ENERGIAKLUB
CLIMATE POLICY INSTITUTE
APPLIED COMMUNICATIONS

REPORT

How European countries without nucler power plants fare in the field of renewable energy

In early 2022, 14 countries of the EU-27 (Ireland, Denmark, Luxembourg, Estonia, Latvia, Lithuania, Austria, Portugal, Italy, Poland, Croatia, Greece, Cyprus and Malta) had no operational nuclear power plants, while 26 of the 44 countries in Europe had no nuclear reactors, including several with a high share of renewables in their energy mix. This paper analyses how these countries manage their energy supply.

Currently, the majority of European countries do not have nuclear power plants, and – given that of the 18 countries which generate nuclear energy 13 are EU member states – more than half of the EU members states do not have nuclear power plants either. Albeit through electricity import even these countries use nuclear energy to some extent (nuclear energy accounts for about a quarter of the EU's power generation), they have made a sovereign energy policy decision of opting for an energy mix that consists exclusively of fossil and/or renewable production units.

Changing positions

At the end of 2022, another member is expected to join the club of nuclear-free countries: after the 2011 Fukushima disaster, Germany decided to phase out all of its nuclear power plants. Although the German government, which took office at the end of 2021, reviewed this decision in the light of the European energy crisis (mainly caused by problems in the natural gas market), it has not yet changed its approach even in consideration of the results of the latest analysis.

Besides Germany, other countries are also preparing for the total decommissioning of their nuclear fleet. In March 2022, after months of negotiation and a compromise decision to phase out nuclear power by 2025, the Belgian coalition government decided to postpone the deadline by 10 years due to uncertainties resulting from Russia's attack on Ukraine. In Switzerland, partly as an impact of the Fukushima accident, citizens rejected the construction of new nuclear power plants in a referendum in 2017, although the debate has recently restarted for the same reasons as in Belgium.

On the other hand, there are plans (partly under implementation) to introduce, in the long term, nuclear power generation to countries which currently do not have such facilities. Examples include Turkey and Poland, where new power plants would start power generation from 2023 onwards, and between 2033 and 2040, respectively. Other countries, such as the UK, the Netherlands or Hungary, are planning to expand their existing nuclear capacities. In contrast to pro-nuclear European countries, led by France, some countries including Austria, Denmark, Germany, Luxembourg and Portugal are strongly opposed to nuclear power.

Water, wind, geothermal and fossil resources

Obviously, in a given country, the attitude of policy makers and public opinion towards nuclear energy is shaped not only by energy policy considerations, but also by historical, cultural and political characteristics, the attitude to environmental protection, a

philosophical approach, so to say, as well as geographical and economic conditions. For example, countries without nuclear reactors are over-represented in northern Europe, the Balkans and southern Europe, where significant hydropower, wind power and even geothermal energy resources are available. In southern Europe, the relatively low level of industrialisation may be a factor that makes dispensable the extremely expensive investment in nuclear power plants, capable of producing large amounts of baseload.

As for their geographical location, European countries that do not have operational nuclear power plants are highly variegated (northern and southern Europe, western, central and eastern Europe). The differences in specific circumstances (which also influence access to fossil and renewable energy resources) are reflected in the differences between the energy mixes of each of these countries. For instance, geothermal energy plays a prominent role in the energy mix in Iceland, the land of geysers. In Norway, which can boast of an abundance of suitable rivers, hydroelectric power generation is of key importance. Coal is the most dominant energy resource in Poland, which has rich fossil reserves.

Given that, in terms of volume, nuclear energy (due to the very size of nuclear power plants) makes up a significant part of the energy mix of the countries concerned, the fossil and/or renewable power plant fleet in nuclear-free countries must be substantially larger so as to be able to produce the necessary amount of energy. Therefore a comparison of the two groups of countries reveals that the share of renewable energy (and, along with that, of fossil energy) in gross final consumption is generally higher in countries which do not have nuclear power plants. Fossil fuel here entails mainly oil and natural gas, given that coal consumption in Europe is close to historical lows even after a rise due to the increase in natural gas prices.

In Europe, fossil fuel extraction is shrinking at a rate which is higher than that of consumption. Back in 2010, the EU produced 107.8 million tonnes of black coal. By 2021, production had fallen to 57.2 million tonnes. In the meantime, consumption shrank from over 250 million tonnes to over 150 million tonnes. In the same period, crude oil production fell from approximately 30 million tonnes to below 20 million tonnes. In 2021, oil product consumption decreased from 366 million tonnes of oil equivalent to 310 million tonnes in, but then in 2021 it bounced back almost to pre-pandemic levels (around 340 million tonnes). In the period from 2010 to 2020, the “domestic” (EU) production of natural gas fell by about a third, to just over 50 billion cubic metres. In the same period, the decrease in consumption was very low (from about 17 million terajoules to 16 million terajoules).

This means that (albeit **all EU member states are net energy importers**), the rate of nuclear-free countries is higher among the countries with the highest dependence on energy imports. In 2020, 13 countries exceeded the EU energy dependency level (57.5%), and four of them had operating nuclear power plants (NPP). The details are as follows: Malta (97.6%, no NPP), Cyprus (93%, no NPP), Luxembourg (92.5%, no NPP), Greece (81%, no NPP), Belgium (78%, NPP), Lithuania (75%, no NPP), Italy (73.5%, no NPP), Ireland (71%, no NPP), Netherlands (68%, NPP), Spain (68%, NPP), Portugal (65%, no NPP), Germany (63.5%, NPP), Austria (58%, no NPP).

In European countries without operating nuclear power plants, the average per-capita carbon emissions exceed those of countries with nuclear power in their energy mix. In spite of their remarkably high share of renewables, Austria, Iceland or Norway have per-capita greenhouse gas (GHG) emissions that well exceed the EU average and are among the highest in Europe. As for carbon intensity (that is, the amount of GHG emitted into the atmosphere per unit of electricity produced), all three countries are top-ranking in Europe. This dichotomy is attributable to the fact that these countries have a relatively large energy sector and demand compared to their population size, but, at the same time, renewable energy resources contribute to gross final consumption (mainly electricity) to a degree well above average.

Annual per-capita emissions are defined as the ratio of a country’s total greenhouse gas emissions in a given year, divided by its population. Carbon intensity is the GHG emissions per unit of energy or of GDP produced. Energy intensity stands for the amount of energy used per

unit of production. These indicators serve as a way of comparing the "cleanliness" of a country's economy, as well as its efficiency of energy use.

The champions of renewable energy: nuclear-free countries in the forefront

In 2020, of European countries Iceland had the highest share (83.7%) of renewables in its gross final energy consumption. Norway, another nuclear-free country, ranked the second at 77.4%. Sweden (60.1%) and Finland (43.8%) came next, both equipped with nuclear reactors, followed by countries that do not have operating nuclear power plants: Latvia (42.1%), Austria (36.5%), Portugal (34%), Denmark (31.6%), Croatia (31%; sharing nuclear power with Slovenia) and Estonia (30.2%). This means that of the 10 European countries that rely most heavily on renewable energy resources, only 3 have operating nuclear power plants, that is – logically – countries that have given up nuclear power are seeking to decarbonise their economies by increasing power generation from renewables.

The energy situation of Iceland, the European or even global "champion of renewables" is unique in several other ways, too. With a population of just under 400,000 people, Iceland has seen its primary energy supply increase by over 160% since 1990, its energy production by approximately 230% and its final electricity consumption by 360%, while its total carbon emissions have been reduced by nearly 14%. In the last decades – in spite of the marked increase in demand – the share of fossil resources in Iceland's overall energy supply has decreased in relative and nominal terms alike. Currently, fossil fuels account for only about 15% of Iceland's total energy mix, while their rate was around 30% in 1990 and nearly 80% in the 1960s, mainly due to the levels of oil consumption. Today, the share of renewables exceeds 80%, which is approximately 20 percentage points above the 2020 target (64%, in itself a very high rate).

The Icelandic energy system is a good example of how location and geology can be decisive factors for countries. Geothermal energy meets about two-thirds of Iceland's primary energy demand. This rate is a world record, and Iceland is active in research and development of the so-called supercritical geothermal energy technology, a highly promising option. By contrast, due to Iceland's specific circumstances, the share of photovoltaic and wind power production (the fastest-growing segments around the world) is minimal.

Sustainable growth from the 1970s

In the 20th century, in terms of per-capita GDP, Iceland went from being one of the poorest countries in Europe to one of the richest in the world. In the meantime, in a relatively short period of time its energy system underwent a major transformation. At the time, the shift towards renewable energy resources was not mainly driven by climate and environmental concerns (which back then were less in the limelight), but by the global oil crisis of the 1970s, urging Iceland to start relying on stable, affordable domestic energy resources instead of imported fossil fuel available at volatile prices.

In the last three decades, Iceland has managed to meet its sharply rising energy demand exclusively from renewable resources, which means that Iceland, in fact, had implemented sustainable growth long before the term was even coined. As for power generation, it has been almost 100% renewable for decades. The key factors are hydropower and geothermal energy, the latter traditionally accounting for all domestic heat generation. Iceland is a world leader in electromobility too. In the new car market, the share of electric models exceeded 80% in 2022, of which fully electric cars made up approximately 45%, meaning that the role of oil is diminishing in the transport sector, too.

Oil makes up the bulk of fossil energy use. Coal has never played a major role, and natural gas is completely missing from Iceland's energy mix. As evidenced by available data, no coal, oil or gas extraction activity is going on in Iceland. There are no international energy

pipelines connected to the Icelandic energy system; that is, imports (which account for approximately 15% of the total primary energy supply) are limited to coal and oil.

Iceland has one of the highest per-capita greenhouse gas emissions rate in Europe. At the same time, its electricity system is among the cleanest and its carbon intensity is among the lowest in Europe. In 2007, almost a decade before the Paris Climate Change Agreement was signed, Iceland had developed a climate change strategy of its own, which entailed the objective of reducing greenhouse gas emissions by 50-75% by 2050 (compared to 1990 levels).

The home of hydropower

Evidently, there is a large number of Nordic countries among those that produce and consume the most renewable energy and do not have operating nuclear power plants. In 2020, Norway had the second highest share of renewable energy in its total gross energy consumption in Europe, at 77.4%, which is also outstanding by international comparison. Primarily as a result of the outstanding share of hydropower, Norway easily met its 67,5% target for 2020 (as had always done every year from 2014 onwards). In fact, as shown by earliest available data, hydropower accounted for two-thirds of Norway's energy mix as early as in the mid-1960s, and its electricity generation relied on renewables for nearly 100% for decades. Rich in hydropower and fossil resources, Norway, as of now, has a low share of other renewables. Its location explains the low-level use of solar energy, but it has orders of magnitude greater wind energy potential – which it has recently started to exploit. Therefore, wind energy currently accounts for 4-5% in Norway's energy mix and 6-7% in its electricity mix.

Norway's fossil fuel extraction is significant; the country exports oil and gas to many European countries. Oil and gas also play an important role in its own energy supply; consequently, its per-capita GHG emissions is 9.3 tonnes per year, which is well above the EU average of 7.5 tonnes (2020). Still, it follows from what was discussed above that Norway's electricity generation is one of the cleanest in Europe, while carbon intensity is the lowest, ranking the first (together with Iceland and Sweden). It is to be mentioned though that since 1990 Norwegian carbon emissions have increased by more than 30%, while its energy production has risen by more than 70%.

The tiny wind energy superpower

In the Scandinavian region, Denmark (with a share of renewables of 31.6% in 2020) also managed to meet successfully its 2020 target of 30%, and is one of the leading European countries in this respect (what is more, in 2019 it achieved a rate of 37%). While the number one renewable energy resource is geothermal energy in Iceland and hydropower in Norway, for Denmark wind energy is of key importance, accounting for more than a quarter of total Danish energy consumption. The share of other renewables is still much lower than that of wind energy, while those of oil and natural gas are still close to 50% and around 15%, respectively. Given the absence of significant fossil fuel production, imports are also indispensable for Denmark's energy supply. Yet the import dependency rate is around 45%, which is quite low in the European Union, being more than 10 percentage points below the EU average.

Eighty-five percent of Denmark's electricity generation is based on renewables: wind power has the lion's share, accounting for nearly 60%. Denmark's approach to wind energy is unique worldwide. With a population of just under 6 million, Denmark was able to turn into a global centre for the development and production of wind turbine technology, due to the fact that it had introduced wind power into its energy mix in 1978, at an unprecedentedly early date. Mainly as a result of this, Denmark's carbon emissions have fallen by around 50% since 1990. (Its annual energy production fell by 7% in the same period.)

Denmark's annual GHG emissions are 7.3 tonnes per capita, which is lower than the EU average. As for its carbon intensity, the Danish electricity system ranks among the lowest in

the EU. As per the Danish National Energy and Climate Plan, Denmark aims to reduce greenhouse gas emissions by 70% by 2030 (compared to the 1990 levels). For that purpose, it plans to increase the share of renewable energy to 50% within total gross final energy consumption.

Success stories from Eastern Europe

For Hungary, it is especially noteworthy that Latvia ranks the fifth among European countries in terms of its share of renewable energy resources (42.1%), which is the best rate among Eastern European EU member states. However, it is also to be pointed out that in 2004, the year of its accession to the EU, Latvia already had a renewable share of almost 33%, the best in the EU, and in Europe was only exceed by Iceland and Norway at the time. Since then, Latvia has successfully increased its rate by less than 10 percentage points (roughly equivalent with Hungary's performance) and thus managed to reach its 2020 target of 40%.

Latvia, although nuclear-free, boasts of the lowest per-capita GHG emissions in the EU. By contrast, its carbon intensity of power generation is clearly among the highest in Europe. This is attributable to its energy mix: above 30% oil, above 20% natural gas, approximately 40% biofuels and waste incineration, about only 0.5% coal and an even smaller share of solar and wind energy, and, as for other renewables, with hydropower as the only significant one with a share of just over 5%. Given that Latvia's oil and gas consumption is not coupled with domestic production, its energy dependency rate is around 45%, and its 2030 target is to decrease the share of import to the 30-40% range.

Compared to the 1990 level, Latvia's energy production has increased by nearly 150%, while its carbon emissions have fallen by more than 60%. Latvia's National Energy and Climate Plan sets the objective of reducing GHG emissions by 65% and to increase the share of renewables to 50% by 2030.

Hydropower accounts for approximately 45% of domestically produced electricity; biofuels and wind have a contribution of nearly 20%, while natural gas gives the bulk of the remainder. In the 1990s, there were periods when the role of hydroelectric power plants was even bigger, accounting for between two-thirds and three-quarters of domestic power generation. It was around 2000 that the contribution of natural gas started to increase, in parallel with a major decline in the use of coal and oil, of which coal had never been of great importance. Given Latvia's geographical conditions, the presence of photovoltaic technology is minimal. The same stands for wind power, too, which accounts for not more than approximately 3% of electricity generation. This means that Latvia has achieved its particularly high share of renewables mainly through the use of bioenergy (biofuels, biomass, and biogases), which has a key role to play not only in the electricity sector, but in heat production too.

It is not uncommon for nuclear-free energy systems to have a high level of use of renewables coupled with a high fossil share. For instance, Estonia, another Baltic state and member of the former "Eastern bloc", has a renewable share of over 30% mainly due to the use of biofuels and waste-to-energy; at the same time, coal continues to account for above 50% of the gross final energy consumption. Consequently, Estonia performs relatively poor in terms of per-capita emissions and the carbon intensity of power generation. By contrast, since 1990 its carbon dioxide emissions have fallen by a massive 75% and, thanks to the high level of domestic extraction, its dependence on energy imports is the lowest in Europe (approximately 10%).

Europe's largest contiguous group of nuclear-free countries is located in the Balkans. Their share of renewable generally exceeds the EU average, especially in Albania (45%) and Montenegro (43.8%). It holds true not only for Albania and Montenegro, but also for the region in general that key renewable resources are hydropower, biomass and waste-to-energy, while oil and/or coal also play a dominant role. Consequently, their emissions performance is not excellent, in spite of the high share of renewables; for instance, the carbon intensity of the Montenegrin electricity system is one of the highest in Europe.

Carbon neutrality in 2040 next door to Hungary?

Austria, having opted for an anti-nuclear approach which it represents at the regional level, has a most ambitious emissions reduction target: it aims to achieve carbon neutrality by 2040.This is an ambitious commitment, especially in the light of the fact that in 2020 Austria's carbon dioxide emissions were still almost 2% higher than the 1990 levels. It is to be added though that in the same period Austria's energy production increased by almost 50%.

Austria's per-capita GHG emissions are above the EU average (8.4 tonnes of carbon dioxide equivalent/year), but the carbon intensity of its electricity system ranks among the best in Europe, as does its 36.5% share of renewables energy resources in the gross final energy consumption (c.f. the target value was 34%). Traditionally, Austria uses a large amount of renewable energy whose share was among the highest as early as in 2004 (22.6%). The key renewable resources are biofuels and energy-from-waste, which together account for 20% of the energy supply. The use of hydropower is also a key factor, with a share of over 10% in the energy mix. By contrast, solar and wind energy, with their share of 3%, currently have a minor role.

The low carbon emissions level of Austria's electricity system is mainly due to the operation of hydroelectric power plants, which accounts for more than 60% of domestically generated power. The share of wind energy is close to 10%, while that of biofuels is above 5%, and solar and waste energy together also exceed 5%. That is, the total rate of fossil fuels in power generation is around 20%. The local importance of bioenergy and hydropower is partly attributable to the fact that Austria (similarly to Latvia) has a high rate of areas covered by forests (around 50%). This is coupled with widespread sustainable forest management practices, and the huge number of high-flow rivers suitable for the installation of hydropower plants.

Of the fossil fuels, oil is of the greatest importance with a share exceeding 30%. Natural gas (20-25%) and coal (5-10%) are also dominant. Given that the domestic extraction of coal, oil and natural gas is modest and shows a decreasing trend in relation to consumption, Austria's energy import dependency level is approximately 60%.

Portugal's performance is outstanding even without the use of solar power

Portugal, yet another country with no operating nuclear power plants, boasts of a renewables share of 34%, an outstanding rate compared to the EU average of 22.1%. It easily met its 2020 target of a 31% renewable share by 2020, mainly thanks to hydropower, wind power, biofuels and waste-to-energy. Renewables, and especially hydropower and wind energy, account for approximately 60% of domestically generated electricity. Interestingly, in spite of Portugal's excellent irradiance, photovoltaic power plants have so far played only a minimal role in local energy supply.

Oil and oil products are the key components of Portugal's energy mix, accounting for above 40% of total energy supply. Similarly to other countries, in recent years Portugal has also seen the role of coal being limited to the minimum (3%) in its energy mix, while the share of natural gas is close to 25%. The significance of natural gas is all the more noteworthy given that before 1997 its share was practically zero. This process of gaining ground is particularly spectacular in power generation, where natural gas currently accounts for approximately one-third, while the other two fossil energy resources (coal and oil) have a share of only a few percent, although in the early 2000s they still accounted for over 50%. In the absence of substantial domestic extraction, the bulk of the fossil fuels used in Portugal comes from imports. This is why Portugal's energy dependency is significant, 65%, which exceeds the EU average of approximately 58%.

In terms of per-capita GHG emissions, Portugal is among the best performers in the EU (5.7 tonnes/year), although the carbon intensity of its electricity system is of a medium level. Compared to the 1990 levels, the carbon dioxide emissions of the Portuguese economy decreased by only 1.5% by 2020, while domestic energy production have increased by about 80%. Portugal's National Energy and Climate Plan in force sets the target of a 45-55% reduction in emissions by 2030 (compared to the 2005 levels rather than to 1990). Compared to 2002 and 2005 (the years which marked historic peaks in Portugal's carbon emissions), carbon emissions had already been reduced by about 40% by 2020, so the target specified in the Plan implies a rather conservative planning. The Plan calls for increasing the share of renewable energy resources in Portugal's energy mix to 47% by 2030, which would be a 13-percentage point increase compared to the 2020 level.

Stuck to dependence on gas?

If a country that does not have an operating nuclear power plant fails to expand its renewable energy production significantly, the direct result will be an above-average share of fossil resources and import dependency in the energy mix. Italy, Europe's largest nuclear-free economy, meets more than 80% of its primary energy needs with the use of fossil resources. The share of low-carbon energy resources is around 20% (c.f. the 2020 target was 17%). In the Italian energy mix, natural gas has the largest share, above 40%, exceeding oil, which currently accounts for slightly less than 40%, but in the early 1970s used to represent 75%. In the absence of nuclear or major coal-fired power plant capacity, the bulk of baseload is produced by gas turbines, which means that natural gas has an almost 50% share in the Italian electricity mix.

Compared to 1990 level, Italy's carbon dioxide emissions have decreased by 28%, while domestic energy production has increased by nearly 40%. Per-capita greenhouse gas emissions are lower than the EU average (6.5 tonnes/year), but the carbon intensity of the local electricity system is of a medium level due to the significant weight of fossil resources. Only a small share of this extensive use of fossil energy resources is covered by domestic production, which means that Italy's dependence on energy imports is extremely high, over 70%.

In 2020, renewable energy resources covered 20.4% of Italy's gross final energy consumption. This rate was higher than those of Germany (19.3%) or France (19.1%), but lower than the EU average (22.1%) or the Greek or the Spanish rate (21.7% and 21.2%, respectively). In spite of Italy's favourable renewable energy production potential, the installation of new photovoltaic and wind power plants has essentially been stagnating in recent years due to economic and structural constraints. In comparison to leading European countries, Italy has an energy policy which specifies moderate ambitions for the renewables. The National Energy and Climate Plan sets a 30% and 55% target for the share of renewables in the overall energy mix and in the electricity mix, respectively. Solar and wind power should cover 34% of electricity consumption. By comparison, Austria, Denmark, Germany, Portugal, Spain, Sweden and the Netherlands intend to achieve a 75% share of renewables in power generation by 2030. As for solar and wind power, Denmark, the Netherlands and Spain make efforts to achieve a share of 94%, Portugal and Germany 54%, and Greece 47% by 2030.

Overall, renewable energy resources represent approximately 40% of Italy's power generation, hydropower being the biggest contributor (with a share of around 20%), solar energy accounting for nearly 10%, and wind and biomass for around 7% each. The remaining renewable power is generated by geothermal energy and municipal waste-to-energy. In the electricity mix, the share of coal is less than 5% and that of oil is slightly above 3%. Natural gas took over the dominant role from oil in the second half of the 1990s.

Zero nuclear resources + low levels of renewables = a high ratio of fossil energy resources

In Europe, the countries with the highest and the lowest (10.7%) share of renewables are countries that do not operate a nuclear power plant. The country with the lowest share is Malta, which has a fossil fuel share of approximately 90%, resulting in an energy import dependency of the same rate. Malta phased coal out of its energy mix in the mid-1990s. Then, until the 2010s, it relied almost exclusively on oil and oil products to ensure supply. Afterwards, renewable capacity started to increase slowly, and natural gas became a dominant factor in the mix (with the start of LNG imports in 2017). Malta, with a relatively low energy demand, has the lowest per-capita carbon emissions rate in the EU, despite the very high share of fossil fuels in its energy mix. Compared to the 1990s levels, it even managed to cut its emissions by nearly 30%.

The other Mediterranean island country, Cyprus, also has a renewable share that is lower than the EU average (16.9%). Given that it is a nuclear-free country, fossil fuels play a prominent role in its energy mix. Yet, unlike Malta, Cyprus has not replaced most of its oil consumption with natural gas, and, consequently, it generates more than 80% of electricity from oil. Therefore, its energy import dependency rate exceeds 90% and the per-capita greenhouse gas emissions are among the highest in the EU (10.3 tonnes/year). Obviously, a realistic assessment of the situation calls for knowledge of specific circumstances: the unique political situation of Cyprus has a major impact on economic development. Therefore, the fact that carbon emissions have increased by more than 60% since 1990 should be understood in the political context and in the light of the fact that the power production of Cyprus has seen an increase of more than 2,500% since the base year.

In conclusion: it follows from the specific energy strategies of each country that there are no perfectly identical energy mixes in Europe. It is to be pointed out that the perception of nuclear energy is very diverse in the European Union. Still, it can be generally concluded that countries which take a stance against nuclear power plants put more emphasis on the installation of renewable energy production units. The exact mix of renewable technologies that results from this approach depends very much on the circumstances of each country, such as geographical location, natural resources, economic and social development and organisation or culture. Yet, ultimately, they should all aim to utilise their renewable potential to the greatest degree possible. To do so, holistic environmental and economic planning as well as a constant quest for sustainable, optimal energy management are indispensable. In each and every country, it is the task and duty of policy makers to promote such efforts, to establish the necessary economic and regulatory environment, and to meet the related social needs of citizens through education, awareness raising and community work.

Nuclear energy: far from being carbon-free

When it comes to nuclear energy, many tend to forget that the bulk of the uranium that fuels the EU's nuclear power plants come from outside the EU. **Approximately 95% of all uranium used in the EU is imported, meaning that nuclear power plants, essentially, make no contribution to energy independence**. Russia accounts for more than 20% of the EU's uranium supply and, moreover, plays an indispensable role in the enrichment of uranium, a prerequisite of use (accounting for 35%, i.e. the largest share in global production). It must be added though that several EU countries, such as Germany, the Netherlands and France, also have enrichment capacity. Moreover, much of the EU's nuclear power plant technology itself comes from Russia: of a total of 103 reactors in Europe, 18 are Russian-made. These 18 power plants operate in five of those 13 EU member states that are engaged in the production of nuclear energy. While the uranium imports from Russia to the EU are not yet subject to sanctions, the outbreak of war made the future of nuclear energy uncertain, too.

Furthermore, there is no energy resource that can be exploited with zero emissions; therefore, nuclear energy is also responsible for the emission of a certain amount of greenhouse gases. Extraction, transport and processing, along with the construction/decommissioning of a power plant all add to the carbon footprint of the technology. And, obviously, the stringent management of spent nuclear fuel for hundreds or

even thousands of years also produces emissions. Rarely do studies deal with the whole life cycle of nuclear power plants, and even if they do, their conclusions are far from being clear. Still, they agree that nuclear power entails a significantly lower level of emissions than the use of fossil resources do, yet mostly agree that the emission level is higher than that of solar and wind power (albeit some studies come to conclusions that partly contradict this observation).

Lessons to consider

The diverse energy systems that countries have developed, along with the energy policy considerations in the background, offer a number of lessons that policy makers may also wish to study. A key conclusion is that originally many of those European countries which currently are leading the way in the use of renewable energy resources did not opt for the increased use of alternative resources of energy for environmental and climate protection reasons or, at least, had other reasons to do so, too. Thus, for example, while "green" considerations has traditionally played a major role in the environmentally conscious countries of Northern Europe, many of them were primarily urged to turn to renewables by their exposure to fossil energy imports and to the volatility of world market prices, and by the negative impact of these on their security of energy supply. Therefore, their main motivation is often to exploit national resources to ensure the maximum self-sufficiency, which, as shown by the examples discussed above, can lead to the establishment of a system which is more sustainable from the perspective of financing and supply security and which contributes more to the development of domestic economy.

Another key conclusion is that several countries have been able to achieve substantial results in the transformation of their energy systems in just a few years' time (which, in the energy sector, is a relatively short period of time). In that field, the role of political will and action cannot be overemphasised, which also sheds light on how untenable it is to see existing systems as unchangeable. Yet it is also evident that the decisions and inaction of political decision-makers make the energy system of a given country "stuck" on an unfavourable path for a long time. This scenario is clearly disadvantageous in crisis situations that regularly arise in the fossil fuel markets, for instance due to high exposure to import.

Currently, the range of new technologies that have emerged in the last decades also contributes to a shift towards sustainability – provided that in the government there is a real will to do so. As shown by the examples discussed above, countries always have a choice when making decisions about a renewable-based redesign of their energy supply. Countries which are truly successful are making attempts to maximise the use of all their own resources in the elaboration of their energy mix, and, doing so, they often better address not only climate protection issues, but also concerns of security of supply than their counterparts which rely mostly on conventional resources do.

Written by: András Major

Sources/references:

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Nuclear_energy_statistics

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU_energy_mix_and_import_dependency#Energy_mix_and_import_dependency

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Coal_production_and_consumption_statistics
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Oil_and_petroleum_products_-_a_statistical_overview&oldid=315177#Production_of_crude_oil

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=EU_energy_mix_and_import_dependency#Natural_gas

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_supply_statistics

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_latest_trends_from_monthly_data#Consumption_of_petroleum_products

https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

https://ec.europa.eu/eurostat/databrowser/view/t2020_rd300/default/table

https://www.economist.com/graphic-detail/2021/08/15/can-europe-go-green-without-nuclear-power

https://www.euronuclear.org/glossary/nuclear-power-plants-in-europe/

https://ember-climate.org/insights/research/european-electricity-review-2022/

https://www.iea.org/countries

https://iea-gia.org/about-us/members/iceland/

https://nea.is/geothermal/

https://app.electricitymap.org/map

https://data.worldbank.org/indicator/AG.LND.FRST.ZS?locations=EU

https://ourworldindata.org/energy#country-profiles

https://www.reuters.com/markets/commodities/belgian-government-reaches-deal-nuclear-exit-media-2021-12-23/

https://www.reuters.com/article/belgium-nuclearpower-idAFL5N2VL56G

https://www.swissinfo.ch/eng/energy-deemed-most-serious-problem-facing-economy/47666048

https://www.swissinfo.ch/eng/nuclear-energy-strategy-switzerland-russia-ukraine-electricity-renewables/47610154

https://www.world-nuclear-news.org/Articles/Majority-of-Swiss-support-nuclear-new-build

https://www.wartsila.com/insights/article/italys-energy-system-basks-in-the-sun

https://www.government.is/topics/business-and-industry/energy/

https://www.un.org/en/chronicle/article/icelands-sustainable-energy-story-model-world

https://www.energymonitor.ai/sectors/power/weekly-data-russian-uranium-supply-chains

https://www.cleanenergywire.org/news/europe-highly-dependent-russian-uranium-nuclear-power-plants-report

https://www.sciencedirect.com/science/article/pii/S0301421521002330

https://wiseinternational.org/sites/default/files/u93/climatenuclear.pdf

https://www.sciencedirect.com/science/article/abs/pii/S0196890408000575