tariff could be implemented a the national level. However, there was limited interest from municipalities and LPG suppliers and in February 2021 the government cancelled the pilot project. Instead, the government aims to implement a programme that will support households in transitioning from LPG heating and cooking to electric heating and cooling (Silva, 2019).

The IEA welcomes the decision to promote electrification to reduce LPG demand as this will reduce building emissions and support the achievement of Portugal's climate neutrality goals. However, electrification of heating and cooling demand should be combined with energy efficiency measures to ensure that the transition away from LPG does allow households to increase thermal comfort and does not lead to increased cost for cosumers, especially vulnerable ones. The government should move quickly to implement the programme for electrification of heating and cooking demand currently met with LPG, and closely monitor its implementation to ensure it effectively addresses concerns over energy poverty without.

The IEA also welcomes the move away from an LPG social tariff. As the government develops Portugal's National Strategy to Combat Energy Poverty, it should consider alternatives to social tariffs and examine options to combat fuel poverty more broadly (also for electricity and natural gas) in ways that do not create the potential for increased consumption of fossil fuels. The numerous programmes aiming to increase energy efficiency, electrification and renewables in buildings could place a priority on assisting low-income households.

The government should also address the limited competition and high margins in the LPG market, to the benefit of all consumers, including low-income households. There is continued concern about market concentration and limited competition in the LPG market. In 2015, the AdC recommended that three companies of the Galp Group be fined EUR 9.29 million for anticompetitive practices in the bottled LPG market. The fine was appealed to the Competition, Regulation and Supervision Court, which confirmed the AdC's findings in January 2016, but reduced the fine to EUR 4 million. This decision was upheld by the Lisbon Court of Appeal in 2017 (OECD, 2018).

The March 2017 AdC report on the bottled LPG market examined the impacts of market concentration, noting high gross margins, especially for propane, and concerns over a lack of competitive dynamics and barriers to entry, especially in relation to access to LPG storage facilities (AdC, 2017). The report made three recommendations to improve competition in the sales bottled LPG: 1) extend the public interest status to those LPG storage facilities capable of receiving competitive imports; 2) implement Regulation No. 109/2016 that addresses the hoarding of bottled LPG in storage facilities; and 3) consider harmonising LPG bottle valves, provided that this measure has a positive cost-benefit evaluation. As with road fuels, the AdC's recommendations for LPG need to be effectively implemented by the government. In August 2020, the ERSE released a report on the bottled LPG market, which found a continued high level of concentration in the market and high profit margins. This report has been forwarded to the AdC to investigate possible anticompetitive behaviours.

The 2019 strikes by tanker drivers delivering fuel were a significant disruption to fuel supplies across the country, which required the government to activate a wide range of policies to maintain fuel supplies and manage demand. The central co-ordination and communication during this crisis were well received by the industry; however, as with any response, there are lessons to be learnt and the government should continue to analyse the strike response and update procedures as needed. In particular, retail fuel station operators indicated that some stations designated for use by emergency services were significantly underutilised during the strike. During the strike, jet fuel supplies to the Lisbon airport proved to be particularly vulnerable. In response, the government is examining a project to construct a jet fuel pipeline to the airport. The government is encouraged to expedite decision making on this project in line with the recent cost-benefit analysis conducted by the ERSE and good procurement practices.

Recommendations

The government of Portugal should:

- ☐ Together with industry and other stakeholders, develop a strategy for the future of Portugal's mid- and downstream oil industry, taking into account decarbonisation and transport policy goals.
- ☐ Consider how to balance the tax system for transport fuels to ensure equity for the consumer and reflect the external social and environmental costs of fuel use.
- ☐ Ensure that the remedies identified by the Portuguese Competition Authority on the road fuels and LPG markets are implemented effectively and without unnecessary delay. This should include a review of the laws on third-party access to storage infrastructure where these have not yet been effective.
- ☐ Set a clear plan to reduce the residential sector's dependency on LPG that focuses on electrification and improved energy efficiency of housing for families in fuel poverty.
- ☐ Support work by the Portuguese Competition Authority to improve competition and reduce prices in the LPG market.

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ANNEX A: Organisations visited

Review criteria

The Shared Goals, adopted by the International Energy Agency (IEA) Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The Shared Goals are presented in Annex C.

Review team and preparation of the report

The IEA's in-depth review of Portugal was conducted on line from 14-25 September 2020. The review team met with government officials, energy suppliers, market participants, interest groups, consumer associations, research institutions and other stakeholders. The report was drafted based on information obtained in these meetings, the review team's assessment of Portugal's energy policy, the government response to the IEA energy policy questionnaire and subsequent research by the IEA. The members of the team were:

IEA member countries

Mr. Gunter Siddiqi, Switzerland (team leader)

Mr. Patrick Todd, The Netherlands

Ms. Eva Kasparek, Germany

Mr. Philip Newsome, Ireland

Mr. Andreas Indinger, Austria

Mr. Juan Bautista Sánchez-Peñuela, Spain

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European Union

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International Energy Agency

Mr. Aad van Bohemen

Mr. Shuto Fukuoka

Mr. Peter Journeay-Kaler

The team is grateful for the co-operation and assistance of the many people who supported the review. Thanks to their hospitality, openness and willingness to share information, the visit was highly informative, productive and enjoyable. The team expresses its gratitude to João Galamba, State Secretary for Energy, and João Bernardo, Director-General of the General Directorate of Energy and Geology (DGEG), for their time and encouragement. The team gives special thanks to Isabel Viegas Soares, Director of the Institutional Affairs and Market Department, DGEG; Carlos Oliveira, Director of Fuel Department, DGEG; and Manuela Fonseca, Director of Department of Energy Planning and Statistics, DGEG, for their endless efforts in organising the team visit, their prompt responses to the team's many requests and their patience throughout the week.

The review was prepared under the guidance of Mr. Aad van Bohemen, Head of the Energy Policy and Security Division, IEA. Mr. Peter Journeay-Kaler managed the review and is the author of the report. Mr. Shuto Fukuoka co-ordinated the emergency response component of the review and contributed to the chapters on oil, natural gas and electricity. Mr. Alessio Scanziani wrote the chapter on energy efficiency. Mr. Alessio Scanziani, Ms. Clémence Lizé, Ms. Dahyeon (Lisa) Yu, Ms. Dasom Kim, Ms. Bomi Kim, Ms. Alan Choi and Ms. Myriam Badri prepared and drafted the sections relating to energy data contained in each chapter. Helpful comments, chapter reviews and updates were provided by the following IEA staff: Mr. Neil Atkinson, Mr. Gergely Molnar, Ms. Alyssa Fischer, Mr. Keith Everhart, Mr. César Alejandro Hernández, Ms. Andrea Dertinger, Mr. Heymi Bahar, Mr. Trevor Criswell, Mr. Simon Bennett and Mr. Kieran McNamara. Ms Martha Baxter from the OECD also contributed.

Special thanks to the IEA secretariat with regard to the data, publication and editing. Ms. Astrid Dumond, Ms. Isabelle Nonain-Semelin and Ms. Tanya Dyhin managed the layout and publication. Ms. Roberta Quadrelli and Mr. Faidon Papadimoulis provided support on statistics. Ms. Therese Walsh managed the editing process. Mr. Jad Mouawad and Mr. Jethro Mullen supported the press launch. Ms. Jennifer Allain edited the manuscript.

Organisation visited

General Directorate of Energy and Geology (DGEG)

AdEPORTO

AGENEAL

AREAM

Areana Tejo

Portuguese Competition Authority (AdC)

DECO

Dorogas

EDP Distribuçao

Endesa

Energy Services Regulatory Authority (ERSE)

Fondation for Science and Technology (FCT)

Galp

Geota

Iberdrola

IMT

Madeira Regional Directorate of Economy and Land Transport

Ministry of Finance

Ministry of Science, Technology and Higher Education

Mobi.e

National Electric Network (REN)

National Entity for the Energy Sector (ENSE)

National Innovation Agency (ANI)

National Laboratory for Civil Engineering (LNEC)

National Laboratory of Energy and Geology (LNEG)

Operator of the Iberic Energy Market (OMIP)

National Agency for energy (ADENE)

Portuguese Association of Companies in the Electricity Sector (Elecpor)

Portuguese Association of Natural Gas Companies (AGN)

Portuguese Association of Renewable Energy (APREN)

Portuguese Cogeneration Association (COGEN)

Portuguese Environment Agency (APA)

Portuguese Petroleum Companies Association (APETRO)

Quercus

REN Portgas

S.ENERGIA

SONORGAS

SUniversal

Universidade EVORA

Zero

ANNEX B: Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2017	2018	2019
TOTAL PRODUCTION		**1.40**	**3.39**	**3.85**	**5.80**	**5.23**	**5.86**	**5.88**
Coal		0.13	0.12	-	-	-	-	-
Peat		-	-	-	-	-	-	-
Oil		-	-	-	-	-	-	-
Natural gas		-	-	-	-	-	-	-
Biofuels and waste[1]		0.64	2.48	2.77	3.38	3.29	3.31	3.54
Nuclear		-	-	-	-	-	-	-
Hydro		0.63	0.79	0.97	1.39	0.51	1.07	0.76
Wind		-	-	0.01	0.79	1.05	1.09	1.18
Geothermal		-	0.00	0.07	0.18	0.20	0.21	0.20
Solar/other[2]		-	0.01	0.02	0.07	0.17	0.18	0.21
TOTAL NET IMPORTS[3]		**5.36**	**13.85**	**20.75**	**17.35**	**17.79**	**16.60**	**15.95**
Coal	Exports	0.01	0.01	0.05	-	-	-	-
	Imports	0.28	3.00	3.97	1.63	3.41	2.67	1.53
	Net imports	0.27	2.99	3.91	1.63	3.41	2.67	1.53
Oil	Exports	0.23	2.47	1.42	2.86	7.01	5.37	4.88
	Imports	6.41	14.38	17.45	15.39	18.42	16.85	16.44
	Int'l marine and aviation bunkers	-1.10	-1.06	-1.31	-1.34	-2.06	-2.17	-2.41
	Net imports	5.09	10.85	14.72	11.20	9.36	9.31	9.16
Natural gas	Exports	-	-	-	-	-	-	-
	Imports	-	-	2.04	4.51	5.44	5.08	5.28
	Net imports	-	-	2.04	4.51	5.44	5.08	5.28
Electricity	Exports	0.01	0.15	0.32	0.27	0.70	0.72	0.40
	Imports	0.01	0.15	0.40	0.50	0.47	0.49	0.70
	Net imports	-0.00	0.00	0.08	0.23	-0.23	-0.23	0.29
TOTAL STOCK CHANGES		**0.14**	**-0.46**	**-0.00**	**0.35**	**-0.24**	**-0.45**	**-0.06**
TOTAL SUPPLY (TES)[4]		**6.90**	**16.78**	**24.60**	**23.50**	**22.77**	**22.01**	**21.77**
Coal		0.51	2.76	3.81	1.66	3.23	2.70	1.25
Peat		-	-	-	-	-	-	-
Oil		5.12	10.74	14.83	11.51	9.33	8.88	9.38
Natural gas		-	-	2.03	4.49	5.42	5.02	5.28
Biofuels and waste[1]		0.64	2.48	2.77	3.19	3.10	3.10	3.22
Nuclear		-	-	-	-	-	-	-
Hydro		0.63	0.79	0.97	1.39	0.51	1.07	0.76
Wind		-	-	0.01	0.79	1.05	1.09	1.18
Geothermal		-	0.00	0.07	0.18	0.20	0.21	0.20
Solar/other[2]		-	0.01	0.02	0.07	0.17	0.18	0.21
Electricity trade[5]		-0.00	0.00	0.08	0.23	-0.23	-0.23	0.29
Shares in TES (%)								
Coal		*7.4*	*16.4*	*15.5*	*7.1*	*14.2*	*12.3*	*5.8*
Peat		-	-	-	-	-	-	-
Oil		*74.3*	*64.0*	*60.3*	*49.0*	*41.0*	*40.3*	*43.1*
Natural gas		-	-	*8.3*	*19.1*	*23.8*	*22.8*	*24.3*
Biofuels and waste[1]		*9.3*	*14.8*	*11.3*	*13.6*	*13.6*	*14.1*	*14.8*
Nuclear		-	-	-	-	-	-	-
Hydro		*9.1*	*4.7*	*4.0*	*5.9*	*2.2*	*4.8*	*3.5*
Wind		-	-	*0.1*	*3.4*	*4.6*	*4.9*	*5.4*
Geothermal		-	*0.0*	*0.3*	*0.8*	*0.9*	*1.0*	*0.9*
Solar/other[2]		-	*0.1*	*0.1*	*0.3*	*0.8*	*0.8*	*1.0*
Electricity trade[5]		-	-	*0.3*	*1.0*	*-1.0*	*-1.0*	*1.3*

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	**5.74**	**13.39**	**19.36**	**18.95**	**16.44**	**16.17**	**16.78**
Coal	0.24	0.65	0.48	0.05	0.01	0.01	0.01
Peat	-	-	-	-	-	-	-
Oil	4.21	8.36	12.23	10.12	8.22	7.75	8.28
Natural gas	-	-	0.79	1.56	1.74	1.80	1.81
Biofuels and waste[1]	0.58	2.33	2.41	2.53	2.16	2.16	2.21
Geothermal	-	-	0.00	0.00	0.00	0.00	0.00
Solar/other[2]	-	0.01	0.02	0.05	0.09	0.09	0.10
Electricity	0.70	2.02	3.30	4.29	4.01	4.12	4.12
Heat	-	0.03	0.13	0.34	0.21	0.23	0.25
Shares in TFC (%)							
Coal	*4.2*	*4.8*	*2.5*	*0.3*	*0.1*	*0.1*	*0.1*
Peat	-	-	-	-	-	-	-
Oil	*73.4*	*62.4*	*63.2*	*53.4*	*50.0*	*48.0*	*49.4*
Natural gas	-	-	*4.1*	*8.3*	*10.6*	*11.1*	*10.8*
Biofuels and waste[1]	*10.1*	*17.4*	*12.5*	*13.4*	*13.1*	*13.4*	*13.2*
Geothermal	-	-	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Solar/other[2]	-	*0.1*	*0.1*	*0.3*	*0.5*	*0.6*	*0.6*
Electricity	*12.3*	*15.1*	*17.0*	*22.6*	*24.4*	*25.5*	*24.5*
Heat	-	*0.2*	*0.7*	*1.8*	*1.3*	*1.4*	*1.5*
TOTAL INDUSTRY[6]	**2.70**	**6.76**	**8.55**	**7.18**	**5.73**	**5.27**	**5.77**
Coal	0.14	0.59	0.43	0.05	0.01	0.01	0.01
Peat	-	-	-	-	-	-	-
Oil	1.80	3.91	4.70	2.75	1.82	1.30	1.70
Natural gas	-	-	0.66	1.05	1.21	1.24	1.25
Biofuels and waste[1]	0.32	1.18	1.26	1.51	1.11	1.10	1.14
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	-	-	-	-
Electricity	0.44	1.05	1.37	1.50	1.39	1.41	1.44
Heat	-	0.03	0.13	0.32	0.18	0.20	0.22
Shares in total industry (%)							
Coal	*5.2*	*8.8*	*5.1*	*0.7*	*0.2*	*0.2*	*0.2*
Peat	-	-	-	-	-	-	-
Oil	*66.7*	*57.8*	*54.9*	*38.3*	*31.8*	*24.7*	*29.5*
Natural gas	-	-	*7.7*	*14.7*	*21.2*	*23.6*	*21.7*
Biofuels and waste[1]	*11.8*	*17.4*	*14.8*	*21.0*	*19.4*	*20.9*	*19.8*
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	-	-	-	-
Electricity	*16.3*	*15.6*	*16.0*	*20.9*	*24.2*	*26.8*	*24.9*
Heat	-	*0.4*	*1.5*	*4.4*	*3.1*	*3.9*	*3.9*
TRANSPORT[4]	**1.60**	**3.25**	**5.86**	**6.43**	**5.75**	**5.81**	**5.94**
OTHER[7]	**1.44**	**3.39**	**4.94**	**5.34**	**4.96**	**5.10**	**5.07**
Coal	0.08	0.05	0.04	-	-	-	-
Peat	-	-	-	-	-	-	-
Oil	0.85	1.23	1.70	1.31	0.95	0.97	0.97
Natural gas	-	-	0.13	0.50	0.51	0.54	0.54
Biofuels and waste[1]	0.26	1.15	1.15	0.72	0.80	0.80	0.80
Geothermal	-	-	0.00	0.00	0.00	0.00	0.00
Solar/other[2]	-	0.01	0.02	0.05	0.09	0.09	0.10
Electricity	0.25	0.95	1.90	2.75	2.58	2.67	2.64
Heat	-	-	0.01	0.02	0.03	0.03	0.03
Shares in other (%)							
Coal	*5.6*	*1.6*	*0.8*	-	-	-	-
Peat	-	-	-	-	-	-	-
Oil	*59.2*	*36.3*	*34.3*	*24.6*	*19.1*	*19.0*	*19.2*
Natural gas	-	-	*2.6*	*9.3*	*10.3*	*10.6*	*10.6*
Biofuels and waste[1]	*18.2*	*33.9*	*23.3*	*13.4*	*16.2*	*15.6*	*15.7*
Geothermal	-	-	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Solar/other[2]	-	*0.3*	*0.4*	*0.9*	*1.8*	*1.8*	*1.9*
Electricity	*17.0*	*27.9*	*38.4*	*51.4*	*52.1*	*52.4*	*52.1*
Heat	-	-	*0.1*	*0.3*	*0.5*	*0.5*	*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							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2017**	**2018**	**2019**
ELECTRICITY GENERATION[8]							
Input (Mtoe)	1.33	5.09	7.61	8.00	9.52	9.09	7.77
Output (Mtoe)	0.84	2.44	3.73	4.62	4.96	5.02	4.45
Output (TWh)	9.79	28.34	43.37	53.69	57.70	58.40	51.73
Output shares (%)							
Coal	*3.9*	*32.1*	*33.9*	*13.2*	*25.4*	*20.6*	*10.7*
Peat	-	-	-	-	-	-	-
Oil	*19.2*	*33.2*	*19.4*	*5.6*	*2.2*	*1.9*	*2.4*
Natural gas	-	-	*16.5*	*27.8*	*32.7*	*26.7*	*33.4*
Biofuels and waste[1]	*2.0*	*2.4*	*3.6*	*5.5*	*6.1*	*5.8*	*7.0*
Nuclear	-	-	-	-	-	-	-
Hydro	*74.8*	*32.3*	*26.1*	*30.1*	*10.2*	*21.2*	*17.0*
Wind	-	-	*0.4*	*17.1*	*21.2*	*21.6*	*26.4*
Geothermal	-	-	*0.2*	*0.4*	*0.4*	*0.4*	*0.4*
Solar/other[2]	-	-	-	*0.4*	*1.7*	*1.7*	*2.6*
TOTAL LOSSES	**1.31**	**2.87**	**5.33**	**4.57**	**6.44**	**5.78**	**4.92**
of which:							
Electricity and heat generation[9]	0.49	2.62	3.75	2.90	4.19	3.67	2.94
Other transformation	0.32	-0.73	0.34	0.16	0.40	0.40	0.38
Own use and transmission/distribution losses	0.51	0.97	1.25	1.51	1.84	1.70	1.61
Statistical differences	**-0.15**	**0.52**	**-0.09**	**-0.02**	**-0.10**	**0.06**	**0.07**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2017**	**2018**	**2019**
GDP (billion 2015 USD)	85.15	145.48	193.40	207.98	210.55	216.11	220.78
Population (millions)	8.72	10.00	10.29	10.57	10.30	10.28	10.28
TES/GDP (toe/1000 USD)[10]	0.08	0.12	0.13	0.11	0.11	0.10	0.10
Energy production/TES	0.20	0.20	0.16	0.25	0.23	0.27	0.27
Per capita TES (toe/capita)	0.79	1.68	2.39	2.22	2.21	2.14	2.12
Oil supply/GDP (toe/1000 USD)[10]	0.06	0.07	0.08	0.06	0.04	0.04	0.04
TFC/GDP (toe/1000 USD)[10]	0.07	0.09	0.10	0.09	0.08	0.07	0.08
Per capita TFC (toe/capita)	0.66	1.34	1.88	1.79	1.60	1.57	1.63
CO_2 emissions from fuel combustion ($MtCO_2$)[11]	16.2	37.9	57.9	47.6	50.8	47.3	42.4
CO_2 emissions from bunkers ($MtCO_2$)[11]	3.5	3.3	4.1	4.1	6.3	6.7	7.4
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-16**	**16-17**	**17-18**	**18-19**
TES	5.4	3.9	-0.5	-1.2	4.4	-3.4	-1.1
Coal	10.5	3.3	-8.0	9.4	13.4	-16.5	-53.6
Peat	-	-	-	-	-	-	-
Oil	4.5	3.3	-2.5	-3.6	1.0	-4.9	5.6
Natural gas	-	-	8.2	-0.6	25.3	-7.2	5.2
Biofuels and waste[1]	8.3	1.1	1.4	-0.5	0.2	-0.0	4.1
Nuclear	-	-	-	-	-	-	-
Hydro	1.3	2.2	3.6	-0.4	-62.5	110.3	-28.9
Wind	-	-	49.7	5.2	-1.9	3.0	8.3
Geothermal	-	37.0	10.0	-2.2	25.9	6.5	-6.6
Solar/other[2]	-	5.6	13.4	15.5	8.8	4.6	17.1
TFC	5.1	3.8	-0.2	-2.6	1.8	-1.6	3.7
Electricity consumption	6.4	5.0	2.7	-1.2	0.5	2.8	-0.2
Energy production	5.3	1.3	4.2	0.6	-13.0	12.1	0.4
Net oil imports	4.6	3.1	-2.7	-3.4	2.9	-0.5	-1.7
GDP	3.2	2.9	0.7	-0.4	3.5	2.6	2.2
TES/GDP	2.1	1.0	-1.2	-0.9	0.9	-5.9	-3.1
TFC/GDP	1.9	0.8	-0.9	-2.3	-1.6	-4.2	1.6

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 and wave.

3 In addition to coal, oil, natural gas and electricity, total net imports also include biofuels and waste.

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 and co-generation 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 10% for geothermal and 100% for hydro, wind and solar photovoltaic.

10 Toe per thousand US dollars at 2015 prices and exchange rates.

11 "CO_2 emissions from fuel combustion" have been estimated using the 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 "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 hydropower, 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 Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, 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

AdC	Competition Authority
ADENE	National Energy Agency
ANI	National Innovation Agency
ARCE	energy consumption rationalisation agreement
BEV	battery electric vehicle
CCGT	combined cycle gas turbine
CCUS	carbon capture, utilisation and storage
CoLAB	collaborative laboratory
CSP	concentrated solar power
DGEEC	Directorate-General for Statistics of Education and Science
DGEG	Directorate-General for Energy and Geology
DSO	distribution system operator
EC	European Commission
EDP	Energias de Portugal
EED	Energy Efficiency Directive
EEF	Energy Efficiency Fund
EEO	energy efficiency obligation
EERA	European Energy Research Alliance
EN-H2	National Hydrogen Strategy
ENEI	National Strategy for Research and Innovation for Intelligent Specialization 2014-2020
ENS	energy not supplied
ENSE	National Entity for the Energy Sector
EPBD	Energy Performance Buildings Directive
EPC	energy performance contract
ERSE	Energy Services Regulatory Authority
ESD	Effort Sharing Decision
ESCO	energy services company
ESR	Effort Sharing Regulation
ETS	Emissions Trading System
EU	European Union
EUR	euro
EV	electric vehicle

FAI	Innovation Support Fund
FCT	Foundation for Science and Technology
FEC	final energy consumption
FIT	feed-in tariff
FITEC	Innovation, Technology Transfer and Circular Economy Fund
GDP	gross domestic product
GGND	Galp Gás Natural Distribuição
GHG	greenhouse gas
IEA	International Energy Agency
IFD	Financial Institution for Development
IFRRU	Financial Instrument for Urban Renovation and Revitalisation
IMO	International Maritime Organisation
INESC	Institute for Systems and Computer Engineering, Technology and Science
IPCTN	National Scientific and Technological Potential Survey
ISP	tax on energy products
ISV	motor vehicle tax
IUC	single road tax
LNEC	National Civil Engineering Laboratory
LNEG	National Laboratory of Energy and Geology
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
NECP	National Energy and Climate Plan
NESO	National Emergency Strategy Organisation
NIP	National Investment Plan
NIR	National Inventory Report
NZEB	nearly zero-energy building
NZEB_LAB	Research Infrastructure on Integration of Solar Energy Systems in Buildings
OECD	Organisation for Economic Co-operation and Development
OLMC	Logistics Operator for Switching Suppliers
OMIP	Operator of the Iberic Energy Market
PDIRGN	plan for the transport network, storage infrastructure and LNG terminal
PEC	primary energy consumption
PEF	primary energy factor
PERIN	Portugal in Europe Research and Innovation Network
PHEV	plug-in hybrid electric vehicle
POSEUR	Programme for Sustainability and Efficient Use of Resources
PPEC	Portuguese Electricity Demand-Side Efficiency Promotion Plan
PPP	purchasing power parity
PRCE	energy consumption rationalisation plan
PREn	energy consumption rationalisation plan

PS	Socialist Party
PSD	Social Democratic Party
PTO	power take-off
PV	photovoltaic
RD&D	research, development and demonstration
RED	Renewable Energy Directive
REE	Red Eléctrica de España
REN	Redes Energéticas Nacionais
REP	execution and progress report
RGCEST	Management of Energy Consumption for the Transport Sector Scheme
RI	research infrastructure
RMSA	Security of Supply Monitoring Report
RNC2050	Roadmap for Carbon Neutrality 2020
SAIDI	system average interruption duration index
SAIFI	system average interruption frequency index
SCE	National Buildings Energy Performance Certification System
SGCIE	System for Management of Intensive Energy Demand
SIFIDE	System of Tax Incentives for Business RD&D
SusCity	Urban Data Driven Models for Creative and Resourceful Urban Transitions project
TERRE	Trans European Replacement Reserves Exchange
TES	total energy supply
TFC	total final consumption
TFEC	total final energy consumption
TIC	technological interface centre
TPES	total primary energy supply
TRC	network capacity reserve title
TSO	transmission system operator
UNFCCC	United Nations Framework Convention on Climate Change
UPP	network capacity reserve title
VAT	value-added tax
VRE	variable renewable energy
VTP	virtual trading point

Units of measure

bcm	billion cubic metres
cm	cubic metre
cm/y	cubic metre per year
g CO_2	gramme of carbon dioxide
GJ	gigajoule
GW	gigawatt

GWh	gigawatt hour
kb/d	thousand barrels per day
kg CO_2	kilogramme of carbon dioxide
ktoe	kilotonne of oil equivalent
kW	kilowatt
kWh	kilowatt hour
kV	kilovolt
kVa	kilovolt-ampere
m^2	square metre
mb	million barrels
mcm	million cubic metres
MJ	megajoule
Mt CO_2	million tonne of carbon dioxide
Mt CO_2-eq	million tonne of carbon dioxide equivalent
Mtoe	million tonne of oil equivalent
MW	megawatt
MWh	megawatt hour
MVA	mega-volt ampere
PJ	petajoule
toe	tonne of oil equivalent
TWh	terawatt hour

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Energy Policy Review

The IEA regularly conducts peer reviews of the energy policies of its member countries. This process supports energy policy development and encourages the exchange of best practices and experiences to help drive secure and affordable energy transitions.

Portugal's energy and climate policies push for carbon neutrality, primarily through broad electrification of energy demand and a rapid expansion of renewable electricity generation, along with increased energy efficiency. There is a strong focus on reducing energy import dependency and maintaining affordable access to energy. In the longer-term Portugal is aiming for hydrogen to play a major role in achieving carbon neutrality.

Portugal has made notable progress on decarbonising electricity generation and on electrification of building energy demand, however, the country's energy mix is still dominated by fossil fuels. The transport, industry and buildings sectors all have considerable work ahead of them to meet Portugal's targets for increasing the share of renewables, lowering energy demand and reducing emissions. In this report, the IEA provides a range of energy policy recommendations to help Portugal smoothly manage the transition to an efficient and flexible carbon-neutral energy system.