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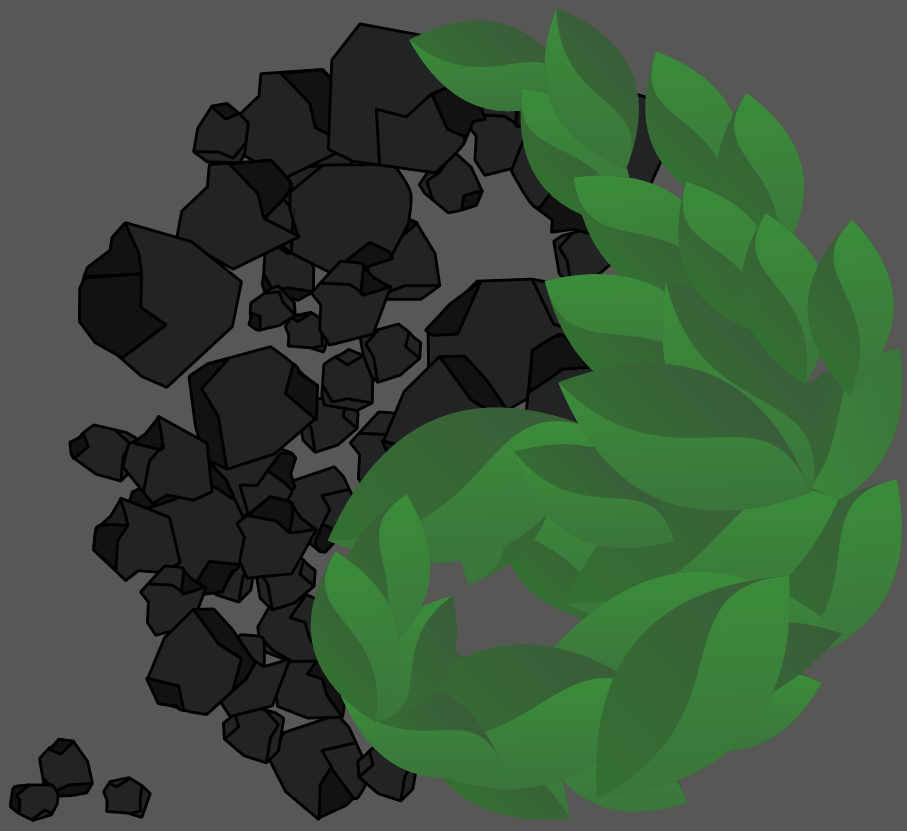

Time for decarbonisation

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Key findings

- **The achievement by EU Member States of climate neutrality by 2050 poses to them a challenge of a varying scale.** It is illustrated by the Energy Transition Index (ETI), incorporating both the starting level of each country and its ability to pursue an ambitious climate policy. Among the 115 countries covered by the ETI, the EU Member States rank between 1st and 77th. Despite the differentiation, as few as three Member States of the EU decided to achieve climate neutrality early: Finland (by 2035), Austria (by 2040) and Sweden (by 2045), whereas Denmark, France and the Netherlands, in spite of their high ranks, plan to achieve the neutrality goal within the same time limit as countries ranked significantly lower.
- **The EU's leaders in the ETI ranking tend to have a high share of hydropower or nuclear power (sometimes both) in the energy production structure, considerably above the proportion of fossil fuels.** In Sweden and Finland, the most important component in the gross electricity production structure[1] is nuclear power. The lie of the land in Austria and Sweden allows them to satisfy much of their energy demand through hydroelectric power plants. As an exception among the leaders, Denmark uses none of the above-mentioned sources; instead, it relies on wind energy.
- **The scale of the challenge posed by the achievement of climate neutrality is defined not only by energy indicators, but also by those reflecting the economic and social development levels.** The low ranks of Bulgaria, Poland and the Czech Republic in ETI ranking (77th, 75th and 49th respectively) result not only from high shares of coal in the energy production structure (thus – high emission intensities), but also from poor flexibility of their energy systems and insufficient stability of business development conditions.
- **By combining the Energy Transition Index data for all the EU Member States and their times for achieving climate neutrality, it is possible to calculate that Poland would be able to attain this objective by 2056.** However, in the version assuming that by 2050 climate neutrality would only be achieved by countries with comprehensive strategies published, the estimated date for Poland would be 2067. Although it seems possible for Poland to achieve climate neutrality by 2050[2], the date currently set for 23 countries fails to reflect their potential.
- **In addition, observations of ETI developments are confirmed by the Energy Trilemma Index prepared by the World Energy Council** and composed of three indicators: Energy Security, Environmental Sustainability and Energy Equity. According to the ranking based on the above-mentioned index, 8 out of the 10 best performers are also in the top 10 in the ETI ranking; those are Western European countries. The advantage of the index over the ETI is the time series allowing to follow transition developments since 2000. In certain index categories, Central and Eastern European countries have made significant progress - for example, Poland stands out in the category of the Environmental Sustainability.
- **In Western Europe, Germany and the United Kingdom were once characterised by shares of fossil fuels similar to**

those currently noted by Central and Eastern European countries. Over nearly 50 years, the two countries have made significant progress in departing from a coal-based economy, due to the use of transitional sources – nuclear energy and gas. Their relatively high income per inhabitant also allowed them to obtain consumer acceptance of higher transition costs reflected in higher energy prices.

The report in numbers

2050	by that year, the EU is supposed to become a climate-neutral continent
2056	the estimated year of Poland's achieving climate neutrality on the basis of the neutrality declaration of all the EU Member States contained in the European Green Deal and their Energy Transition Index scores
2067	the estimated year of Poland's achieving climate neutrality on the basis of neutrality declarations of some of the EU Member States contained in their national strategies and their Energy Transition Index scores
3 Member States of the European Union	(FI, SE, AU) have committed to achieving climate neutrality before 2050
6 Member States of the EU	(SE, FI, DK, AU, FR, NL) are among the top ten performers in the Energy Transition Index ranking that covers 115 countries worldwide
75th and 77th	the respective ranks of Poland and Bulgaria, the lowest in the Energy Transition Index ranking among all the EU Member States

8 out of the 10 countries

with the highest scores in terms of the Energy Trilemma Index prepared by the World Energy Council are also among the top ten performers according to the WEF ranking

53rd and 54th

the respective ranks of Poland and Cyprus among the 128 countries covered by the Energy Trilemma Index prepared by the World Energy Council, the lowest in the group of EU Member States

50 years

the duration of the United Kingdom's efforts to reduce its coal output by 99 per cent to 3 million tonnes by 2018

Introduction

The achievement of net climate neutrality by 2050 is the primary long-term goal of the European Union. In practice, it means that is it necessary to reduce greenhouse gas emissions to the amount absorbed by forests across the EU.

The EU's climate neutrality is central to the European Green Deal – a strategy adopted in December 2019 by the new European Commission. The document is another step where the EU specifies its earlier commitments, initially made under the Paris Agreement negotiated between the parties to the climate convention in 2015. The Agreement was intended to lead to holding the increase in the global average temperature to well below 2 °C (optimally, even below 1.5 °C). Those commitments were developed into policy measures during the previous terms of office of the Commission (in 2018) and the European Parliament (in 2019).

For the EU to meet this ambitious challenge, it is necessary to depart from the current ways of economic and social functioning. To that end, the European Green Deal proposes to limit the use of resources while maintaining economic growth and protecting the well-being of citizens and the most vulnerable regions.

This report focusses on describing the differentiation of Member States in picking up the gauntlet. To this end, it relies on one of the most comprehensive energy transition indicators (the Energy Transition Index – ETI) prepared by the World Economic Forum. The ETI compares 115 countries worldwide, including all the EU Member States, in terms of characteristics of their current energy systems and their transition capacities. The index is not reduced to greenhouse gas emissions or even a broader group of energy indicators. It incorporates the resilience of the economy to accelerating the transition as well as society's ability to meet the challenge.

The differences between EU Member States are compared to their declared times for achieving climate neutrality. By the time of the publication of this report, efforts to achieve the neutrality objective earlier have been declared by 3 out of the 27 Member States – Finland, Austria and Sweden. It is largely consistent with their leading positions in the ETI ranking. Poland is the only Member State to have postponed taking the decision on achieving the 2050 goal until June 2020; its position in the ETI ranking is among the lowest as well. The other Member States, despite their varying ranks, have adopted 2050 as the binding deadline.

Our analysis aims to determine the degree to which the differentiation between Member States affects their ability to attain the climate neutrality objective. To this end, Chapter 1 simulates the year of the potential achievement by Poland of climate neutrality, taking account of the circumstances of the three European leaders and the other Member States of the EU. Chapter 2 describes in more detail the situation of the best and the worst performers in the ETI ranking. Chapter 3 supplements the information on energy transition with another comprehensive indicator – the Energy Trilemma Index prepared by the World Energy Council (WEC). Lastly, Chapter 4 presents historical aspects of the energy transition in two selected countries whose experiences may be of interest in discussions on the future transition in Central and Eastern European countries. he transfer of knowledge acquired in the process of expansion abroad, specifically with regard to technology, *know-how* and knowledge about the functioning of foreign markets as well as to innovation.

↘ **Infographic 1.** Greenhouse gas emissions per inhabitant in 2017 and the decarbonisation year as declared by EU Member States

Source: prepared on the basis of the Eurostat database and BBC (2019); Morgan (2019); Government Offices of Sweden (2019).

Calculations of the time for decarbonisation for Poland

This chapter presents the idea behind the creation by the World Economic Forum (WEF) of the Energy Transition Index (ETI) and – based on ETI scores for EU Member States – attempts to estimate the time necessary for Poland to achieve climate neutrality. It mostly relies on the 2019 edition of the report (WEF, 2019). We performed the calculations in two versions with different initial assumptions

STRUCTURE OF THE ENERGY TRANSITION INDEX (ETI)

When the plan to transform the EU into the first zero-carbon economy by 2050 was announced in 2019 the Member States were at different transition stages and faced challenges of varying difficulty. The differentiation between countries can be illustrated with the Energy Transition Index created by the World Economic Forum. The authors of the ETI covered 115 countries worldwide (including all the EU Member States) and compared 40 indicators aggregated at three levels, answering two essential questions:

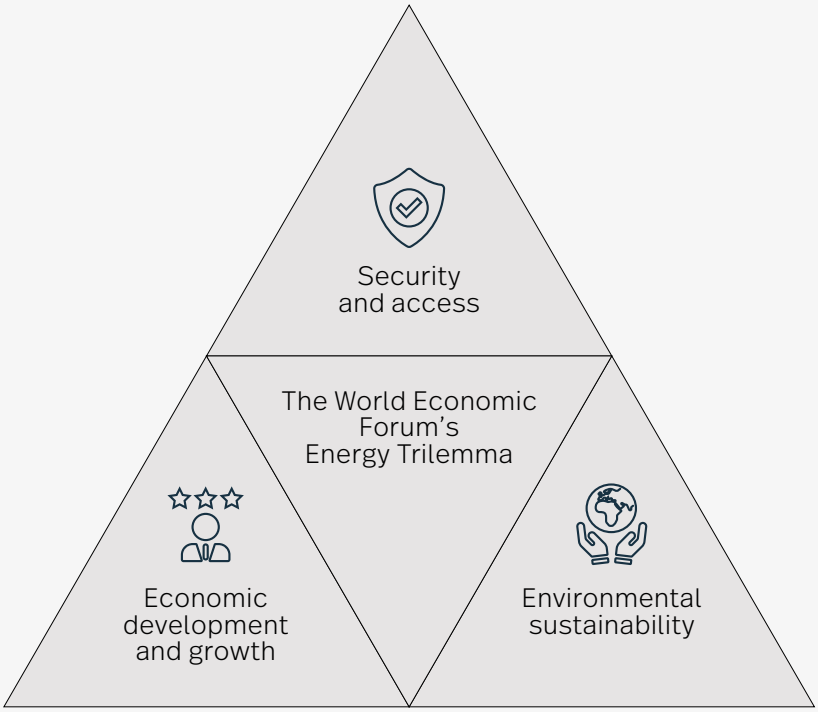
1. What is the current level of achieving the energy policy objectives (system performance)?
2. To what degree will the energy policy environment be conducive to the achievement of the energy transition goals (transition readiness)?

The answer to the first question was analysed in the 'energy triangle' dimensions. The triangle includes security and access, environmental sustainability as well as economic development and growth.

The answer to the second question was examined on the basis of six elements: the energy system structure, capital and investment, regulation and political commitment, human capital and consumer participation, infrastructure and innovative business environment as well as institutions and governance.

The Energy Transition Index does not only include the energy production structure, but also the socio-economic potential for reducing emissions from the energy sector. However, as shown by practice, those processes are clearly interrelated, whereas energy security, human capital or the innovative business environment are indispensable toachieving climate neutrality in the long term.

↘ **Infographic 2.** Energy Trilemma



Source: prepared by the PEI.

METHODOLOGY

The calculations of the time for decarbonisation for Poland are based on the ETI scores for particular EU Member States and take account of the climate neutrality years declared by the countries concerned. In the case of 23 Member States, it is 2050, whereas three countries – Finland, Austria and Sweden – declared efforts to attain that level of performance by 2035, 2040 and 2045 respectively. At the first stage of work, we calculated the annual average change in ETI scores on the basis of differences between the times for decarbonisation declared by EU Member States. The method was chosen due to the lack of a time series illustrating changes in the ETI scores and its components in subsequent years (the ETI preparation methodology was significantly modified in 2019). The calculations were performed at the following stages:

1. The calculation of the annual average change in the ETI score ('step') for each of the three countries having declared earlier achievement of neutrality, in accordance with the following formula:

$$K_i = \frac{x_i - \bar{a}}{2050 - b_i}$$

where:

K_i – the annual average change in the ETI score (step) for country i,
x_i – the ETI score for country i,
$\bar{a}$ – the average ETI score for the 23 EU Member States having declared the achievement of neutrality by 2050,
b_i – the year of declared neutrality for country i,
$i = A, F, S$ – the ETI score for Austria, Finland and Sweden.

2. The mean of annual average changes in the ETI scores for Austria, Finland and Sweden:

$$\bar{K} = \frac{K_S + K_A + K_F}{3}$$

where:

K_S – the step for Sweden,
K_A – the step for Austria,
K_F – the step for Finland.

3. The calculation of the ETI score for each of the 23 EU Member States (excluding Austria, Finland and Sweden, serving as the benchmark) in the year of declared achievement of climate neutrality, in accordance with the following formula:

$$ETI_{i,D} = ETI_{2019} + (D - 2019) * K$$

where:

$ETI_{i,D}$ – the ETI score for each of the 23 EU Member States,
ETI_{2019} – the ETI score for the country concerned in 2019,
D – the declared year of decarbonisation for country i.

followed by the calculation of the mean of the $ETI_{i,D}$ scores for the 23 EU Member States (excluding Poland, Finland, Austria and Sweden). The mean score cannot exceed 100. It results from the fact that normalised base indicators incorporated into the aggregate ETI cannot exceed 100, thus their weighted average cannot be higher than 100 either. However, it is possible that climate neutrality will be achieved with several of the disaggregates below 100, therefore – with the overall ETI also lower than 100.

4. The calculation of the average ETI score for the achievement of climate neutrality by Poland, in accordance with the following formula:

$$Year_{PL} = 2019 + \frac{(\overline{ETI}_{i,D} - ETI_{PL\_2019})}{\bar{K}}$$

where:

$\overline{ETI}_{i,D}$ – the average ETI score to be obtained by the other 23 EU Member States in 2050,
ETI_{PL_2019} – the ETI score for Poland in 2019.

We calculated the year of Poland's achieving climate neutrality in two versions: **(a)** taking into consideration the ETI scores for all the EU Member States (EU-23), excluding data used for calculating the annual average changes in the ETI scores for Austria, Finland and Sweden,

(b) only taking account of the countries with comprehensive climate neutrality strategies published, i.e.: Sweden, Finland, Austria, Germany, France, Denmark, Portugal, Belgium, Ireland and Latvia (as in the first version, data concerning Sweden, Finland and Austria were only used for the calculation of the annual average changes in the ETI scores). The calculation results – the time of the achievement of climate neutrality by Poland.

The simulation presented below combines data on the scores obtained by particular countries in the ETI ranking with the times for achieving climate neutrality declared by the leaders (Sweden, Finland, Austria) and by the other 23 EU Member States. We used the findings to conclude on the possible time for Poland to achieve the neutrality objective.

After the calculation methodology modifications, the Energy Transition Index is only available for 2019 at the time of the simulation. Neither does the WEF provide any historical data, which significantly limits the possibility to carry out analyses of the evolution of particular countries or to create more advanced functions. As a result, the calculated average simulated change in the ETI scores for EU Member States is a linear function.

At the time of achieving climate neutrality, the estimated ETI score for all the 23 Member States (apart from Poland – which chose not to declare the achievement of climate neutrality by a specific year – and Sweden, Austria i Finland) is 100[3]. It means that the annual average change in the ETI score in those countries is 1.32. On the basis of the above calculations, we estimate that Poland is able to achieve climate neutrality by the end of 2056.

The version of calculations performed on the basis of the main components of the ETI – system performance and transition readiness – produces similar results. Considering the current system performance, the predicted year of the achievement by Poland of climate neutrality is the second half of 2059. As regards transition readiness, neutrality could be achieved by 2055.

Not all the Member States that agreed on the objective of climate neutrality by 2050 subsequently published comprehensive implementation strategies. Therefore, calculations were also performed in another version, solely taking account of the Member States which based their neutrality commitments not only on the Council decision, but also on comprehensive strategies for attaining that objective. The group includes the following: Sweden, Denmark, Austria, Finland, Germany, France, Portugal, Belgium, Ireland and Latvia.

Those Member States lead the ETI ranking (with only Belgium and Latvia ranked outside the top twenty, 22nd and 23rd respectively). The annual average change in the ETI scores for those countries is 0.84, whereas the average overall ETI score at the time of achieving climate neutrality – 91.8. In this version of calculations, Poland would achieve climate neutrality much later – as late as the second half of 2066.

In the calculations based on the main ETI components – system performance and transition readiness – we obtain similar results. Considering the current system performance, the predicted year of the achievement by Poland of climate neutrality is estimated at 2067. As regards transition readiness, climate neutrality could be achieved by 2068.

↘ Table 1. **Predicted year of the achievement by Poland of climate neutrality depending on the version of calculations and the index under analysis**

	Version of calculations covering all the EU Member States			Version of calculations only covering Member States with comprehensive transition strategies		
	ETI	Transition Readiness	System Performance	ETI	Transition Readiness	System Performance
Predicted year of achieving climate neutrality	2056.9	2055	2059.6	2067.9	2068.4	2067.2

Source: prepared by the PEI on the basis of WEF data.

The Energy Transition Index (ETI) in selected countries

This chapter discusses the structure of energy production processes in countries standing out in the ETI ranking. Focussing on the European Union, we analyse the Member States ranked as the first four and the last four. We describe their energy production structures (with regard to both elec-tricity and primary energy) and the determinants of a country's rank. In the case of the leaders, we also discuss their strategies for achieving zero emissions. Finally, the chapter presents an analysis of selected non-European countries leading the ETI ranking and compares them with EU Member States.

THE EU'S VANGUARD AND REARGUARD

Poland's ETI score is significantly lower than those obtained by most Member States of the EU. In 2019, it was 51.4, ranking Poland last but one in the EU. The lowest-ranking Member State, with a score of 50.95, was Bulgaria. The highest scores characterised Scandinavian countries – Sweden, Finland and Denmark (Chart 1).

↘ Chart 1. ETI scores of EU Member States in 2019

Source: WEF (2019).

Among the top 20 performers in the ETI ranking, 16 are European countries, including 12 European Union Member States, of which 10 belong to the so-called 'old' EU (in addition, the EU Member States ranked in the top twenty also included Lithuania and Estonia). Only 4 non-European countries obtained similarly favourable scores in terms of energy transition (Uruguay, Singapore, New Zealand and Japan).

Sweden

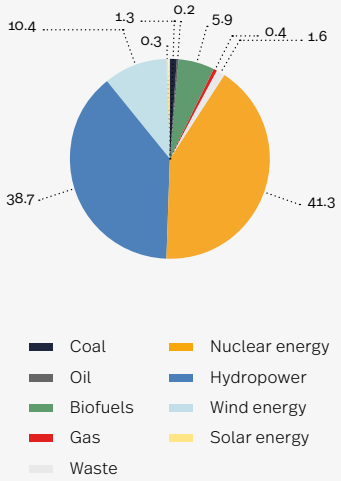
The energy sector in Sweden is largely based on nuclear energy (35 per cent of total primary energy in 2018), biofuels and waste (25 per cent) as well as on crude oil (20 per cent). Hydropower contributes as well, accounting for 11 per cent of total primary energy.

Electricity production is mainly based on nuclear energy (66 TWh) and hydropower (62 TWh). The two sources combined supply 80 per cent of Sweden's total electricity output (Chart 2). That energy production structure ranks Sweden among the EU Member States characterised by the lowest carbon intensity (approx. 13 g of CO_2/kWh, compared to the EU average of nearly 300 g of CO_2/kWh in 2016).

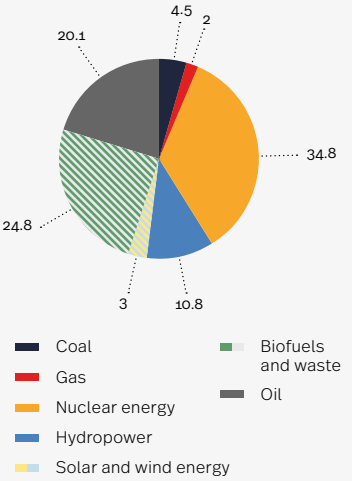
Sweden is regarded as one of the most active supporters of rapid reduction in greenhouse gas emissions. It is one of the three Member States of the European Union having voluntarily declared early achievement of climate neutrality. Despite the favourable energy production structure ensuring low emissions, Sweden is characterised by high energy consumption *per capita* (over 5,100 kg of oil equivalent *per capita*, with the EU average at 3,207 kg in 2015), which is typical of advanced economies.

In terms of the overall ETI score, Sweden ranks the highest in the EU and tops the ranking as well. However, Sweden's system performance is assessed more favourably than its transition readiness, although the country continues to lead the way in both dimensions – ranked 2nd and 5th respectively. At a more disaggregated level, Sweden is among the world's leaders in categories such as the credit rating (the best possible rating in addition to 9 other countries), the level of airborne PM2.5 (the top performer with 5.2 mg/m^2) or energy efficiency investment. It performs worse in areas such as energy supply *per capita* or electricity system flexibility (measured as a percentage of electricity from hydro, gas and oil), ranked 97th and 82nd respectively.

↘ Chart 2. Electricity production in Sweden by source in 2018 (in per cent)



↘ Chart 3. Primary energy supply in Sweden by source in 2018 (in per cent)



Source: prepared by the PEI on the basis of IEA data.

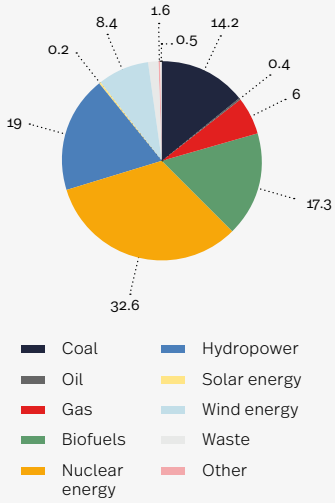
In 2017, Sweden adopted a statutory act obliging subsequent governments to achieve climate neutrality by 2045. Under its provisions, the government must present annual climate reports in the budget act and update the climate strategy every 4 years (The Swedish climate policy framework, 2020). In order to achieve CO_2 neutrality, Sweden needs to cut its emissions by a minimum of 85 per cent on the 1990 level, which is predicted to mean less than one tonne of CO_2 emissions *per capita* (it was 3.8 tonnes *per capita* in 2017).

Finland

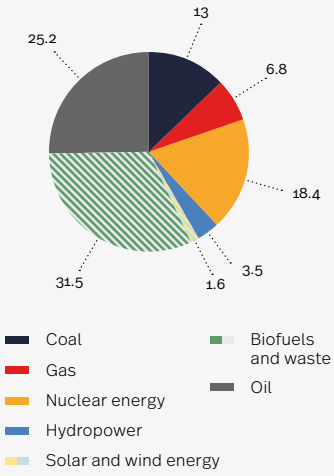
As in the case of Sweden, Finland significantly relies on nuclear energy (33 per cent in 2018) and hydropower (19 per cent). Biofuels and coal contribute as well (17 per cent and 14 per cent respectively). Although most of the Finnish energy sector is based on renewables and nuclear energy, the substantial share of biofuels may be problematic – particularly in the context of significant deforestation which continues in the country in question.

Half of primary energy is produced from biofuels and waste (31 per cent) and from oil (25 per cent) (Chart 5). Other major contributors are nuclear energy (18 per cent), coal (13 per cent) and gas (7 per cent).

↘ Chart 4. Electricity production in Finland by source in 2018 (in per cent)



↘ Chart 5. Primary energy supply in Finland by source in 2018 (in per cent)



Source: prepared by the PEI on the basis of IEA data.

At the same time, despite very ambitious plans to rapidly achieve climate neutrality (2035), Finland has a higher emission intensity of the energy sector than Sweden (112.8 g of CO_2/kWh in 2016). However, it is still less than half of the EU average. Finland is also characterised by high energy consumption *per capita* (5.925 kg of oil equivalent *per capita*).

Finland has the fourth ETI score, as the second-best performer in the EU. In spite of being ranked 11th in terms of system performance, Finland tops the ranking with regard to transition readiness. At a higher level of disaggregation, Finland leads the way in categories such as energy efficiency investment (0.29 per cent of total investment, among the 26 best countries), education quality (3rd place) or jobs in low-carbon industries (related to renewables) (0.1 per cent of all jobs, ranked 5th). Finland's weakness is energy consumption *per capita*; given a higher emission intensity than in Sweden, it also results in substantial CO_2 emissions per inhabitant (8.3 tonnes in 2017, the 95th position in the ranking).

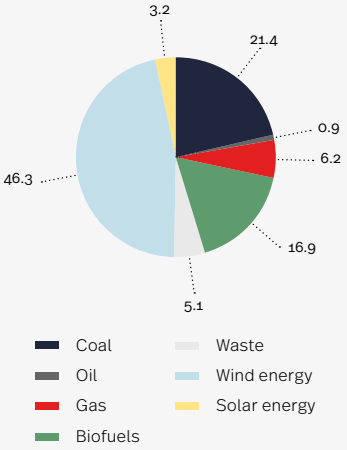
In order to achieve climate neutrality by 2035, Finland intends to take broad measures, including the phasing out of coal by May 2029. One element of Finland's strategy is a tax reform providing for additional tax relief for offshore wind farms. Simultaneously, the plan is to eliminate the system of tax allowances concerning electricity for industry. In addition, Finland intends reducing deforestation accompanied by launching afforestation programmes and limiting the carbon footprint of construction by introducing special schemes of subsidies aimed to improve energy efficiency and to cut emissions from heating to zero (Finnish Government, 2020).

Denmark

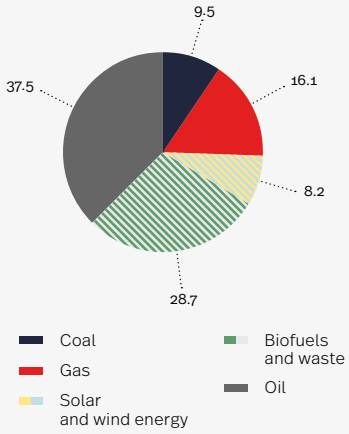
The most important role in electricity production in Denmark is played by wind farms (46 per cent), still significantly complemented by coal-fired power plants (21 per cent) and – as in the case of Sweden and Finland – biofuels (17 per cent).

Primary energy supply still relies on crude oil (38 per cent), followed by biofuels (29 per cent) and gas (16 per cent) (Chart 7). Denmark made significant progress with regard to the emission intensity of its energy sector – whereas in 2007 the emission intensity slightly exceeded 400 g of CO_2/kWh, in 2016 it dropped to 166 g of CO_2/kWh. It allowed Denmark to reduce its emission intensity to nearly half of the EU-28 average. Although its emission intensity continues to be higher than for the other leaders, the country was characterised by the most rapid changes from 1990 (Chart 8).

↘ **Chart 6. Electricity production in Denmark by source in 2018 (in per cent)**



↘ **Chart 7. Primary energy supply in Denmark by source in 2018 (in per cent)**

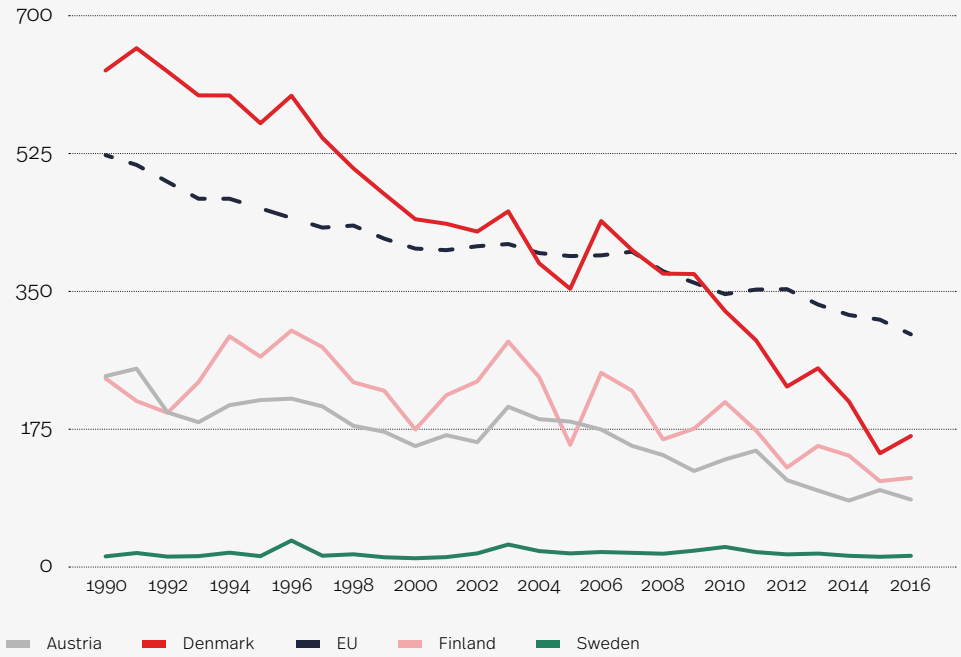


Source: prepared by the PEI on the basis of IEA data.

As in the case of Finland, Denmark is ranked lower (12th) in terms of system performance, still obtaining a high (the 2nd best in the world) score for transition readiness. As a result, it ranks 5th worldwide and 3rd in the EU in terms of the overall ETI score. In addition to Sweden, it is among the top 10 countries with the highest credit ratings. At the same time, it allocates a major percentage of investment to energy efficiency and ranks high in terms of transparency (2nd) and investment freedom (3rd).

The lowest scores for the Danish system concern high electricity prices for industry (102th)[4] and for households (69th). The final rank of the country is also driven down by high energy supply *per capita* and low electricity system flexibility.

↘ Chart 8. **The leaders' emission intensities as compared to the EU average in 1990–2016 (in g of CO_2/kWh)**



Note: the 'EU' in the legend of the chart refers to the average emission intensity for the European Union Member States in the year concerned.

Source: prepared by the PEI on the basis of the European Environment Agency data.

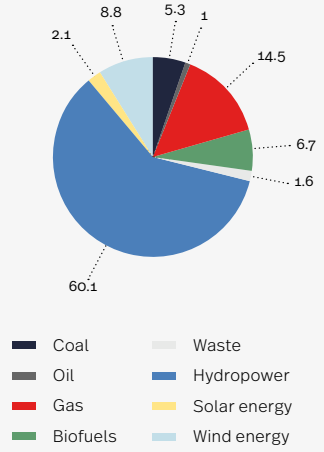
The Danish plan for achieving climate neutrality provides for reducing greenhouse gas emissions by 70 per cent by 2030 (against 1990) and full emission neutrality by 2050. The measures planned comprise a ban on selling vehicles with petrol or diesel engines after 2030, launching afforestation programmes and building the first 'energy island'[5]. The intention is to increase the share of renewable energy sources to 54 per cent (in the case of electricity – to 109[6] per cent, heating and cooling – to 60 per cent, transport – to 19 per cent) and the elimination of coal by 2030. (Klima-, Energi- og Forsyningsministeriet, 2019).

Austria

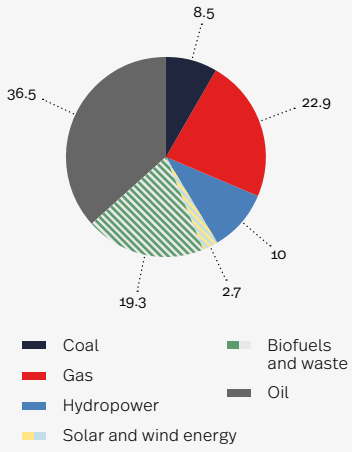
Austria is ranked 4th in the European Union and 6th worldwide; it is also the third EU Member States to have decided to endeavour to achieve energy neutrality early (by 2040). It mostly satisfies its demand for electricity production thanks to hydropower (60 per cent); other sources include gas (14 per cent) and wind energy (9 per cent). Therefore, Austria is distinguished by a lower emission intensity in comparison with Denmark or Finland (85.1 g of CO_2/kWh in 2016), less than one-third of the EU average.

Oil accounts for the highest share in primary energy supply (36 per cent), followed by gas (23 per cent), biofuels and waste (19 per cent) as well as by hydropower (approx. 10 per cent).

↘ Chart 9. Electricity production in Austria by source in 2018 (in per cent)



↘ Chart 10. Primary energy supply in Austria by source in 2018 (in per cent)



Source: prepared by the PEI on the basis of IEA data.

As in the case of Denmark and Finland, in terms of transition readiness Austria is ranked much higher (3rd) than for system performance (17th place). The country's high rank is due to energy efficiency investment (0.29 per cent of investment in 2016); it also obtained very high scores in investment freedom (2nd, e.g. next to Denmark) and logistics performance. It ranks worse in categories such as net energy imports (87th), energy supply *per capita* (90th) or CO_2 emissions *per capita* (which results from high consumption despite a relatively low emission intensity measured in grams of CO_2 per kWh).

In January 2020, the Austrian government announced that under an agreement with the Green Party it declared changing the time for achieving climate neutrality to 2040. According to preliminary announcements, by 2030 Austria is supposed to generate 100 per cent of its electricity from renewable sources, having eliminated any contribution from fossil fuels. The planned regulations are to affect industries such as air transport – especially domestic flights – which is expected to become

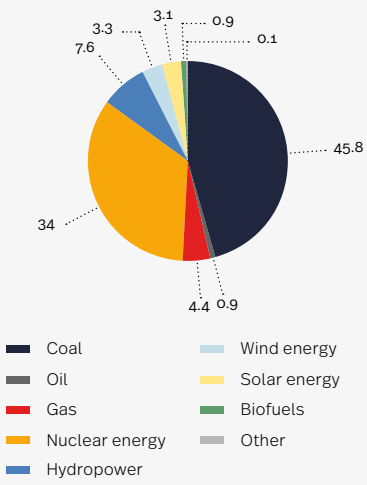
more expensive, thus encouraging the population to switch to other modes of transport, primarily the railways (Austria's New Government Sets Goal to Be Carbon Neutral by 2040 - EcoWatch, 2020).

Bulgaria

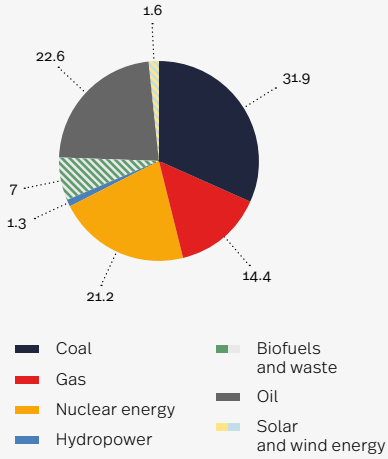
Among the European Union Member States, the lowest overall ETI score was noted by Bulgaria, ranked 77th out of the 115 countries covered. It was rated slightly higher in terms of transition readiness (71st place), but less favourably for system performance (82nd position in the ranking). It obtained the lowest scores for fossil fuel subsidies (112th place in the ranking), low electricity system flexibility (105th) and a major share of coal in the electricity production structure (99th). At the same time, it ranks high in areas such as the percentage of jobs in low-carbon industries (11th), renewable energy regulations or the diversity of total primary energy supply (TPES) measured by the Herfindahl index (10th).

Nearly half of electricity in Bulgaria is still produced from coal. Another vital source nuclear energy, accounting for 34 per cent of electricity supply in 2018. The most significant renewable energy sources encompass hydropower (8 per cent), wind (3 per cent) and solar energy (3 per cent as well).

↘ Chart 11. **Electricity production in Bulgaria by source in 2018 (in per cent)**



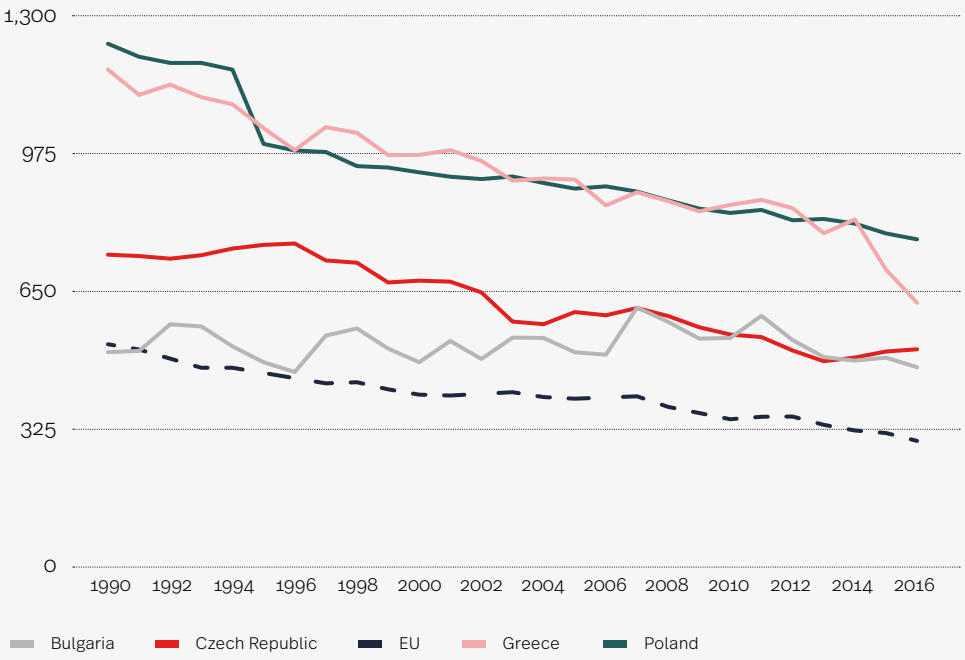
↘ Chart 12. **Primary energy supply in Bulgaria by source in 2018 (in per cent)**



Source: prepared by the PEI on the basis of IEA data.

In Bulgaria, 32 per cent of primary energy comes from coal, 23 per cent – from crude oil, 21 per cent – from nuclear power plants, whereas 14 per cent – from gas. In spite of its last position in the ETI ranking among the EU Member States, Bulgaria's emission intensity is below those of the other 'weakest' Member States discussed here, at approx. 470 g of CO_2/kWh (the EU average is less than 300 g of CO_2/kWh).

↘ Chart 13. **Emission intensities of the EU Member States with the lowest ETI scores as compared to the EU average in 1990–2016 (in g of CO_2/kWh)**



Note: the 'EU' in the legend of the chart refers to the average emission intensity for the European Union Member States in the year concerned.

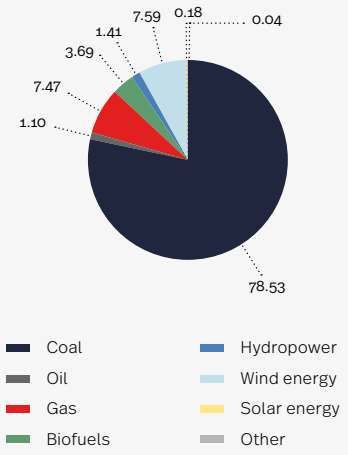
Source: prepared by the PEI on the basis of the European Environment Agency data.

Poland

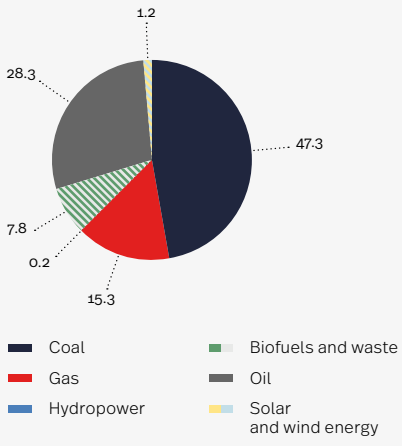
Ranked 75th, Poland is next to last in the ETI ranking among the EU Member States. In contrast to Bulgaria, it ranks higher in terms of system performance (71st) than with regard to transition readiness (78th). Poland obtained the highest scores for investing in energy efficiency (among the 26 best performers, 0.29 per cent of total investment), access to clean cooking fuels (among 32 countries with a share of 100 per cent) as well as high ranks in terms of investment freedom and logistics performance (23rd and 26th respectively). Poland is assessed the least favourably in categories such as the share of electricity from coal (112th place), electricity system flexibility (110th), policy stability for business (102th) and the emission intensity of primary energy measured in kg/GJ (108th).

Coal continue to account for a vast share of electricity supply in Poland. In 2018, coal-fired power plants produced 79 per cent of electricity. Other major electricity supply sources include wind energy (8 per cent), gas (7 per cent) and biofuels (4 per cent). Due to the dominant share of electricity from coal in Poland, its energy sector is characterised by the second highest emission intensity in the European Union (773 g of CO_2/kWh, against less than 300 g of CO_2/kWh in the EU). A higher emission intensity is only noted by Estonia (over 800 g of CO_2/kWh), which results from its high share of bituminous shale oil in electricity supply (73 per cent in 2018) (IEA, 2018).

↘ Chart 14. Electricity production in Poland by source in 2018 (in per cent)



↘ Chart 15. Primary energy supply in Poland by source in 2018 (in per cent)



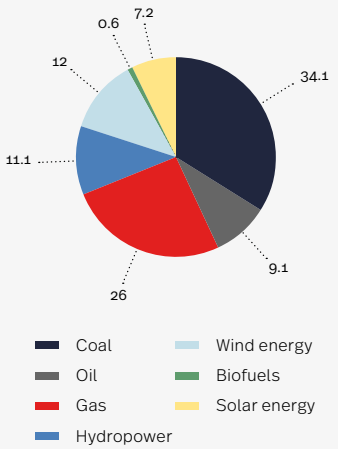
Source: prepared by the PEI on the basis of IEA data.

Nearly half, i.e. 47 per cent, of primary energy in the Polish economy comes from coal, another 28 per cent – from oil, 15 per cent – from gas, whereas 8 per cent – from biofuels and waste. Only 1 per cent of primary energy demand is met by wind and solar energy.

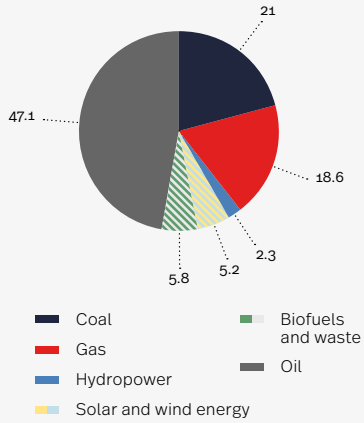
Greece

Occupying the 54th place in the ETI ranking, Greece ranks significantly higher than Poland and Bulgaria, but still 25th among the 27 European Union Member States. It is a country with one of the widest gaps between the scores for system performance (38th) and transition readiness (79th, i.e. below Bulgaria and Poland). Greece's strengths include a low PM2.5 concentration in the atmosphere (16th place in the ranking) and the diversity of energy imports measured by the Herfindahl index (29th position). A number of issues faced by Greece stem from its poor regulatory and political system: it ranks low in terms of rule of law (90th), innovative business environment (102th) or policy stability for business (114th, only ahead of Venezuela). Combined with a low credit rating (85th place) and high electricity prices for enterprises (99th position), those factors pose major obstacles on the road to energy neutrality.

↘ Chart 16. Electricity production in Greece by source in 2018 (in per cent)



↘ Chart 17. Primary energy supply in Greece by source in 2018 (in per cent)



Source: prepared by the PEI on the basis of IEA data.

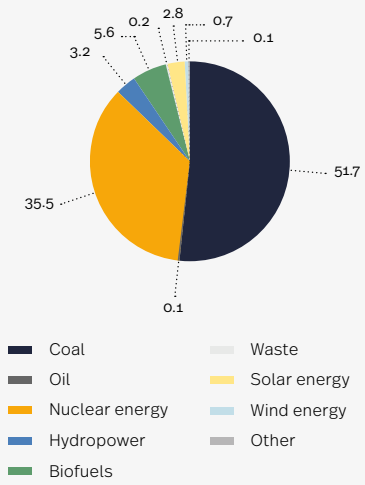
As in Poland and Bulgaria, in Greece coal accounts for the highest share of electricity production (34 per cent), followed by gas (24 per cent); shares of other energy sources are comparable: crude oil (9 per cent), wind energy (12 per cent), hydropower (11 per cent) and solar energy (7 per cent). Due to a rise in the proportions of gas and solar energy in the Greek structure of electricity production in 2013–2016, there was a considerable fall in the emission intensity – from over 800 g of CO_2/kWh to slightly above 600 g of CO_2/kWh (still more than double the EU average).

Nearly 90 per cent of primary energy in Greece comes from fossil fuels. The highest share, as much as 47 per cent, is that of crude oil, followed by major proportions of coal (21 per cent) and gas (19 per cent). RES account for 13 per cent of primary energy supply – 6 per cent comes from biofuels and waste, 5 per cent – from wind and solar energy, whereas 2 per cent – from hydropower.

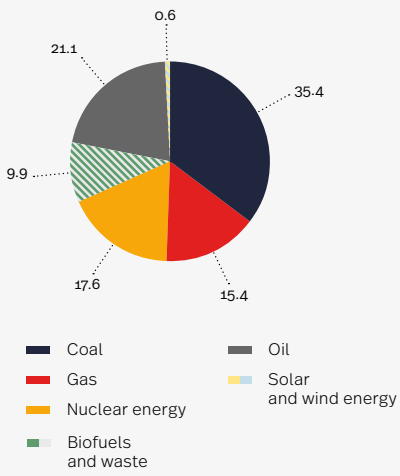
The Czech Republic

In the 49th place in the ETI ranking, simultaneously the Czech Republic ranks 24th among the European Union Member States. The country in question also shows a major discrepancy between its significantly higher rank in terms of transition readiness (38th) and that for system performance (62nd). The Czech Republic obtained high scores in areas such as the credit rating (22nd position), logistics performance (21st), renewable energy regulations (18th) and energy efficiency investment (among the 26 countries with the highest percentage of 0.29 per cent of total investment). The overall ETI rank is pushed down by a high share of coal in the energy mix (103th), low electricity system flexibility (111th) and a high CO_2 intensity – both in *per capita* terms (99th) and with regard to primary energy as measured in kg/GJ (89th).

↘ Chart 18. **Electricity production in the Czech Republic by source in 2018 (in per cent)**



↘ Chart 19. **Primary energy supply in the Czech Republic by source in 2018 (in per cent)**



Source: prepared by the PEI on the basis of IEA data.

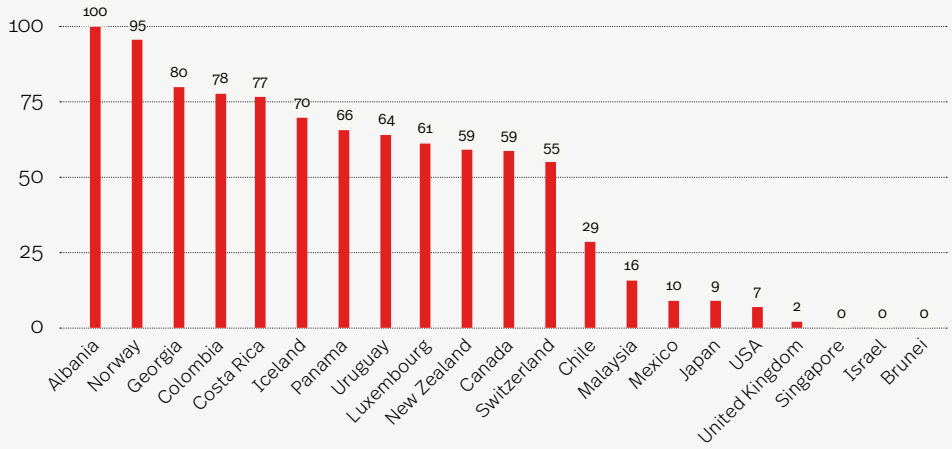
In 2016, the emission intensity of Czech electricity production was 512 g of CO_2/kWh. It primarily stemmed from a high share of electricity from coal (52 per cent). Other sources are dominated by nuclear energy (36 per cent). RES account for approx. 13 per cent of electricity production – 6 per cent comes from biofuels, hydropower and solar energy supply 3 per cent each, whereas wind farms generate 1 per cent of electricity.

In the Czech Republic 33 per cent of primary energy is supplied from coal, followed by crude oil (21 per cent), gas (15 per cent), nuclear energy (18 per cent), biofuels and waste (10 per cent).

NON-EU TRANSITION LEADERS

21 out of the top 40 countries in the ETI ranking are not European Union Member States. In as many as 12 out of the 21 non-EU countries, hydropower accounts for more than 50 per cent of electricity production. The highest shares are noted by Albania (100 per cent) and Norway (95 per cent). Among the 21 non-EU countries under analysis, only three have no hydroelectric power plants – those are Singapore, Israel and Brunei.

↘ Chart 20. **Share of hydropower in the energy mix of non-EU countries among the top 40 performers according to the ETI ranking (in per cent)**

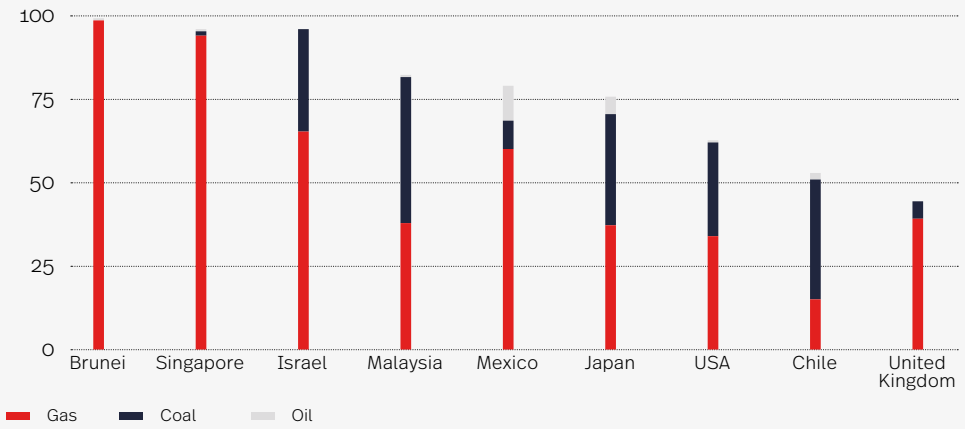


Source: as in Chart 2.

Hydropower plays a crucial role in two out of the four EU Member States leading the ETI ranking (Austria and Sweden), as well as in 4 out of the 5 non-EU countries in Europe (Switzerland, Norway, Iceland, Albania). The share of hydropower in the structure of electricity production results from the lie of the land in the countries concerned – abundant in mountains and rivers.

In 9 out of the 21 non-EU countries included in the top forty ETI performers, hydropower accounts for less than 50 per cent of electricity production. Among those, in Chile and Malaysia the share of hydropower exceeds 10 per cent (below 29 per cent and slightly above 16 per cent respectively). In each of the 9 countries, electricity production relies on fossil fuels (from slightly more than 40 per cent in the United Kingdom to 100 per cent in Brunei).

↘ Chart 21. Share of fossil fuels (oil, coal and gas) in the energy mix of selected non-EU countries from the top 40 in the ETI ranking (in per cent)



Source: as in Chart 2.

In each of the 9 countries discussed, gas plays a vital role in electricity production (from below 16 per cent in Chile to 95 per cent in Singapore and 99 per cent in Brunei). In 7 out of the 9 countries, its share exceeds that of coal (with the exception of Chile and Malaysia). Since gas is a fuel with almost half of the CO_2 intensity of coal (Juhrich, 2016), its high proportion in electricity production partly determines the inclusion of the countries concerned in the top forty in the ETI ranking.

These countries also share several other characteristics that determine their high ranking position. The majority are favourably evaluated in terms of regulation and political commitment to energy transition (ranks in the top thirty). Only Mexico and Brunei are ranked lower (42nd and 62nd respectively). They also obtained high scores for the stability and transparency of institutions and governance (with as few as three countries outside the top thirty – Malaysia (39th), Brunei (41st) and Mexico (52nd). Infrastructure and innovative business environments in most of the countries discussed are evaluated positively. Mexico and Brunei again are the exceptions that are ranked slightly lower, on the 52nd and 64th positions. However, both countries obtained very favourable scores for economic development: Mexico ranked 7th and Brunei – 15th.

Description of the Energy Trilemma Index prepared by the WEC

The World Energy Council (WEC) developed an Energy Trilemma Index based on three dimensions and aimed to illustrate the performance of a country's energy sector, as in the case of the WEF's Energy Transition Index. The Energy Trilemma Index prepared by the WEC is composed of Energy Security, Environmental Sustainability and Energy Equity. Its indicators allow to compare 128 countries and – based on such comparisons – take decisions on supporting specific energy transition areas. The Energy Trilemma Index of the WEC is based on 32 quantitative indicators from 59 databases of various institutions, e.g. the World Bank, the World Energy Forum and the International Energy Agency.

↘ Table 2. Core dimensions of the WEC's Energy Trilemma Index

Energy Security	Energy Equity	Environmental Sustainability
It reflects the ability of a country to meet its energy needs and to ensure the continuity of the energy system in crises.	It allows to assess universal access in the country concerned to affordable energy in wholesale and retail trade.	It describes the energy transition of a country orientated towards reducing adverse effects on the environment and climate change.

Source: prepared by the PEI on the basis of WEC data.

Eight out of the top ten performers in terms of the WEC's Energy Trilemma Index are also in top ten in the ETI ranking. The other two (Luxembourg and Germany) respectively occupy the 15th and 17th positions in the ETI ranking; Poland ranks 53rd with a score of 68.3 and with regard to the main components: 58 in Energy Security (70th place), 83 in Energy Equity (55th place) and 63 in Environmental Sustainability (58th place).

↘ Table 3. Top 10 countries with the highest scores according to the Energy Trilemma Index prepared by the WEC (in per cent)

The highest Energy Trilemma Index score	The final Energy Trilemma Index score	Country	Rank		
			Energy Security	Energy Equity	Environmental Sustainability
1	85.8	Switzerland	11	11	1
2	85.2	Sweden	1	40	3
3	84.7	Denmark	2	28	2
4	81.5	United Kingdom	28	19	6
5	81.1	Finland	3	33	28
6	80.8	France	27	29	4
7	80.7	Austria	18	22	16
8	80.4	Luxembourg	56	1	8
9	79.4	Germany	16	30	23
10	79.4	New Zealand	20	26	29

Source: WEC (2019).

↘ Table 4. Top 10 countries with the lowest scores according to the Energy Trilemma Index prepared by the WEC (in per cent)

The lowest Energy Trilemma Index scores	The final Energy Trilemma Index score	Country	Rank		
			Energy Security	Energy Equity	Environmental Sustainability
119	42.5	Tanzania	101	121	95
120	42.3	Ethiopia	116	120	91
121	42.2	Madagascar	80	125	77
122	41.4	Mozambique	103	123	83
123	40.7	Nigeria	62	119	126
124	39.1	Malawi	112	128	60
125	36.3	Benin	111	122	121
126	33.8	Chad	113	124	120
127	33.8	Congo (DRC)	121	126	100
128	30	Niger	106	127	127

Source: WEC (2019).

Among the top ten performers in the WEC's Energy Trilemma Index ranking, eight countries are European Union Member States. As a Member State, Poland ranks next to last, only ahead of Cyprus; the EU average is 76.3 per cent.

↘ Chart 22. The WEC's Energy Trilemma Index scores for EU Member States

Source: WEC (2019).

The Energy Trilemma Index prepared by the WEC allows to compare data since 2000. Changes in scores for each of its three main dimensions are expressed in per cent (in comparison with the 2000 baseline set as 100 per cent). Thus, it is possible to observe transition advancements in the countries covered for the past 20 years.

Among the countries under analysis, in 2019 Cambodia, Myanmar and the Dominican Republic showed the most significant increases – by as much as 30 to 40 per cent – in the WEC's Energy Trilemma Index scores from the 2000 levels. Such improvements were attained through growing electrification, energy generation diversity and infrastructure investment. As regards Energy Security, the most significant improvers were Malta (84 per cent), Jordan (70 per cent) and the Dominican Republic (61.7 per cent), thanks to measures such as increased supplier diversity and investment in enhancing grid stability. Energy Equity increased

the most in Cambodia (140 per cent), Nepal (131.3 per cent) and Myanmar (113.7 per cent). As regards Environmental Sustainability, the most successful countries were Poland (61.9 per cent) and China (57 per cent), tangibly decarbonising their economies in previous years.

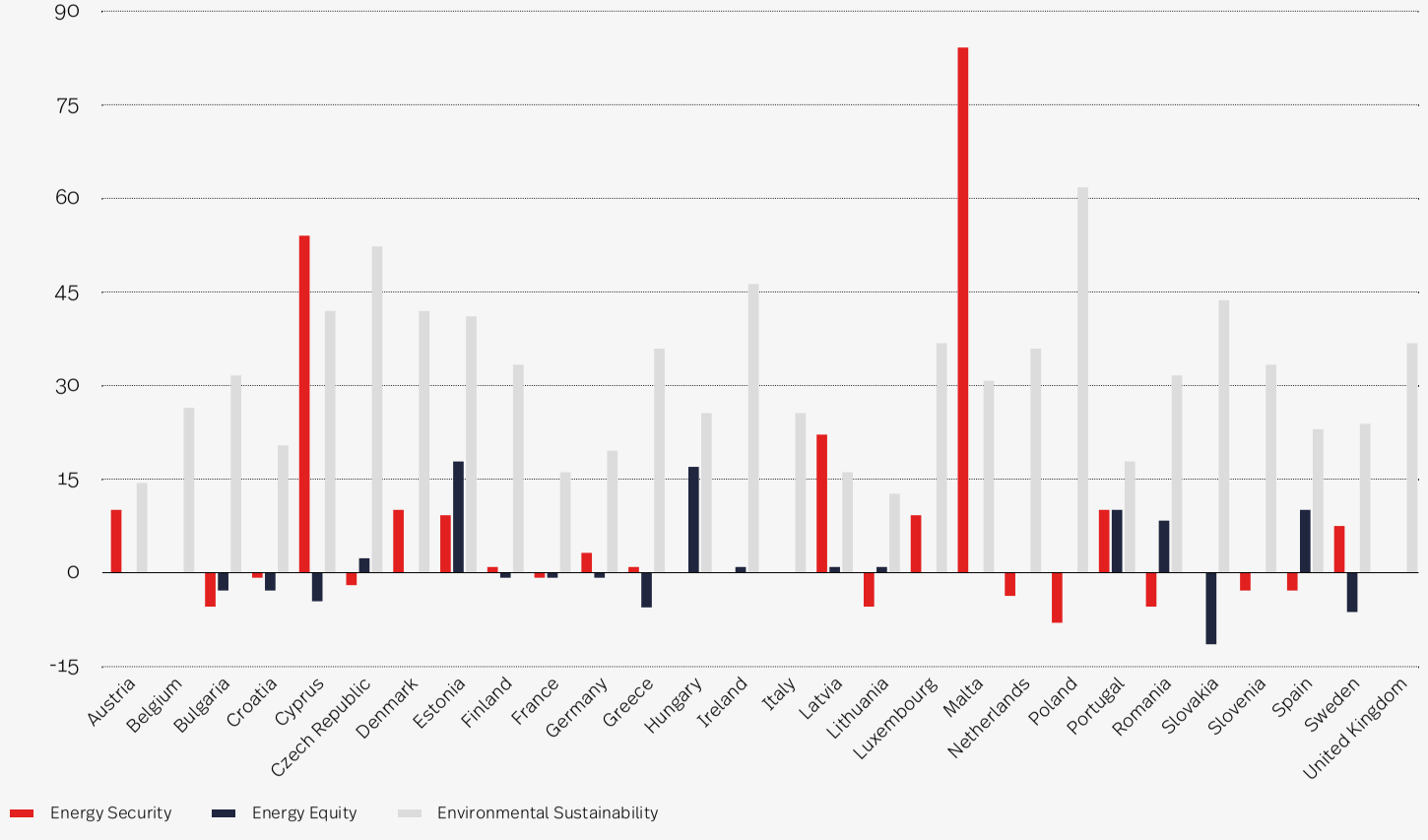
Among the European Union Member States, the most buoyant growth in Energy Security, in addition the above-mentioned Malta, was found in Cyprus (53.8 per cent). On account of the rise in the indicator in question, Malta and Cyprus ranked in the top five among all the countries covered. According to the authors of the WEC report, that improvement was largely due to their joining the European Union and increased oil stock levels. In contrast, the Energy Security scores dropped for Poland (-7.9) and Romania (-5.8).

An increase in one component of the WEC's Energy Trilemma Index may be accompanied by a fall in another. For example, for some countries a declining share of fossil fuels may be related to lower imports, thus reduced dependence. At the same time, fossil fuels are frequently replaced with renewable sources which involve greater dependence on weather conditions in energy production. In addition, their development promotes decentralisation and – consequently – digitisation in the energy sector. As a result, it involves an increased risk of cyber-attacks, issues related to grid reliability and integration, which – according to the authors of the WEC's Energy Trilemma Index – drives down the score in the Energy Security dimension.

The Energy Equity scores for EU Member States were relatively high. Only five Member States were outside the top fifty: Lithuania, Poland, Slovakia, Latvia and Romania. The group included countries with high gas or electricity prices. In Slovakia, the Energy Equity score decreased by 11.8 per cent, whereas it went up in Hungary (25.3 per cent) and Estonia (17.7 per cent).

None of the EU Member States noted a fall in the Environmental Sustainability score in 2019 against the 2000 baseline. Apart from Poland (up by 61.9 per cent), the top improvers also included the Czech Republic (52.1 per cent), Ireland (46.5 per cent) and Slovakia (43.4 per cent). In the European Union Member States, the development of energy transition policies is mostly fuelled by the objectives adopted for policies combating climate change (WEC, 2019).

↘ Chart 23. Historical changes in the WEC's Energy Trilemma Index scores in 2000–2019 (in per cent)



Note: the adopted baseline year is 2000, with scores for the core dimensions of the WEC's Energy Trilemma Index set at 100 per cent.

Source: WEC (2019).

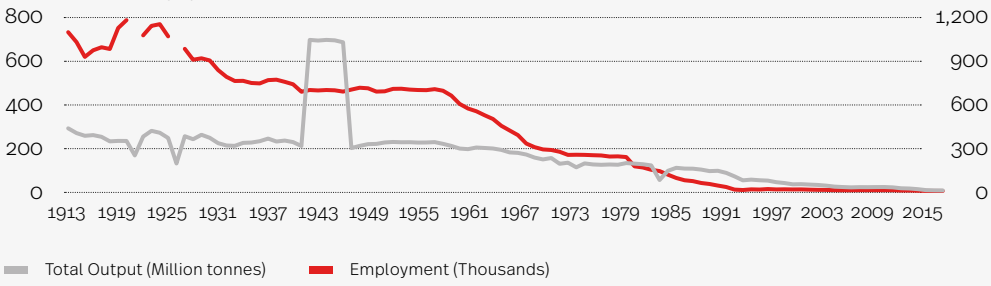
Energy transition in selected EU Member States

This chapter examines energy transition in three European countries. In particular, we describe how and why the countries selected can now be regarded as the leaders (although to a varying degree) of energy transition. With a focus on long-term trends concerning the main components of primary energy supply, we also point to changes in the labour market and the ownership structure in the sector.

THE UNITED KINGDOM

In ETI terms, with a score of 70.2, the United Kingdom occupies seventh place in the ranking prepared by the World Energy Forum; as regards the index created by the World Energy Council, the energy sector of the United Kingdom ranks fourth among the countries covered, with a score of 81.5. The industry concerned needed to undergo a long transition process before such an advancement could be achieved. In the early 1910s, mining employment exceeded one million (in a population of more than 40 million), whereas annual output ranged between 200 and 300 million tonnes (at that time, the UK was only outperformed by the United States). In the late 1940s, mines were nationalised and received government subsidies, under the control of a new authority – the National Coal Board. However, it was insufficient to prevent their collapse as British coal became ever less competitive in global markets. The 1950s and the 1960s witnessed the greatest number of mine shut-downs in the UK's history. Employment and output began to decline, to approx. 600,000 persons employed and ca. 200 million tonnes in the 1960s. In the second half of the 20th century, coal production from underground deposits decreased at a varying rate (Fothergill, 2017).

↘ Chart 24. Output (left axis) and employment (right axis) in mining in the United Kingdom in 1913–2018



Source: prepared on the basis of data from the Digest of United Kingdom Energy Statistics (DUKES).

From 1970s, the United Kingdom developed nuclear energy. The oil crisis also stimulated seeking alternative energy sources such as wave, tidal or wind energy. In addition, crude oil and natural gas began to be extracted from the North Sea with the use of domestic industry. But in connection with a surge in oil prices, initially in 1973–1974 and then again in 1979, the government of the United Kingdom created a new nuclear energy programme aimed at building nuclear power plants with a capacity of 15 GW. Due to criticism from domestic organisations, those plans were not fully implemented. It showed the extent of challenges posed by long-term and large-scale projects in the energy sector. Before the 1990s, projects implemented only comprised investments in coal-fired or nuclear power plants, with no recognition of the potential of gas and no predictions of coal price rises in the future. The UK also faced increasing problems with domestic gas and electricity prices as well as with the inefficiency of state-owned enterprises (Pearson, Watson, 2012).

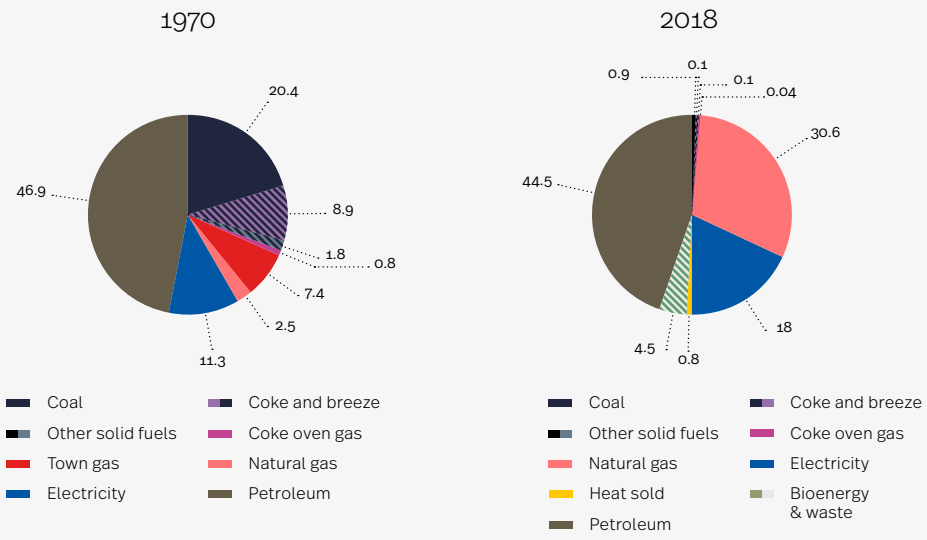
The energy industry in the United Kingdom underwent various changes concerning state ownership. The year 1986 marked the beginning of the privatisation of the gas sector[7], whereas 1990 – of the electricity sector. The privatisation was implemented in stages; initially, the state held majority stakes or preference shares in certain electricity companies[8]. At present, electricity companies are managed by French and German energy corporations. In 1994, the British Coal Company (formerly: the National Coal Board) was privatised, unprofitable mines were shut down; extractive operations were merely continued in 16 mines (there were nearly 1,000 in 1947) (Department of Energy&Climate Change, 2014). In the case of the coal sector, unlike the electricity and gas industries, those changes were not aimed at full privatisation; rather, some of the assets were supposed to remain the property of the state and taxpayers (Pearson, Watson, 2012).

The privatisation of the energy sector changed the energy market. In 1990, British Coal signed multiannual agreements with the new electricity producers for the sale of coal priced higher than imported coal. The companies also had contracts for selling energy to regional distribution undertakings which in turn transferred increased energy costs due to the domestic coal price to final prices of energy charged to their monopolised customers. As a result, a decade later, many distributors decided to discontinue purchases from already private, centralised coal-fired power plants and started building gas-fired sources of electricity. It was a method for the market regulator to stimulate competition. As regards supply, from the 1990s the UK imported cheaper coal, mostly from Russia, the United States and Australia (Fothergill, 2017). Possibly, even despite lower prices of imported coal and the 'dash for gas', the hard coal output would not have been higher, e.g. due to the lack of new replacement investments as those appeared to be unprofitable in the mid-1980s. The output from oil and gas fields peaked in the 1990s. From 2004, the United Kingdom became an importer of natural gas and from 2005 – of crude oil (Pearson, Watson, 2012).

In connection with the gradual closing down of old nuclear power stations, the previous sources were replaced with renewables. Nowadays, RES account for more than 15 per cent of generated electricity, of which 52 per cent is produced by wind farms, solar and biomass power plants. Initially, as early as the 1980s, the United Kingdom launched its own programme of building wind farms, but technologies from Denmark, Germany and the USA took over the market quickly (Elliott, 2019). The development of renewable sources was possible due to guaranteed selling prices of green energy.

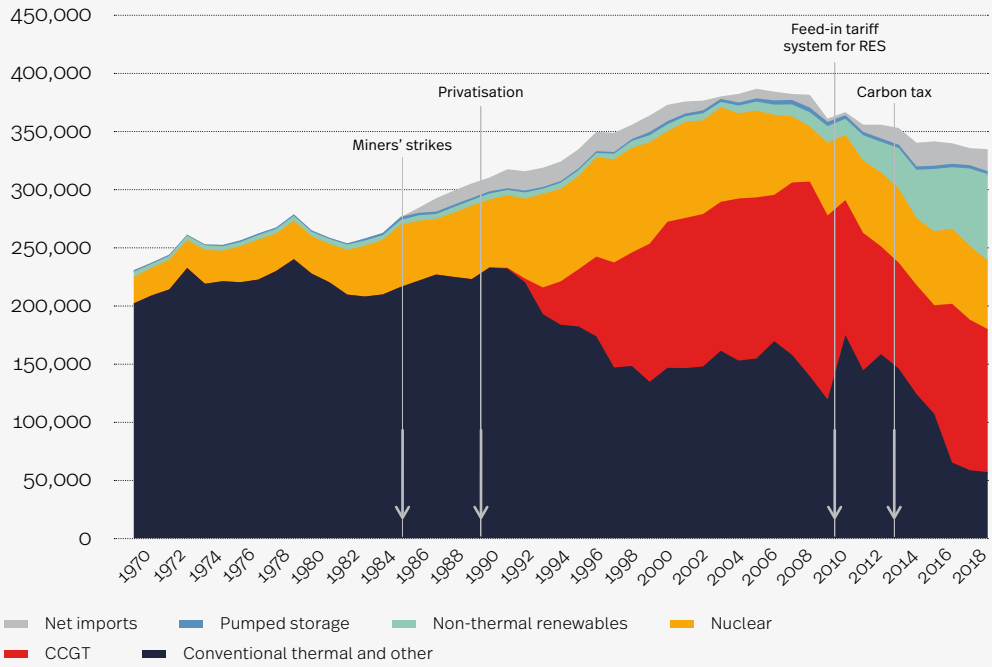
But in the last years the share of energy from coal was pushed down, especially, by the 2013 introduction of tax on CO_2 emissions – the so-called carbon tax or carbon price support. Actually, apart from environmental considerations, the introduction of the tax was supposed to provide budget revenue in times of deficit. Attempts were made to build a new coal-fired power plant, but the opposition protested firmly, whereas the plan for the construction of a carbon capture and storage installation for a coal-fired power plant in Scotland was rejected due to high investment expenditure. At present, as a result of transition, it is more cost-effective to produce energy from gas-fired power stations, characterised by lower emissions and higher efficiency than old coal-fired units, even when coal prices are low. Therefore, gas has replaced coal in the UK's energy sector (Fothergill, 2017; IEA, 2019b). According to Eurostat data, more than 50 per cent of gas is now imported, mostly from Norway, Qatar and the United States.

↘ Chart 25. **Primary energy consumption in the United Kingdom by source in 1970 and 2018 (in per cent)**



Source: prepared on the basis of data from the Digest of United Kingdom Energy Statistics (DUKES).

↘ Chart 26. **Electricity output in the United Kingdom 1970–2018 (in MWh)**



Source: prepared on the basis of data from the Digest of United Kingdom Energy Statistics (DUKES); Fothergill (2017).

The transition in the United Kingdom mostly affected miners due to lay-offs as well as final customers through electricity price increases. From the late 1940s, new industries began to grow in regions were mines were being shut down. There were attempts at moving redundant miners to other mines, whereas others were provided with various benefits and assistance, e.g. retraining. The economic recovery of post-mining areas also relied on the EU's structural funds (still granted in the South Wales Coalfield (Welsh Government, 2018)). The last underground mine was closed down in 2015, but in 2019 it was decided to open a new one in North West England, with planned employment of 500 persons (State Mining Authority, 2019).

Germany

Early after World War II, coal was the pillar of the socio-economic and political reconstruction of Germany's potential (particularly that of West Germany). The coal-based energy sector helped regain trust in international relations, as exemplified by accession to the European Coal and Steel Community (ECSC) in 1951. The year 1957 witnessed peak employment in mining (approx. 600,000 registered employees) and the peak output of hard coal (more than 150 million tonnes) (Brauers, Herpich, Oei, 2019).

1958 marked the beginning of a gradual decline in mining employment hard coal production. It was due to the deregulation of and a fall in coal prices, previously regulated by the ECSC. As a result, German production was squeezed out by cheap imported coal and due to a growing role of imported oil in the heating sector. Similarly, imports of natural gas steadily gained in importance. Retrained miners found jobs in other industries (the steel industry), which prevented the unemployment rate from soaring. As coal played a diminishing role, economic activities were diversified through measures such as introducing more efficient connections between mining regions and the neighbouring urban areas. It stimulated the mobility of miners (they were more likely to effectively take up employment in sectors other than mining) and increased the investor attractiveness of the region concerned (Brauers, Herpich, Oei, 2019).

The late 1960s saw a sharp rise in environmentally friendly attitudes, reflected in increased importance of green organisations and their gradual transformation into political parties. As early as 1971, the government of the Federal Republic of Germany presented the first environmental protection programme; three years later, the Federal Environment Agency was established in Berlin. It was a response to public support for nuclear energy in Germany in 1970–1980. As argued by advocates of nuclear power solutions, oil prices were subject to significant fluctuations (e.g. the price shock of 1973–1974), although the main rationale was to increase energy security – through the diversification of energy sources and the development of stable electricity generation methods (World Nuclear Association, 2019).

The year 1980 witnessed the creation of the Green Party (Die Grünen), putting environmental protection issues on Germany's political agenda. Initially, it mainly objected to nuclear energy; over time, it also addressed issues related to harmful emissions resulting from industrial production or acid rains. Those groups are also believed to have helped internalise the costs of pollution from emissions of harmful substances to the atmosphere as well as support and develop renewable energy sources.

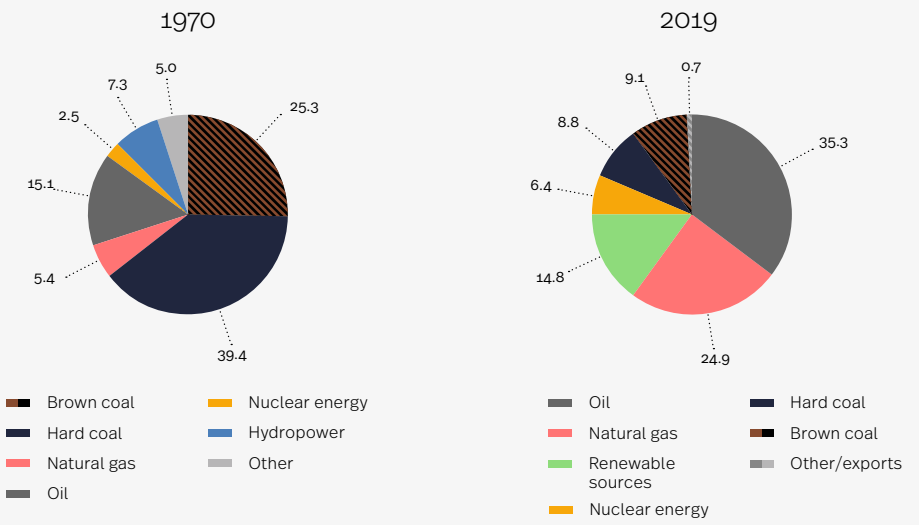
The turn of the 1980s and the 1990s was also a period of the implementation of structural programmes aimed to diversify the economic structure of West Germany towards cultural and environmental aspects. Various economic activities were promoted, including services (Goch, 2009). As a result, both the Ruhr and Saar regions – successful in developing industry in the past – started to develop the service sector as well. It was facilitated, inter alia, by increased outsourcing of services by previously consolidated firms in the industrial sector (Lerch, Simon, 2011). The share of employment in production dropped from 58 per cent in 1976 to 26 per cent in 2014, whereas the number of persons employed in services rose from 42 per cent to 74 per cent in the period in question (Brauers, Herpich, Oei, 2019).

After the Chernobyl accident in 1986, a bill was passed to depart from nuclear energy within ten years. As late as the 1990s, nuclear energy represented 29 per cent of domestic electricity generation. After 2000, that share was on the decline (26 per cent in 2005, 22 per cent in 2010). Following the Fukushima nuclear power station accident in 2011, the proportion of generated electricity fell abruptly, to 15 per cent in 2013.

In 1999, an environmental tax was introduced, pushing up energy consumption costs through additional financing from receipts from the tax. After the 2000 introduction of the feed-in tariff system for RES, forcing customers to purchase energy at fixed (higher) rates and additionally supporting independent suppliers, there was dramatic growth of renewable energy sources. It was a milestone in the development of renewable energy in Germany, facilitating Germany's subsequent high share of the global

market in RES. In 2010, Germany was the largest investor in photovoltaic solutions and biogas production worldwide and the fifth largest investor in wind energy.

↘ Chart 27. **Primary energy consumption in Germany by source in 1970 and 2019 (in per cent)**



Source: prepared on the basis of data from Statistik der Kohlenwirtschaft i AG Energiebilanzen e.V.

Due to pressure from the EU and from the German population, the financing of hard coal production was discontinued in 2007. The last mines in the Saar region were closed down in 2012, whereas in the Ruhr valley – in 2018. The German Parliament estimated the costs of the phasing out of coal in 2006–2018 at approx. EUR 38 billion. In addition, appropriations of EUR 2 billion were allocated to retirement pensions for miners and to compensate for the losses of mines, whereas an amount of EUR 7 billion was assigned to cover the long-term costs to be incurred by future generations (Brauers, Herpich, Oei, 2018; Bundesregierung, 2007).

The situation is different for brown coal. In spite of structural changes, particularly in eastern regions, Germany continues to be the largest producer and consumer of brown coal worldwide (IEA, 2019a); more than half of electricity for public needs is generated from that raw material (64.5 per cent in 2018). Another important element of the electricity sector is gas, accounting for 25 per cent of primary energy supply in Germany in 2019 (Chart 27). Germany's plans to extend its gas infrastructure do not suggest that the fuel is treated as a transitional alternative; on the contrary, they seem to have a permanent place in the German strategy, thus decreasing the independence and security of the country. Raising the production of energy from RES resulted in increasing electricity exports (Brauers, Herpich, Oei, 2018).

The overarching aim of the current decarbonisation measures is to eliminate coal from the energy sector by 2038. The main targets are to reduce electricity generated from hard coal to 15 GW and from brown coal to 15 GW by the end of 2022, followed by further reductions to 8 GW

(hard coal) and to 9 GW (brown coal) by 2030; the final step will be the elimination of coal by 2038. The support package of EUR 40 billion will be allocated to regions with active brown coal mines and coal-fired power plants. Furthermore, an amount of EUR 4.35 billion will be assigned to coal-fired power plants until 2030 as compensation for lost production (the eastern region – EUR 1.75 billion, the western region – EUR 2.6 billion). Granted until 2048, government funds of EUR 5 billion will also comprise compensation for older employees in respect of lost jobs (Agora Energiewende, 2019; Clean Energy Wire, 2020).

List of charts, infographics and tables

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Endnotes

[1] Further in the report, we use the term 'electricity' as meaning 'gross electricity'.

[2] As the only Member State, Poland temporarily chose not to join the declaration of achieving climate neutrality by 2050.

[3] The ETI components are normalised on a scale from 0 to 100, whereas the overall ETI is the average of particular countries' scores for all the components. Therefore, the maximum score should not exceed 100 either. The calculations assume that it is not necessary for climate neutrality itself to be 100 (the average of the maximum scores for all the components) and can be achieved earlier.

[4] Higher prices translate into a lower rank.

[5] An island with the total offshore wind capacity of 10 GW.

[6] It means that Denmark intends to produce from renewables 9 per cent more electricity than it needs, which will enable selling electricity to other countries. In the case of Member States, such a transaction may help achieve the climate objective if a country is unable to produce a sufficient amount of electricity from renewable sources on its own.

[7] In some companies, the supervisory authority introduced gas price control for the tariff sector.

[8] Electricity grids were managed by National Grid Company whose shareholders were 12 regional distribution companies; for the first few years (until 1995), preference shares were held by the state. Energy generation was transferred to three firms: PowerGen, NationalPower and Nuclear Electric. Before 1995, nuclear power plants concentrated in the last company were state-owned, whereas the state held 60 per cent of shares in the other two.

Notes

The Polish Economic Institute

The Polish Economic Institute is a public economic think-tank dating back to 1928. Its research spans trade, macroeconomics, energy and the digital economy, with strategic analysis on key areas of social and public life in Poland. The Institute provides analysis and expertise for the implementation of the Strategy for Responsible Development and helps popularise Polish economic and social research in the country and abroad.