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Portugal's energy security in the context of moving away from fossil fuels

ABSTRACT: Portugal is a country on the Iberian Peninsula with a population of just over 10 million people.

The country has no reserves of energy resources such as oil, natural gas, or coal and is therefore dependent on their imports. Nevertheless, it has no problems ensuring energy security. It imports oil from countries such as Brazil, Nigeria, Saudi Arabia and Angola, and gas from Algeria, Nigeria, the United States of America and Qatar. All imports of crude oil and most imports of petroleum products pass through the two main ports of Sines and Leixões, while gas is imported via the Sines LNG terminal and two cross-border gas pipelines at Campo Maior and Valença do Minho. Coal imports are no longer a problem following the closure of the last coal-fired power plant in 2021. As recently as 2019, fossil fuels accounted for as much as 76% of Portugal's total primary energy supply, with oil accounting for 43%, but the majority of this demand was consumed by road transport (51%), followed by oil-based industries (16%) and household heating (5%). Now, however, the situation is changing. Hydropower and rapidly developing wind and solar energy account for a large share of electricity generation. By 2030, Portugal plans to commission between 600 and 900 MW of new solar capacity annually. Energy security in Portugal is the responsibility of the government and the relevant ministries. As in many other European countries, there is a clear drive towards decarbonization and measures are being taken to ensure that this process takes place as soon as

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possible, as is explicitly stated in Portuguese government documents. The analysis presented in this article shows that Portugal, despite lacking significant energy resources, can guarantee its energy security at a high level.

KEYWORDS: energy policy, energy security, energy sources

Introduction

Portugal is a country on the Iberian Peninsula with a population of just over 10 million people. The country has no reserves of energy resources such as oil, natural gas, or coal and is therefore dependent on their imports. Despite efforts to switch to renewable energy, fossil fuels still accounted for as much as 76% of Portugal's total primary energy supply in 2019. Oil accounted for 43%, but most of this demand related to road transport (51%), followed by oil-based industries (16%) and household heating (5%). According to the IEA (International Energy Agency) report, Portugal's dependence on energy imports in 2019 was 74% (Portugal 2021).

As for the consumption of primary energy carriers in 2021, the share of fossil fuels in the total supply decreased to 67%, i.e. by 10 percentage points. This is a major shift showing how determined Portugal is to move towards renewable energy and thus become independent of energy imports.

Figure 1 shows primary energy consumption by source in 2021.

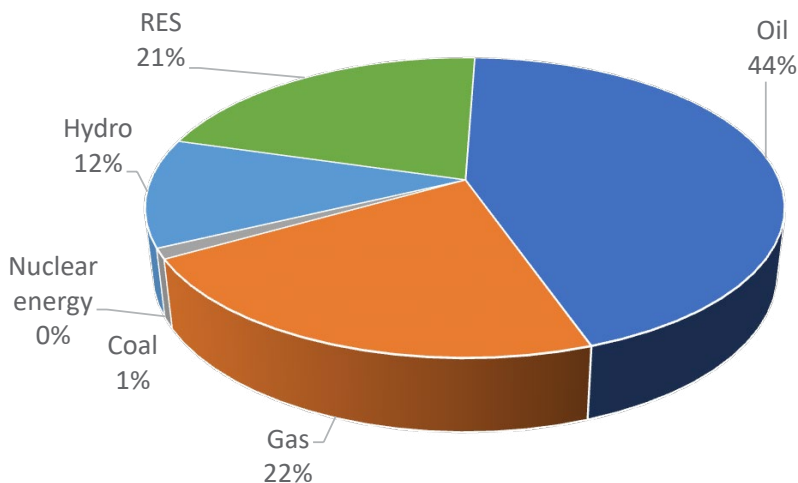


Fig. 1. Primary energy consumption by source in 2021
Source: own work based on (BP 2022)

Rys. 1. Zużycie energii pierwotnej według źródła w 2021 r.

Portugal's energy policy, including energy security and the environment, is the responsibility of the Ministry of Environment and Energy Transition (Ministério do Ambiente e da Transição Energética). Its main tasks include caring for the environment, implementing energy transition and environmental policy, as well as urban planning, suburban and road passenger transport, climate, nature and energy conservation (portugal.gov.pt 2023). The ministry prepared a document in 2019 called the Roadmap to Carbon Neutrality by 2050 (RNC2050 2019), which is a long-term low greenhouse gas emission development strategy envisaged by the Paris Agreement. To answer the question of how Portugal currently ensures its energy security and how it will do so in the future, it is necessary to focus on the individual sectors of the Portuguese energy sector.

1. Crude oil security

Crude oil accounts for the largest share of primary energy consumption. This raw material is mainly used in road transport, but also, in small quantities, in industry, the service sector, and the household sector to generate heat and electricity, as well as in agriculture, forestry, and fishing.

While crude oil is entirely imported from abroad, the majority of petroleum products are produced domestically by the country's refineries. Oil is imported through two ports, Sines and Leixões. These ports are directly connected to refineries, which greatly facilitates the transport of crude oil. The port of Sines supplies crude oil to the refinery of the same name, while the port of Leixões supplies crude oil to the port of Matosinhos. The former has a higher capacity of 17 Mt, while the latter has a capacity of 7.7 Mt (Portugal Oil Security Policy 2022). It is worth mentioning that the Sines refinery is one of the largest refineries on the Iberian Peninsula. Petroleum products are also exported and imported through other smaller ports in Aveiro, Lisbon, Setubal, the Azores, and Madeira. Since 2012, exports of petroleum products have exceeded imports. Two pipelines, which have no cross-border connections, are used to transport petroleum products. The main pipeline is a 147 km pipeline connecting the refinery in Sines with the oil depots in Aveiras in the center of the country. This pipeline is managed by the company – Companhia Logística de Combustíveis, s.a. (CLC 2023). Figure 2 shows oil consumption in Portugal from 1965 to 2021.

Portugal's oil consumption increased steadily from the mid-nineteen-sixties until 2002 when it peaked at 16.3 million tons. After a slight decline, back in 2005, consumption reached 16.2 million tonnes, slightly less than in the record year 2002, but from then on, it began to decrease sharply until 2012. This was due to the economic crisis, which prevented Portugal from developing properly for many years. Then, however, Portugal signed an agreement with the International Monetary Fund (IMF) and the European Union and received 78 billion euros for reforms. In return for the loan, Portugal embarked on a severe austerity program, which included cuts of several percent in public wages, increases in most taxes, and the successive sale of state holdings, mainly in energy, transport, and postal companies. Around 180,000 people lost their

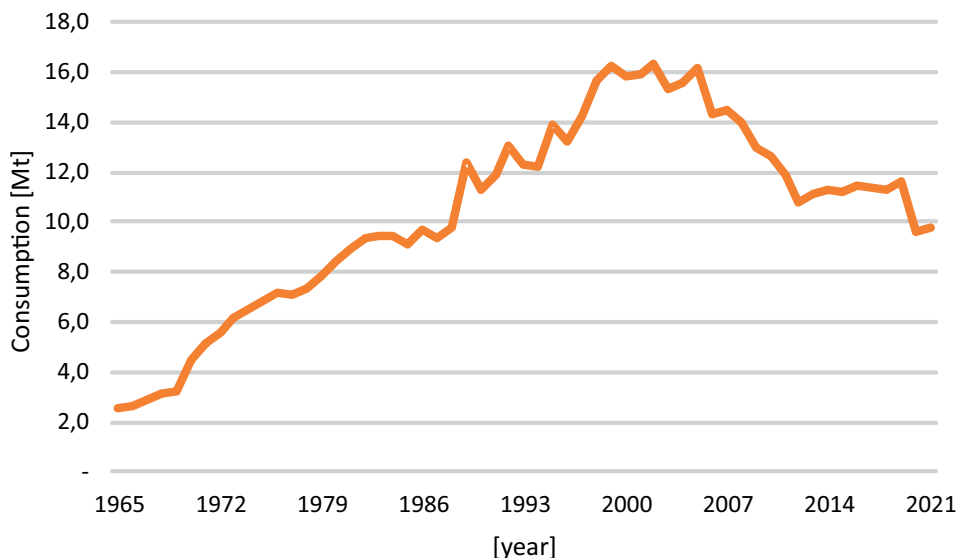


Fig. 2. Oil consumption
 Source: own work based on (BP 2022)

Rys. 2. Zużycie ropy naftowej

jobs as a result of the reforms (Zatyka 2015). After several years of stabilization of crude oil consumption, there was another decrease in 2019 caused by the COVID-19 pandemic.

Oil imports are highly diversified. Portugal imports this raw material from several countries, the largest recent contributors being Brazil, Nigeria, Saudi Arabia, Angola, Norway, Equatorial Guinea, Azerbaijan, and the USA.

To ensure energy security, Portugal has many crude oil storage facilities with a total capacity of approximately 273.61 m³, the largest of which are located at the Sines refineries – 117.31 m³ and Matosinhos – 72.78 m³. The remaining storage sites are located in different parts of the country on the mainland and in the autonomous regions of the Azores and Madeira (Portugal Oil Security Policy 2022).

In the event of an energy crisis, the Minister of Environment and Climate Action authorizes the use of reserves after consultation with the Prime Minister and the Council of Ministers.

2. Natural gas security

Natural gas is the second source of primary energy in Portugal after oil. Figure 3 shows natural gas consumption in Portugal in the years 1965–2021.

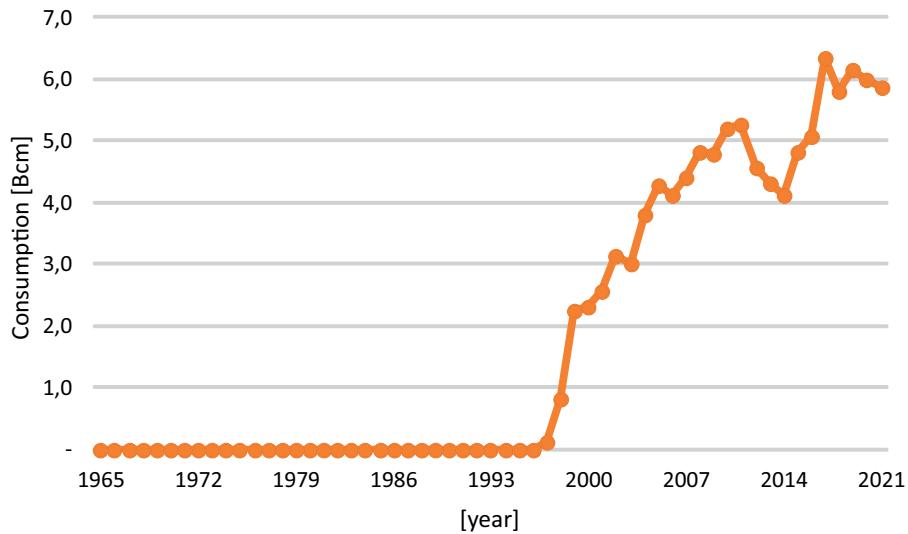


Fig. 3. Consumption of natural gas
 Source: own work based on (BP 2022)

Rys. 3. Zużycie gazu ziemnego

As can be seen from the figure, natural gas has only been used in Portugal since 1997. Since Portugal does not have its gas resources, all gas is imported from abroad. Natural gas is supplied to Portugal through the LNG terminal located in the port of Sines and the two cross-border pipeline connections at Campo Maior and Valença do Minho. It is mainly used for heat and electricity production, as well as in industry and the household sector, services and transport ([Portugal Natural Gas Security Policy 2022](#)). The natural gas transmission network is operated by the national transmission system operator REN Gasodutos and has 1,375 km of high-pressure gas pipelines. The distribution network has a total length of 19,100 km and includes medium and low-pressure pipelines. There are eleven private distribution system operators in Portugal; however, Galp Gás Natural Distribuição (GGND) owns or has a controlling stake in nine of them and covers the majority of the country's gas needs.

The only LNG terminal in Portugal is the LNG terminal in Sines, the construction of which was completed in September 2012. The terminal can receive gas from large tankers with a capacity of up to 215,000 m³. The first delivery of liquefied natural gas took place in the spring of 2013. This was a delivery of 74,000 m³ (after regasification) of natural gas from Algeria ([netTG.pl 2022a](#)). Currently, the LNG terminal in Sines meets 89% of the Portuguese demand ([ren.pl 2023](#)). Natural gas is mainly imported from Algeria, Nigeria, the USA, Russia and Qatar. In 2021, 98% of imports were liquefied natural gas (LNG), compared to only 33% in 2015 ([National Energy Balance 2022](#)). For natural gas energy security, Portugal has two large Carriço UGS gas storage facilities and an LNG storage facility at the Sines terminal with a total capacity of 600 million m³. The Carriço underground gas storage facility consists of six salt caverns and

the storage at the Sines terminal has three storage tanks. Figure 4 shows the storage tanks at the Sines terminal.



Fig. 4. LNG terminal in Sines

Source: REN (ren.pl 2023)

Rys. 4. Terminal LNG w Sines

The security of the natural gas supply in Portugal is the responsibility of the government through the Directorate General of Energy and Geology (DGEG) and the Portuguese National Emergency Strategy Organisation (NESO). The Hydrogen Strategy, adopted in August 2020, states that by 2050, most of the demand for gas will be met by renewable sources, such as low-carbon hydrogen.

3. Bituminous coal security

Portugal, like almost all European countries, used coal to generate electricity. In November 2021, a groundbreaking change took place. The last coal-fired power plant, Pego, located in Abrantes, was shut down. Earlier in January 2021, the Sines coal-fired power plant was shut down. Thus, Portugal joined Belgium, Austria, and Sweden, which have completely abandoned the use of coal for electricity generation (netTG.pl 2022b). The Pego power plant was the most modern coal-fired power plant operating on the Iberian Peninsula. It had two generating units, each equipped with a steam generator, one turbine-generator unit, and a main transformer. Under

Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants, significant investments have been made to minimize air pollutant emissions from the Pego thermal power plant. Nevertheless, the discussed power plant has been closed. Work is currently underway to adapt the plant to burn either natural gas or wood pellets (tejoenergia.com 2022).

Figure 5 shows the consumption of bituminous coal in Portugal from 1965 to 2021.

As can be seen from the figure, the current consumption of coal in Portugal is negligible.

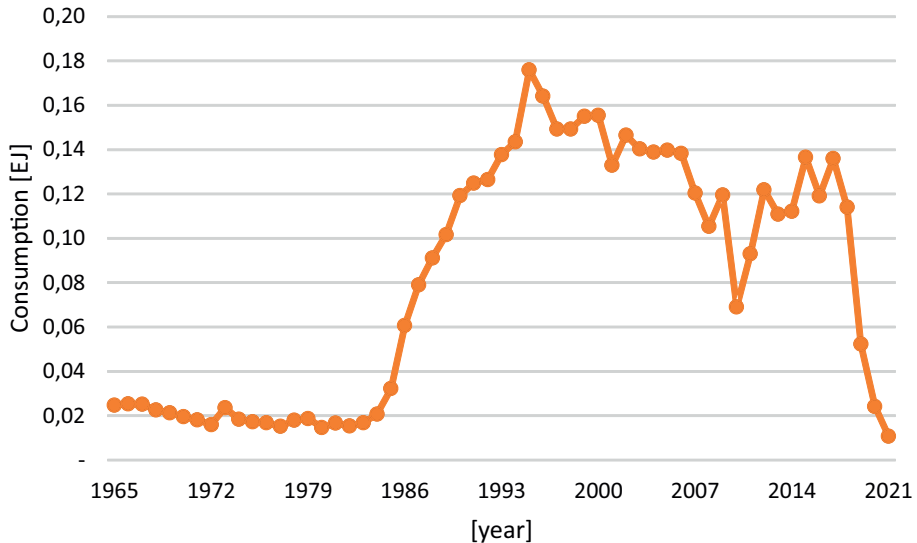


Fig. 5. Bituminous coal consumption
 Source: own work based on (BP 2022)

Rys. 5. Zużycie węgla kamiennego

4. Electricity generation security

The energy sector in Portugal, as in other countries around the world, is a fundamental sector that allows the economy to function at a socially acceptable level and is essential for modern society to function.

The energy sector in Portugal consists of three subsectors (portugalenergia.pt 2023):

- ◆ the electricity sector,
- ◆ the natural gas sector,
- ◆ the oil sector.

Each of these sectors consists of three regulatory entities:

- ◆ ERSE – the *Energy Services Regulatory Authority*,
- ◆ DGEG – the *Directorate General of Energy and Geology*,
- ◆ ENSE – the *National Entity for the Energy Sector*.

Portugal generates about 50 TWh of electricity annually. As recently as the nineteen-eighties, Portugal was one of Europe's poorer countries, with a GDP *per capita* of less than \$3,000. After joining the European community in 1986, Portugal's economy began to grow rapidly, and by the early nineteen-nineties, GDP *per capita* exceeded \$10,000. The Portuguese economy accelerated again at the beginning of the current century, where GDP grew very rapidly and in 2008, reached its peak of almost \$25,000 *per capita* ([macrotrends.net](https://www.macrotrends.net) 2023). Economic development required increased electricity generation, as shown in Figure 6. It can be seen that in the mid-nineteen-eighties, electricity production was less than 20 TWh, and just twelve years later, it exceeded 30 TWh. Another rapid increase in production took place in 2008–2010, by as much as 8.1 TWh, and the highest-ever production was recorded in 2016, when it reached 60.3 TWh.

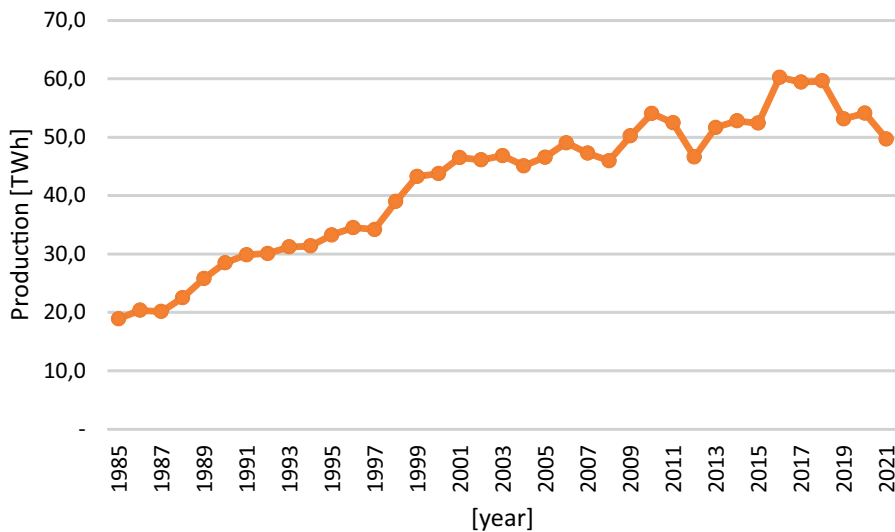


Fig. 6. Electricity production
 Source: own work based on (BP 2022)

Rys. 6. Produkcja energii elektrycznej

Today, after the closure of the last coal-fired power plants in Sines and Pego, the Portuguese power system generates 39% of its electricity from natural gas and the remaining 61% from renewable energy sources (2021 figures), the most important of which are wind, photovoltaics, hydropower, and biomass ([IEA](https://www.iea.org) 2022).

The electricity consumption is lower than production and is illustrated in Figure 7.

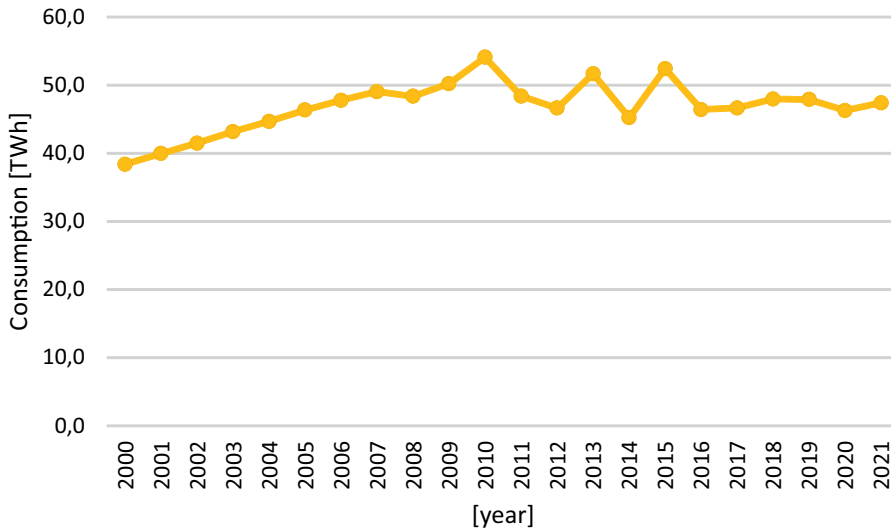


Fig. 7. Electricity consumption

Source: own work based on IEA 2022 (IEA 2022)

Rys. 7. Zużycie energii elektrycznej

Since around 2006, electricity consumption has remained at around 50 TWh. The share of renewable energy sources in electricity production and consumption has been increasing year by year.

To show a complete picture of the electricity balance, electricity exports and imports must also be taken into account (Fig. 8). Portugal has imported more electricity in the twenty-first century than it has exported. The situation was different only between 2016 and 2018 when exports exceeded imports. In the last year analyzed, 2021, imports exceeded exports by 2.7 TWh.

The energy balance still needs to take into account losses, which had different values in different years, ranging from about 3.18 TWh in 2007 to 5.50 TWh in 2013 (IEA 2022).

5. Renewable energy

Renewable energy in Portugal has always played a significant role in the national economy, but in recent years, it has become particularly important with the move away from fossil fuels.

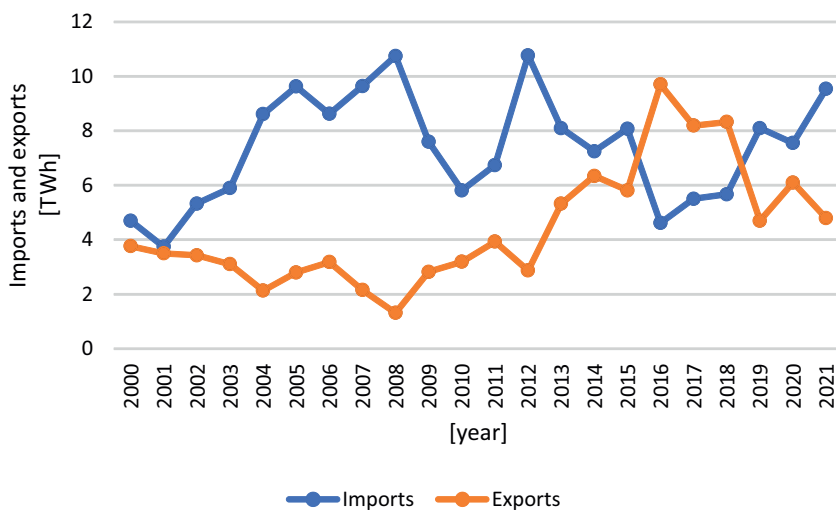


Fig. 8. Electricity imports and exports
 Source: own work based on (IEA 2022)

Rys. 8. Import i eksport energii elektrycznej

Figure 9 shows the installed capacity of renewable energy sources (RES) from 2011 to 2020.

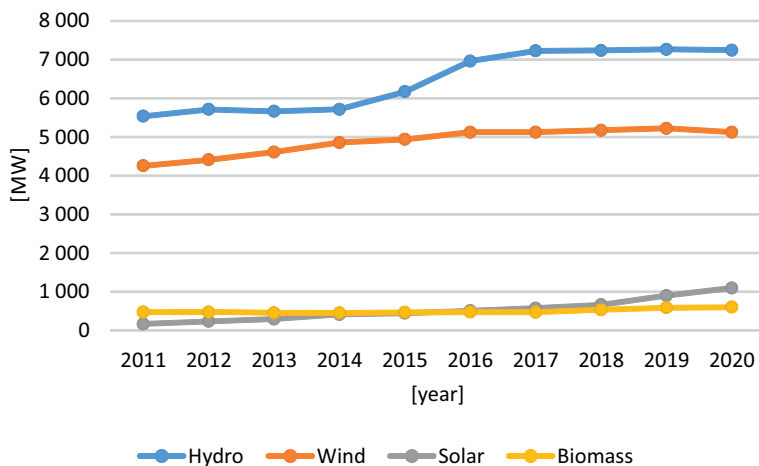


Fig. 9. Capacity installed in RES in the years 2011–2020
 Source: own work based on (Eurostat 2022)

Rys. 9. Moc zainstalowana w OZE w latach 2011–2020

When analyzing renewable energy (RES) in Portugal, special attention should be paid to hydropower. This type of energy has the most installed capacity in the country, ahead of other types such as wind energy, photovoltaics, or biomass.

Portugal currently has about 120 small hydropower plants, i.e., those with a capacity of less than 10 MW, with a total installed capacity of about 370 MW. Power plants with an installed capacity of 10–30 MW, of which there are fifteen, have a total installed capacity exceeding 660 MW, while the capacity of thirty-eight large hydropower plants, above 30 MW, exceeds 6,000 MW (Hidroerg 2023). The terrain and water resources are the reasons why most of the small hydropower plants are located in the northern part of the country and this is the location of the most promising areas for further investments.

When it comes to wind power, Portugal has an installed capacity of more than 5 GW, but it mainly uses onshore wind power as it only has 25 MW of installed capacity offshore and only recently, as it only had 8 MW in 2019, with the remaining capacity installed in 2020 (IRENA 2022).

In the case of photovoltaics, in 2021 the installed capacity reached 1.6 GW, which is 10.8% of the total installed RES capacity. About 40% of the installed photovoltaic capacity accounts for decentralized installations (Energy in Numbers 2022).

Of other renewables, Portugal has just 75 MW of installed capacity in biogas and 29 MW in geothermal energy (IRENA 2022). The main biomass sources used in Portugal include wood and plant waste from forestry and agriculture, wood pellets, and others. It is estimated that approximately 55% of biomass is used for domestic consumption and services, and the remaining 45% is used to produce electricity and heat (Sarilho 2023).

Figure 10 shows the production of renewable energy in Portugal in 2021. Wind power accounts for the largest share of this production at 13.2 TWh, with other types of energy being of far less importance.

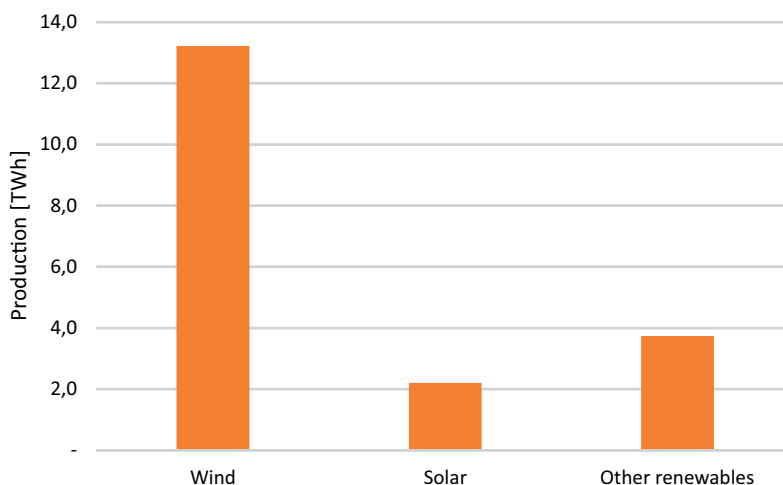


Fig. 10. Electricity production from RES in 2021

* Includes electricity generated from geothermal, biomass and other sources of renewable energy (not yet itemized)

Source: own work based on (BP 2022)

Rys. 10. Produkcja energii elektrycznej z OZE w 2021 roku

The low share of hydropower in electricity production may come as a surprise, despite the largest capacity installed in water turbines. However, the low production is related to the huge droughts that have been affecting the country in recent years. This problem affects not only Portugal but also other European countries experiencing unprecedentedly high temperatures and long periods without rainfall.

6. Plans for the future

In 2020, the National Energy and Climate Plan 2030 (PNEC 2030) was adopted by the Council of Ministers. This document sets out the objectives of the national climate and energy policy. The PNEC 2030 sets new national targets for reducing greenhouse gas emissions, including sectoral targets that take into account renewable energy and energy efficiency, as well as courses of action and measures to be taken for decarbonization and the energy transition. It contains fifty-eight lines of action and 206 measures to achieve its objectives and includes measures relating to the internal energy market and energy security. Some objectives have already been achieved, such as the closure of the last coal-fired power plants in Pego and Sines. It also envisages increasing the use of renewable sources, including doubling the capacity of photovoltaic installations. Other measures include the promotion of power auctions as well as the use of hydrogen. Also noteworthy is the commitment to the development of electromobility.

Specific goals adopted in the National Energy and Climate Plan 2021–2030 (NECP 2030) Portugal, December 2019) include (NECP 2030):

- ◆ decarbonization of the national economy;
- ◆ improvement of energy efficiency;
- ◆ increasing the share of renewable energy and reducing the country's energy dependency;
- ◆ ensuring the security of supplies;
- ◆ promoting sustainable mobility;
- ◆ promoting sustainable agriculture and forestry and promoting carbon capture and storage;
- ◆ developing an innovative and competitive industry;
- ◆ ensuring a fair, democratic, and coherent transition.

As can be seen, these goals are consistent with the energy policy of the European Union and international treaties aimed at eliminating fossil fuels from the energy sector and at broadly understood environmental protection.

Conclusions

Portugal, like many other European countries, is aiming to achieve climate neutrality as soon as possible. To achieve this, it is developing renewable energy and increasing energy efficiency. The development of RES aims to not only improve the environment but also, perhaps most importantly, to make the country independent of imports of energy resources which Portugal does not have. The main document influencing Portugal's energy policymaking is the National Energy and Climate Plan. It is the main tool of the National Climate and Energy Policy for 2021–2030, aimed at achieving carbon neutrality in the future.

As its contribution to the global and European goals set under the Paris Agreement, Portugal has committed to becoming climate neutral by 2050. Achieving this goal requires a reduction in greenhouse gas emissions of more than 85% compared to 2005 emissions and a carbon sequestration capacity of thirteen million tons. The projected costs of the energy transition in Portugal are expected to amount to EUR 25 billion by 2030. During this time, i.e. by 2030, Portugal aims to achieve a 47% share of renewable energy in final energy consumption and 20% of renewable energy in transport (Directorate-General for Energy and Geology 2023). As in many other European countries, there is a clear drive towards decarbonization and measures are being taken to ensure that this decarbonization happens as soon as possible, as is explicitly stated in Portuguese government documents. As part of shaping the energy policy, it is envisaged to, among other aims, achieve the following objectives: reduce carbon dioxide emissions; improve energy efficiency; implement investments in the field of hydrogen, including hydrogen refueling stations; increase the production of solar and wind energy; promote the storage of electricity generated from renewable sources; implement interconnection systems; promote the production of synthetic biofuels including green ammonia and methanol; use biomethane produced from biomass, wastewater, or sewage sludge; implement the long-term building retrofit strategy adopted in 2021, which includes an action plan with indicative measures and targets for 2030, 2040 and 2050, and the national long-term energy poverty strategy for 2021–2050.

The analysis presented above shows that Portugal, despite the lack of significant resources of energy resources, can guarantee itself a high level of energy security. This security is based on an increasing year-on-year share of renewable energy sources making it possible to reduce fuel imports and thus reduce its energy dependence, and if such imports are necessary, diversified supplies from various sources are guaranteed.

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Tadeusz OLKUSKI

Bezpieczeństwo energetyczne Portugalii w kontekście odchodzenia od paliw kopalnych

Streszczenie

Portugalia jest krajem położonym na Półwyspie Iberyjskim o liczbie mieszkańców nieznacznie przekraczającej 10 milionów. Nie posiada zasobów surowców energetycznych takich jak: ropa naftowa, gaz ziemny, czy też węgiel i dlatego całkowicie jest uzależniona od ich importu. Niemniej jednak kraj ten nie ma problemów z zapewnieniem bezpieczeństwa energetycznego. Ropę naftową sprowadza z takich krajów jak: Brazylia, Nigeria, Arabia Saudyjska czy Angola, a gaz z Algierii, Nigerii, Stanów Zjednoczonych Ameryki Północnej oraz z Kataru. Cały import ropy naftowej i większość importu produktów naftowych przechodzi przez dwa główne porty: Sines i Leixões, natomiast gaz sprowadzany jest przez terminal LNG Sines oraz dwa transgraniczne gazociągi Campo Maior i Valença do Minho. Import węgla przestał być problemem po zamknięciu w 2021 roku ostatniej elektrowni węglowej. Jeszcze w 2019 r. paliwa kopalne stanowiły aż 76% całkowitej podaży energii pierwotnej w Portugalii, w tym na ropę naftową przypadało 43%, ale większość tego zapotrzebowania zużywał transport drogowy (51%), następnie przemysł oparty na ropie (16%) i ogrzewanie budynków (5%). Teraz jednak sytuacja się zmienia. Duży udział w produkcji energii elektrycznej stanowi energetyka wodna oraz coraz szybciej rozwijana energetyka wiatrowa i słoneczna. Do 2030 roku Portugalia planuje oddawanie rocznie do eksploatacji od 600 do 900 MW nowych mocy w energetyce słonecznej. Za bezpieczeństwo energetyczne w Portugalii odpowiada rząd za pośrednictwem odpowiednich ministerstw. Tak jak i w wielu innych krajach europejskich widać wyraźnie, co zresztą jest zapisane wprost w portugalskich dokumentach rządowych, dążenie do dekarbonizacji i podejmowanie takich działań, aby ta dekarbonizacja nastąpiła jak najszybciej. Z przedstawionych w artykule analiz wynika, że Portugalia, pomimo braku znaczących zasobów surowców energetycznych, jest w stanie zagwarantować sobie bezpieczeństwo energetyczne na wysokim poziomie.

SŁOWA KLUCZOWE: polityka energetyczna, bezpieczeństwo energetyczne, surowce energetyczne

