# Energy in Slovenia and Worldwide

OVERVIEW OF THE STATE OF THE ENERGY INDUSTRY, ITS TRENDS AND CHALLENGES

EICS ENERGY INDUSTRY CHAMBER OF SLOVENIA

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Ana Vučina Vršnak, MSc

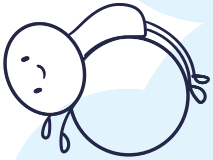
EICS ENERGY INDUSTRY CHAMBER OF SLOVENIA

# *WHAT IS ENERGY?*

# THE YOUNG

Mark, now 11: Energy is essential for life. Without it there is no life or anything. It is important that energy is “good” and that it is not destructive.

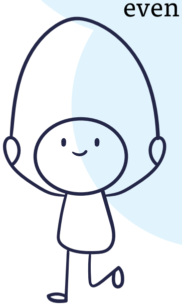
Ana, 10: You get energy when you wake up in the morning because you produced it during the night. You need it above all to do sport, hang out with friends and have fun. We extract energy from the sun's rays with solar panels, from lightning, water and wind.



Adam, 6: Energy is POWER! Energy powers an electric car.

Iva, 14: Energy is the ability to do work, it is indestructible but it can change its form.

Zala, 12: Energy is something that flows. It's all around us, even if we can't see it.

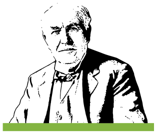


Lana and Zoja, 14 and 11: Energy is inside us and all around us. Energy helps us create.

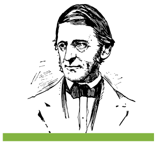
# THE FAMOUS

Talent is like electricity. We don't understand electricity. We use it.
Maya Angelou

I have not failed. I've just found 10,000 ways that won't work.
Thomas Edison



The world belongs to the energetic.
Ralph Waldo Emerson



Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.
Marie Skłodowska-Curie

# PREFACE

The updated publication *Energy in Slovenia: Overview of the State of the Energy Industry, Its Course, and Its Challenges*, which was first published in April 2021, is being upgraded with this second edition published in 2025. In just four years, we have seen significant shifts in the world and in the energy sector as a whole. With Russia's aggression against Ukraine, the energy landscape in Europe and the world has changed.

Digitalisation is bringing more and more challenges, including large data centres, which are a major consumer of energy. Consumers and companies are particularly interested in the price of the energy they need to live and work. We have included all these important aspects in the second edition of this publication. However, we have retained the essential sections from the first edition, which shed light on the energy sector in Slovenia, the European Union and the world, as well as the activities of the Energy Industry Chamber of Slovenia. We have updated this central part to include the latest data available until autumn 2024.

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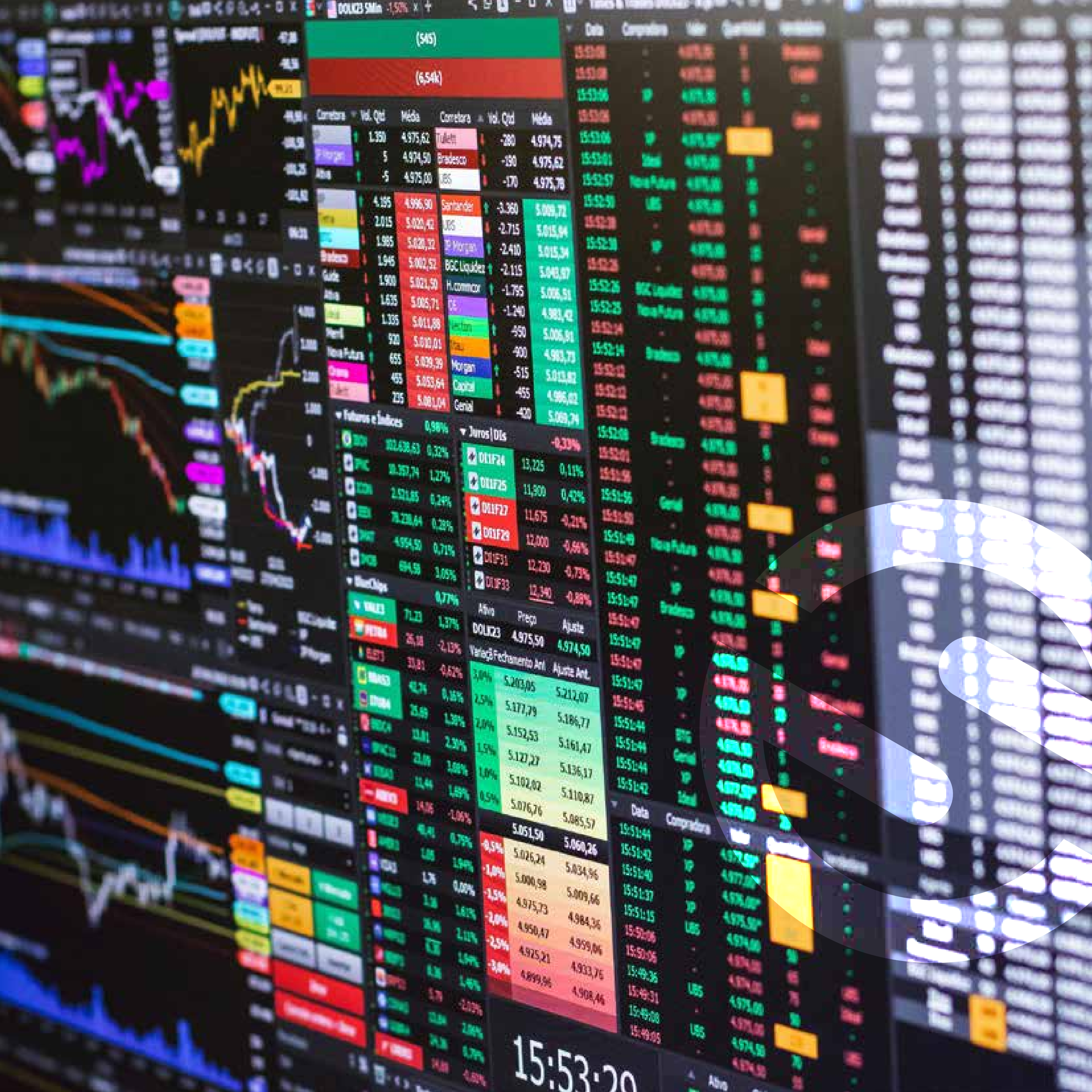
# 1

## VERIFIED DATA IS RELIABLE DATA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BlueChips
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In a world awash with data, the right information—that is, information to which we attach value—is worth its weight in gold. Having the right information at the right time can make all the difference to anyone, whether an individual, a household, a business, an institution or an entire country.

We must endeavour to ensure that our analyses and strategies only use validated data provided by qualified institutions. This includes data from official institutions that deal with statistics: At local level this is the Statistical Office of the Republic of Slovenia (SURS) and at EU level it is Eurostat. Verified data ensure objectivity and reliability, which is crucial for the development of effective energy policies and strategies.

Any discussion or planning must be based on accurate, official and high-quality data. That way, we always know what we are talking about. Energy affects different groups, practically all groups in society, who have different views and interests. It is therefore not unusual that in debates about energy and the highly topical energy transition, opinions clash on issues such as energy sources (fossil fuels, gas, renewables), infrastructure (which facilities are suitable and where), ownership and, of course, price…

In addition to data quality, it is also important to use the right descriptors (definitions) for the phenomena. For example, when we say “energy mix”, do we know exactly what we are talking about? When we say that greenhouse gas emissions have increased, do we know what time period we are talking about? When we talk about expensive electricity because we believe our electricity bill is too high, do we know exactly what we are paying and what the prices are in other countries?

In addition to the statistical offices, data is published by various other institutions and a number of companies that are trusted by a large majority. In the energy sector, analyses from the Paris-based International Energy Agency (IEA), the US Energy Information Administration (US EIA), the International Renewable Energy Agency (IRENA), a number of energy regulators and their associations, as well as various interest groups and companies (BP's Energy Outlook is a well-known example) are frequently cited. Reports and analyses based on verified, i.e. reliable data, provide valuable insights into the state, trends and challenges and thus form a basis for energy forecasts.

The Energy Industry Chamber of Slovenia (EICS) comprises several sections that are linked to various European or global organisations that are equally trustworthy. These include:

- Eurelectric, the Brussels-based association of the European electricity industry (there is a Eurelectric Section within EICS).
- International Association for Energy Economics (IEE), based in Cleveland, Ohio (a section within EICS is called the Slovenian Association for Energy Economics (SAEE)).
- World Energy Council (WEC) based in London, UK (a section within EICS is the Slovenian National Committee of WEC (SNK WEC)).

## *EICS is a member of Energy Statistics Advisory Committee and Price Statistics Advisory Committee at SURS*

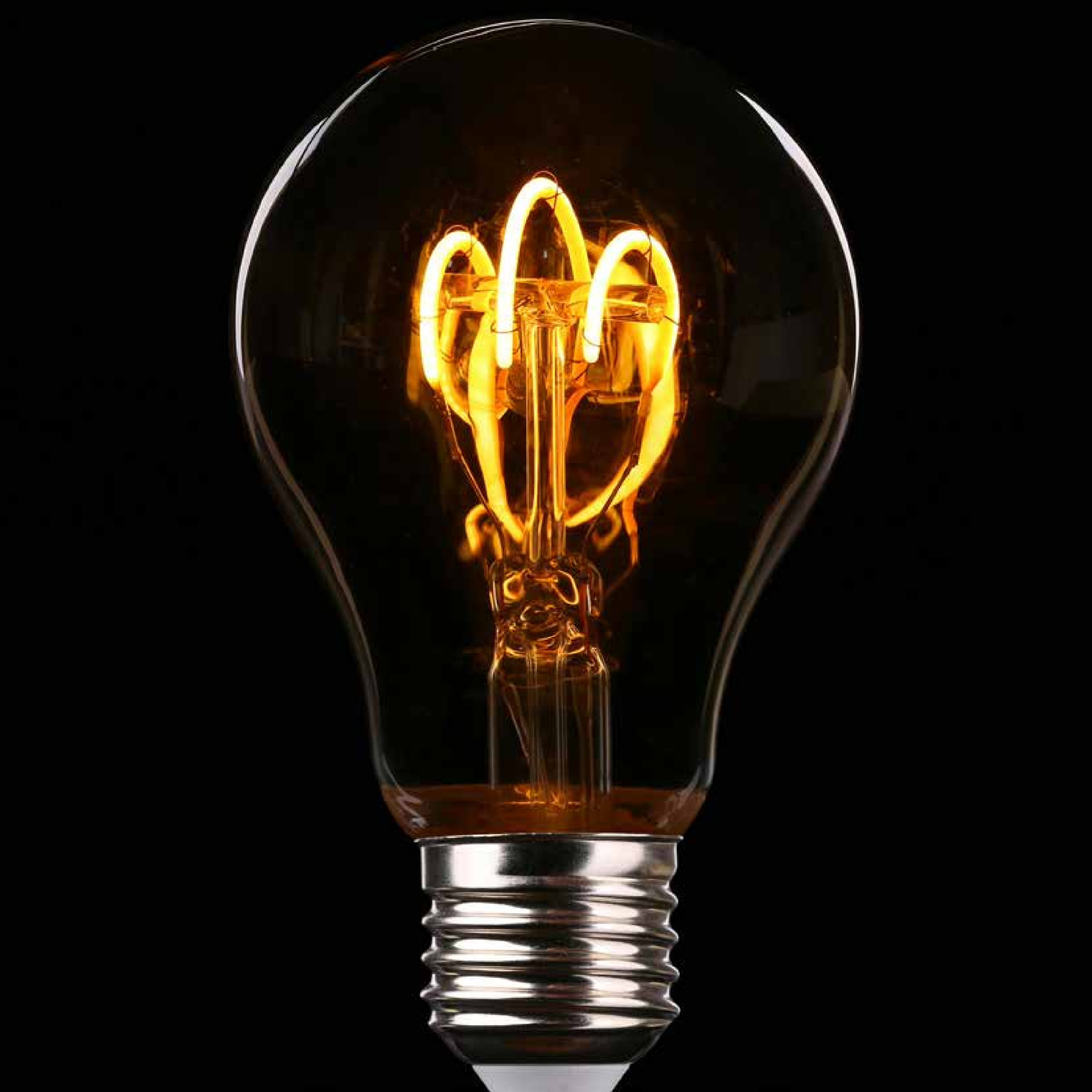
EICS endeavours to focus on the quality of the information it uses in its discussions and decisions on energy issues, both at national level and at sectoral or individual (company) level.

EICS is a member of the Price Statistics Advisory Committee within Statistical Office of the Republic of Slovenia (SURS). The aim of this advisory committee is to keep its members informed about current achievements and activities related to the collection of price information and the publication of research results, and to exchange important information on changes in methodology and other aspects in this area.

EICS is also a member of the Energy Statistics Advisory Committee within Statistical Office of the Republic of Slovenia (SURS), whose aim is to provide a broader expert community with an insight into the current situation regarding energy statistics and the opportunity to participate in the decision-making process on the course and scope of statistical research in this area. A priority task of this advisory committee is to ensure that all changes in the energy sector are appropriately translated into changes and amendments to statistical research.

# 2

## HOW DO WE MEASURE ENERGY?



# *How do we measure energy?*

The basic unit of energy is the joule (J). As the joule is a relatively small unit of measurement, it is often preceded by metric prefixes such as kilo (k), mega (M), giga (G), tera (T), peta (P), each of which indicates multiplication by a thousand. So:
1 kJ = 1,000 J; 1 MJ = 1,000 kJ; 1 GJ = 1,000 MJ; 1 TJ = 1,000 GJ; 1 PJ = 1,000 TJ.

Other energy units are used in other areas, to name just a few examples:

- In the food sector, the unit of energy used is the kilocalorie (kcal), where 1 kcal = 4,184 J.
- In the energy sector, the unit used is the watt hour (Wh), where 1 Wh = 3,600 J.
- In the energy sector, we also use tonnes of oil equivalent (toe), where 1 toe = 0.01163 GWh or 1 GWh = 86 toe (one toe is the amount of energy released when 1 tonne of crude oil is burned).

***1 PJ = $10^{15}$ J = 278 GWh = 24,000 toe***

# *How do we "measure" the height of our energy bill?*

The joule is not the most useful unit when it comes to large amounts of energy consumed in households or industry. For this purpose, the kilowatt hour (kWh) has been agreed upon, which indicates how many kW (i.e. how many times 1,000 W) of energy is delivered in one hour.

Example: If a 40 W light bulb burns for 24 hours, we "decant" 40 W x 24 h = 960 Wh (almost 1 kWh) of electricity into light and heat.

At the end of each billing period, the electricity suppliers receive the data from the now mostly digital metres, which can measure consumption at 15-minute intervals. Based on this, the suppliers issue the electricity bill to the consumer. The amount on the bill depends on the electricity consumed (in kWh) and the contracted capacity (in kW) in different time blocks and seasons. By adjusting consumption in the individual time periods, consumers can control their energy costs.

**The difference between kW and kWh:**

- The kW (kilowatt) refers to the power, i.e. the current load on the electricity grid. For example, if you have an electric heater with an output of 2 kW, this means that it consumes 2 kW of power while it is running.
- The kWh (kilowatt hour) indicates the energy consumption over time. If a 2-kW heater runs for one hour, it consumes 2 kWh of energy. If it runs for half an hour, it consumes 1 kWh.

**Why is this important for billing?**

The network charge is currently calculated not only on the basis of total consumption (kWh), but also on the basis of the maximum load (kW) during certain periods. If you exceed the contracted capacity (kW), you may be charged a higher tariff. This means that it is not only important how much energy you use, but also when and how you use it.

3

# PRIMARY ENERGY WORLDWIDE

WHICH COUNTRIES HAVE THE MOST NATURAL ENERGY SOURCES AND WHICH ARE THE BIGGEST EXPORTERS?

# *Natural resources in the form of primary energy sources are distributed diversely*

When we speak of primary energy sources, we mean oil, natural gas including liquefied natural gas or petroleum gas, nuclear energy (uranium), coal, biomass.

Biomass in the form of firewood, wood chips or wood pellets belongs to the renewable energy sources, which also include resources from ongoing natural processes of the sun, wind and water, and also geothermal energy.

Everything else stated above—oil, gas, coal, uranium—is categorised as non-renewable energy.

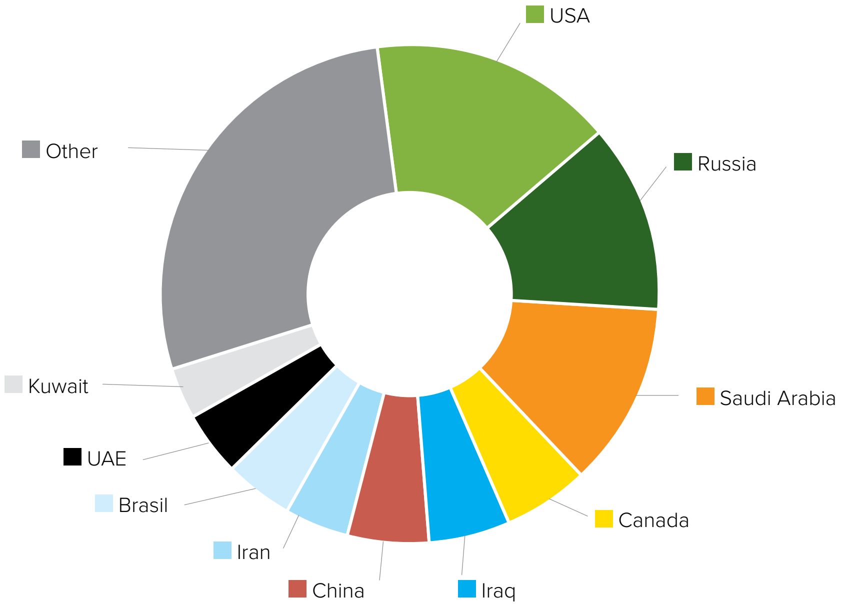
Electricity is not a primary energy source, but a secondary source, as it is derived from primary energy (*see next chapter*).

# *Which countries have the most primary energy sources (i.e. which are the biggest energy producers)?*

Some countries have an abundance of energy sources while others do not.

For example, the U.S., Saudi Arabia, and Russia are the largest oil producers, while in Europe oil is only produced in countries such as Norway, the UK, Romania, Denmark and Italy (US EIA, 2025).

*Figure 1: Crude oil production by countries in 2023 (in million barrels per day and as %)*




| 2023 | Million barrels per day | Percentage |
|---|---|---|
| **World** | **81.7** | **100** |
| | | |
| USA | 12.9 | 15.8 |
| Russia | 10.1 | 12.4 |
| Saudi Arabia | 9.7 | 11.9 |
| Canada | 4.6 | 5.6 |
| Iraq | 4.3 | 5.3 |
| China | 4.2 | 5.1 |
| Iran | 3.6 | 4.4 |
| Brazil | 3.4 | 4.2 |
| United Arab Emirates | 3.4 | 4.2 |
| Kuwait | 2.7 | 3.3 |
| OTHER | 22.8 | 27.9 |

*Source: US EIA (2024)*

The U.S. and Russia are the leading producers of natural gas, followed far behind by Iran, China, Canada, Qatar, Australia, and Norway (US IEA, 2025).

China is by far the largest coal producer in the world, followed by India, Indonesia, the U.S., Australia, Russia, South Africa, Germany, and Poland (US EIA, 2025).

Kazakhstan, Canada, and Namibia are the three largest producers of uranium for nuclear energy utilisation. These three countries account for more than two thirds of global uranium production (World Nuclear Association, 2024).

## *Which countries are the biggest exporters?*

Some countries export their energy sources, while others import them. Based on each country's energy imports, we can calculate its energy import dependency. However, not all countries export energy, as some use certain resources themselves.

The top exported commodity in the world today is oil. The biggest oil exporters are also the biggest oil producers, the only difference being different ranks on both lists. The four largest exporters in 2023 were the U.S., Russia, Saudi Arabia, and Canada. Their combined share accounted for over 40% of global crude oil exports (The Observatory of Economic Complexity (OEC), 2025).

In recent years, the U.S. has been the leading oil exporter, followed by Russia and Saudi Arabia, which alternated in second and third places, and Canada ranking fourth. These four countries appear to be holding on to their top positions in crude oil exports (OEC, 2025).

The top five exporters of natural gas in 2022 were the U.S., Russia, Qatar, Norway, and Australia. They sold more than half (56.9%) of the natural gas shipped worldwide. Russia was the leading gas exporter in 2020 and 2021, followed by the U.S. (US EIA, 2025).

In 2023, the U.S. became the world's largest exporter of liquefied natural gas (LNG) with an average of 11.9 billion cubic metres per day, an increase of 12% compared to 2022. The majority of exported LNG went to Europe (66%), followed by Asia (26%), and Latin America and the Middle East (8% combined). Other large exporters of LNG, following the U.S., include Australia, Qatar, Russia, and Malaysia. European demand remains strong due to lower imports of Russian pipeline gas (US EIA, 2024).

And what about coal export? The world’s leading exporters of coal are Indonesia, Australia, Russia, the U.S., and South Africa. In 2022, they together accounted for 85.2% of the total value of coal sold on international markets (US EIA, 2025). However, the largest exporters do not include the two largest producers, China and India, as they consume most of what they produce themselves.

It should be added that primary resources are consumed directly or indirectly. Direct consumption includes, for example, fuel for vehicles or machinery, while indirect consumption includes fuel for electricity and heat generation (*see next chapter*).

# 4

# SECONDARY (ELECTRIC) ENERGY WORLDWIDE

FOSSIL FUELS / NUCLEAR ENERGY / RENEWABLES

Electricity is generated in power plants from a variety of primary energy sources such as fossil fuels (coal, gas, oil), nuclear energy and renewable energy sources, mainly hydro, wind and solar energy. In power plants, primary forms of energy are converted into electricity via turbines and electrical generators (or more precisely: primary forms of energy are converted into kinetic energy, which is then converted into mechanical work in turbines; the latter drives the generator and we in turn obtain electricity through conversion).

Electricity is a type of energy generated by the movement of electrically charged particles, usually electrons, through a conductor. It is used to power many devices and systems, from household appliances to industrial machines.

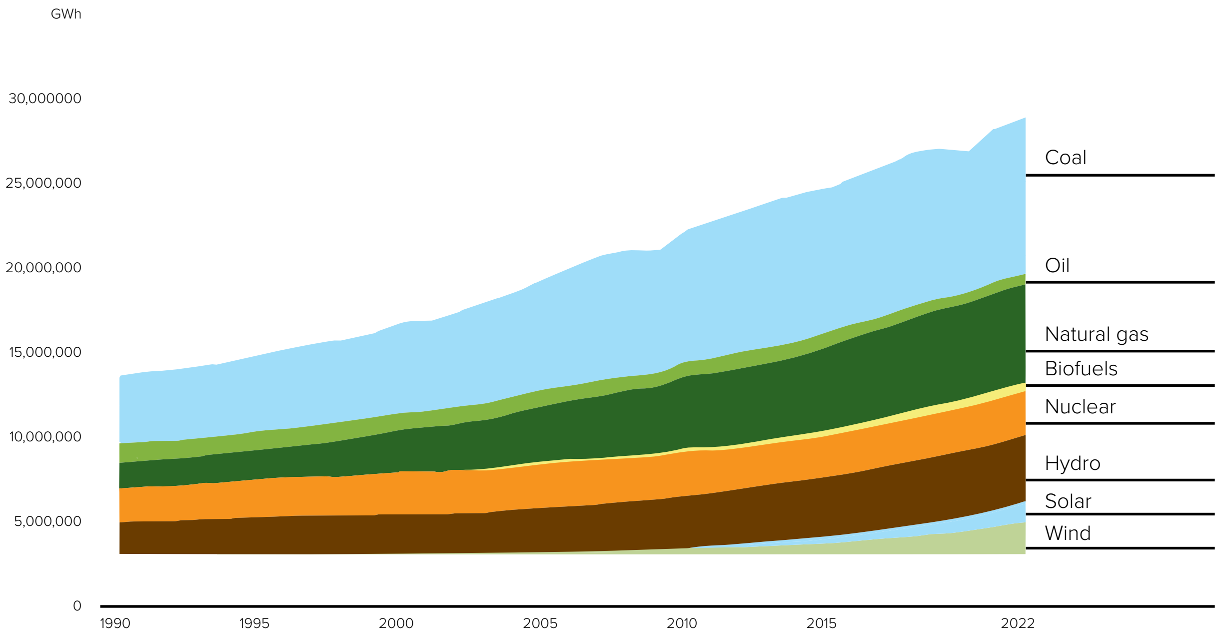
Electricity is one of the most useful forms of energy. Its advantage is that it can be transmitted efficiently (i.e. without significant losses) over long distances and easily converted into other forms of energy such as mechanical energy, light, and heat. The conversion of electricity into other forms of energy does not pollute the environment. These are some of the reasons why electricity is considered by experts to be a high-quality form of energy.

While primary energy sources such as coal, oil, or gas can be stored, this is not quite the case with electricity. It cannot be stored directly, as it is an energy flow. This also means (and therefore poses an additional challenge) that there must always be a balance in the electricity system between the generation and consumption of electricity. This balance is ensured by system operators (such as ELES in Slovenia) through primary, secondary and tertiary regulation. Although it is possible to store electricity in storage devices (batteries), this is only suitable for limited, small quantities and not for huge volumes. Pumped-storage hydropower plants are another way of storing electricity. In times of electricity surplus, the power plant pumps water from the lower reservoir to the upper reservoir (of course, consuming some energy in the process), while in times of electricity shortage, the water from the upper reservoir is released to the lower reservoir, generating electricity on its way down. There is a pumped-storage hydropower plant in Slovenia—the Avče hydropower plant on the Soča River—which has been in operation since 2009.

As a society, we want to have electricity available at all times. This means that there must always be a bit more (or at least the same amount) of electricity in the system than is consumed.

Countries around the world generate most of their electricity from coal, gas and oil—in other words, from fossil fuels—, followed by renewables and nuclear power. Hydropower, solar and wind dominate the renewable energy sector. The transition from an energy system based primarily on fossil fuels to a system based on renewable energy sources is known as the energy transition or green transition.

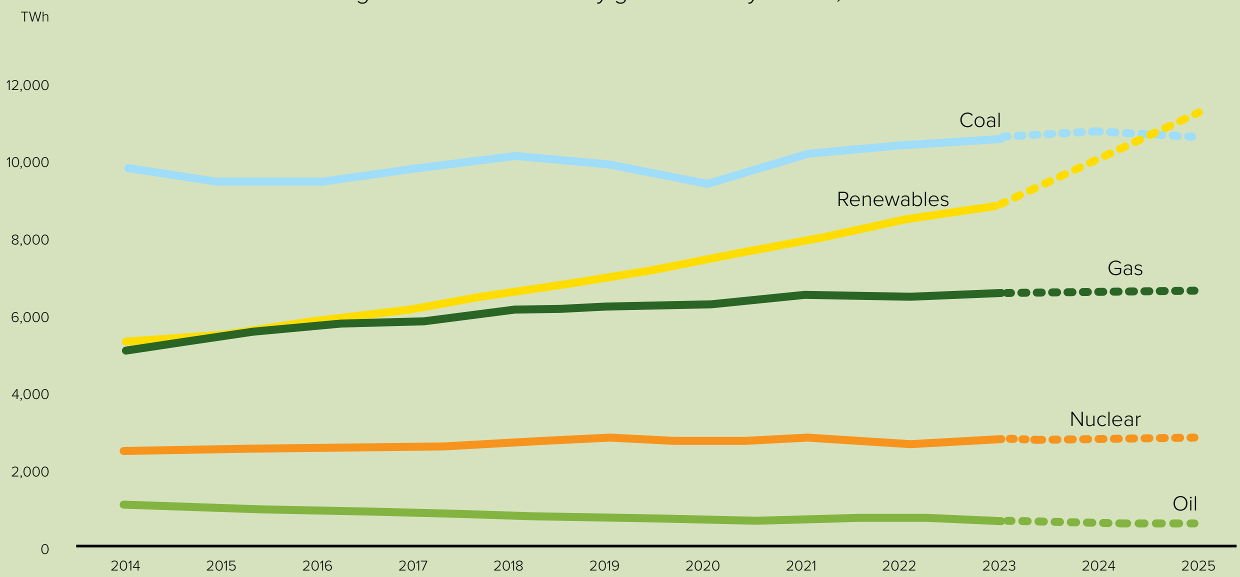
*Figure 2: Global electricity generation by source, 1990-2022*




*Source: IEA (2024)*

Over the last decade, electricity generation from all sources has remained almost constant, with the notable exception of renewable energy sources (RES), whose share has grown steadily.

*Figure 3: Global electricity generation by source, 2014-2025*




*Source: IEA (2024)*

It should be added that the Americas, Australia, and Europe continue to produce a relatively constant amount of electricity, while on the other hand electricity production in Asia is growing. Total global electricity production is therefore increasing, mainly on account of Asia.

# *Fossil fuels*

Fossil fuels have formed from the remains of plants and animals that lived millions of years ago. They include coal, crude oil and natural gas, but also uranium. They provide the majority of the energy we need today for cooking, powering cars and transport, and for heating.

**Coal** has been used for centuries. It was used as a fuel by the Chinese 3000 years ago and later by the Greeks (4th century BC) and the Romans. The earliest records of the use of coal in Europe date back to the Middle Ages in England, where coal was first used by local blacksmiths. In Slovenia, coal was first mentioned in 1647 and then again in 1678 in the inventory records of pharmacies in Ljubljana under the name “dragon's blood” (lat. *Sangvis draconis*). Valvasor also wrote in 1689 that coal, i.e. dragon's blood, was often used by pharmacists to cure sick cattle. The first accidental discoveries of coal in Slovenia date back to the 17th century, while more systematic coal prospecting began in the second half of the 18th century.

**Crude oil** has been known and used since ancient times. It was mainly used as an ointment for medicinal purposes. The world only began to use crude oil as a fuel after the invention of the internal combustion engine about 100 years ago. Apart from transport, it is also used for many other purposes: for the production of plastics, chemical products, asphalt, fertilisers, pesticides and other chemical compounds, as well as for fuels.

**Natural gas** was used in China as early as 900 BC as a gas for lamps. Between 100 and 125 AD, there were written records of the “eternal flames” in Iraq. Researchers believe that the gas escaping from the ground was ignited by a lightning strike. Around 1800, gas was piped into homes so that people could use it for cooking, lighting, and heating.

Fossil fuels are associated with air pollution and climate change, yet they are still used to generate much of our electricity and heat. Burning fossil fuels releases air pollutants (nitrogen oxides, sulphur oxides, non-methane volatile organic compounds and particulate matter) and greenhouse gases (carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$) and the so-called F-gases, which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$)) into the atmosphere. The combustion of biomass can also have a similar impact on air quality and climate change. Natural gas is the cleanest of the fossil fuels, as no air pollutants are produced during its combustion. It is colourless, odourless, tasteless, lighter than air and non-toxic. It consists mainly of the gaseous hydrocarbon methane, which is highly flammable and burns almost completely. It can also be used to produce other gaseous hydrocarbons such as propane and butane, which are sold as household gas in gas cylinders. Although natural gas burns without smoke and does not pollute the environment, its combustion produces carbon dioxide gas. Although the latter is non-toxic, large quantities of it cause global warming.

Fossil fuels are a non-renewable energy source and are not available in unlimited quantities, so their exploitation is finite.

Replacing coal and crude oil with cleaner alternatives can undoubtedly contribute to a significant reduction in greenhouse gas (GHG) emissions—especially in industrial sectors that are closely linked to electricity consumption in particular. Such a move will indeed contribute to the energy transition we are witnessing in Europe and beyond—it is a shift from a fossil fuel-based energy system to one based on low-carbon and renewable energy sources (RES).

If the transition is to be successful, the whole world must be involved. In 2015, world leaders agreed on targets to combat climate change under the Paris Agreement. Its long-term goal is to limit the increase in the global average temperature to well below 2°C above pre industrial levels or 1.5°C. At EU level, however, in December 2019, countries agreed on a new growth strategy to transform the Union into a modern, resource-efficient and competitive economy. The European Green Deal aims to reduce net greenhouse gas emissions to zero by 2050, create an economy that is no longer dependent on resource use, and leave no one behind.

# *Nuclear energy*

**Uranium**, a silvery white solid metal that is also a fossil fuel but is treated here under nuclear energy, is used to power commercial nuclear reactors to generate electricity and to produce isotopes that are used worldwide for medical, industrial and military purposes.

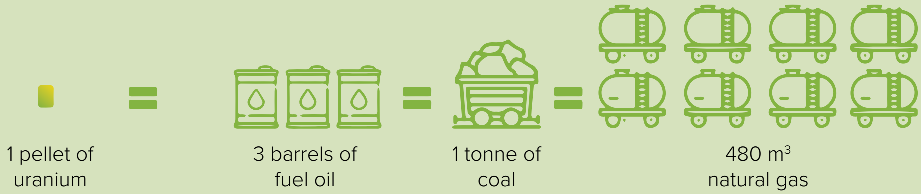
Uranium is a chemical element that has been present in the Earth's crust since the formation of our planet. It is an unstable element which gradually decays, releasing energy in the process and thus contributing to the geothermal energy of our planet. The element was discovered in 1789 in the ore uraninite (also known as pitchblende) and was initially used for many years mainly as a colourant for ceramic glazes and for toning in the early days of photography. In 1896, the French physicist Antoine Henri Becquerel discovered that it is radioactive. The phenomenon was well researched by the French physicist Pierre Curie and the Polish-born physicist and chemist Marie Skłodowska-Curie. For their work on radioactivity, all three were awarded the Nobel Prize in Physics in 1903 (one half to Becquerel and the other half jointly to Pierre and Marie Curie).

## *Marie Skłodowska-Curie and the concept of radioactivity*

In 1896, Antoine Henri Becquerel discovered that uranium salts radiate (i.e. emit energy). Marie Curie then chose to investigate this new natural phenomenon as the subject of her doctoral thesis. This research also led to the discovery of two new elements, radium and polonium. She realised that the radioactivity of uranium ore is stronger than that of pure uranium. She discovered that the radiation is produced when the nuclei of uranium atoms decay. She called the radiation radioactivity. She made a major contribution to advances in cancer treatment. She is the first woman to win the Nobel Prize and the only woman to have received two Nobel Prizes in different fields (physics and chemistry).

Radioactivity is a phenomenon in which an unstable atomic nucleus decays. During decay, another nucleus is created and a high-energy particle is released at the same time. The potential of using uranium as an energy source was only recognised in the middle of the 20th century.

*Figure 4: Power of a uranium pellet*




*Source: NEK (2025)*

A uranium fuel pellet (1 cm in size) contains as much energy as eight tank containers of natural gas. Nuclear fission takes place in the core of the reactor. It is also known as a controlled chain reaction, as the uranium nuclei are split in a controlled manner, releasing energy in the form of heat.

Slovenia mined uranium ore at Žirovski vrh in the Poljanska dolina valley from 1982 to 1990, but the mine has not been in operation since then and is currently being closed.

Nuclear energy is considered a low-carbon energy source because nuclear power plants do not emit greenhouse gases into the atmosphere during their operation. Even if we take into account fuel production and nuclear waste disposal over the entire operating cycle, the carbon ($CO_2$) footprint of a nuclear power plant is small compared to other power generating technologies.

Each country can decide on its own energy mix and is completely independent in its decision. This means that the decision in favour of or against nuclear energy is entirely up to the country and is not imposed on it by anyone, not even the European Commission within the EU. In the EU, around a good fifth (22.8% in 2023) of electricity is generated from nuclear energy, making it one of the most important energy sources alongside fossil fuels and renewables (Eurostat, 2025).

According to the World Nuclear Association (WNA), there are around 440 nuclear reactors in operation worldwide, located in around 30 countries (WNA, 2025).

In 2020, for example, around 440 nuclear reactors were in operation in 30 countries and Taiwan. In 2019, they supplied 2,657 TWh of electricity, or more than 10% of the world's electricity. In 2023, they contributed 2,602 TWh of electricity (including an estimate of Ukraine's production for 2022 and 2023), which corresponds to around 9% of global electricity generation. In 2025, 440 nuclear reactors were in operation in 31 countries around the globe (WNA, 2025).

These figures alone can be misleading, as the situation appears to be more or less unchanged. In reality, only the number of reactors has remained stable, while the background is quite dynamic. New nuclear power plants come online and older ones are retired, so that the ratio remains more or less balanced. In the last 20 years (2004-2023), 107 reactors have been retired and 100 have come online. However, the new reactors were on average larger than those that were taken off the grid, meaning that capacity has increased by around 19 GW. By 2040, a further 66 reactors are to close and 308 new reactors (including 31 Japanese reactors) are to be connected to the grid (WNA, 2024).

According to the World Nuclear Association, 55 reactors were under construction in 15 countries in 2020, with China, India, Russia and the United Arab Emirates (UAE) leading the way. In 2024, 64 reactors were under construction in 16 countries, most of them in Asia (of which 30 in China). In Europe, nuclear reactors were being built in France, Slovakia, the UK, Turkey, and Ukraine. Additional 88 reactors were planned worldwide in 2024, including 41 in China, 14 in Russia, and 12 in India. In Europe, new reactors are planned in Bulgaria, the Czech Republic, Hungary, Poland, Romania, Sweden, the UK, and Ukraine (WNA, 2025).

China is therefore the leader when it comes to the construction and planning of new nuclear power plants. However, China is not building nuclear reactors in other parts of the world. Despite the war in Ukraine, Russia is still the market leader in the global construction of nuclear reactors, according to The World Nuclear Industry Status Report 2023 (A Mycle Schneider Consulting Project, 2023).

We have already mentioned that more than 100 reactors have been shut down worldwide in the last two decades. Some countries, notably Germany, have decided to decommission nuclear power plants. Germany and Switzerland, for example, are phasing out nuclear energy. In Germany, public opinion is not in favour of building new nuclear power plants and it became even stronger after the accident in Fukushima, Japan, in 2011. What happened? There was an earthquake, which did not damage the power plant's safety systems, but a massive aftershock (tsunami) flooded the Fukushima Daiichi multi-reactor nuclear power plant and disabled the safety systems. After the Fukushima event, analyses of the resilience of nuclear power plants to extreme events were carried out around the world, including in Slovenia, and improvements to the safety features of the plants were introduced. Additional investments were made in maintenance and safety measures.

Some countries are seen as traditional opponents of nuclear energy and are trying to enforce this position on other countries. One such example is Austria, which has drawn attention to various aspects of nuclear power plants in its neighbouring countries, such as Slovenia. It is interesting to note that Austria opted for nuclear energy in the 1960s and built its first nuclear power plant, but never commissioned it due to a referendum in 1978 in which voters were against it.

## *Small Modular Reactors (SMRs)*

Small Modular Reactors (SMRs) represent a new direction in the development of nuclear energy. They combine an innovative modular design and advanced safety systems, with a maximum output of 300 MWe per unit—about a third of the capacity of conventional nuclear reactors. As a low-carbon energy source, they offer a number of advantages: smaller size compared to conventional reactors, the ability to assemble systems and components in factories, and easy transport to the installation site. However, their operation is based on the same principle as larger reactors—nuclear fission produces heat, which is then converted into electricity.

Although NuScale Power was the first company to licence its SMR design, the technology has not yet reached the stage of commercial deployment. Currently, the only commercially operating SMR is the Russian Akademik Lomonosov—a floating nuclear power plant with two 35 MWe units. The first commercial SMRs are planned for the next decade, although their successful realisation still depends on further development and regulatory processes. Nevertheless, they represent a significant technological advance and offer a promising option for a stable, low-carbon energy future.

# *Renewable energy sources (RES)*

As fossil resources are limited, humanity is looking for energy sources that can be utilised without fear of them running out or damaging the planet. Renewable energy sources include all energy sources that we obtain from ongoing natural processes—they never run out (even though we know that nothing lasts forever!) and they are fairly evenly distributed. Renewable energy includes solar radiation, wind, the flow of water in rivers, photosynthesis (biomass), terrestrial heat flows (geothermal energy) and ocean currents (waves, tides).

Compared to fossil fuels, the use of RES produces fewer greenhouse gas emissions. Therefore, the impact of RES on environmental quality is much lower. While some argue in favour of increasing the use of only certain renewable energy sources, it is advisable to consider all potentials in a given area and develop them in line with sustainable development guidelines.

Slovenia, for example, has a large amount of forests, so biomass undoubtedly represents a great potential in terms of using wood as an energy source, thus promoting the transition to a higher share of renewable energy. Slovenia is in fact one of the most densely forested countries in Europe, with around 60% of the country's surface area covered by forest. The country should also not neglect the possibility of producing biomethane from wood biomass, municipal waste, sludge from wastewater treatment plants, chemical residues, and other sources. Slovenia is also a water-rich country with plenty water resources worth utilising. As regards both biomass and water, the tendency is to follow the principles of sustainable development, including the preservation of biodiversity.

On the other hand, a desert country where the sun shines all day will surely utilise the land primarily for solar energy. Windy areas, particularly offshore, are suitable for wind turbines, and it makes sense to harness the wave power of the sea as well.

Geothermal energy is the energy contained in the Earth's hot interior, which has not yet cooled down since its formation and is partly heated further by nuclear reactions in the Earth's core. The heat is transferred from the core via the Earth's mantle to the surface. It can be used both for heating and to generate electricity in geothermal power stations—in principle, it can be utilised anywhere.

In general, there are four types of renewable energy that are at the forefront of electricity generation. In 2022 their shares were distributed as follows (IRENA, 2024):

- hydropower (51%)
- onshore wind energy (about 23%)
- solar (15%)
- solid biofuel (a good 5%)

Other renewable energies are utilised to a much lesser extent, but should not be neglected as they can be particularly important in a specific area. These include offshore wind energy, geothermal energy, biofuels, and renewable municipal waste (each contributing between 1 and 2%). The International Renewable Energy Agency (IRENA) under the United Nations adds some other renewables at the end of the list, namely concentrated solar power, liquid biofuels, and ocean energy (IRENA, 2024).

Looking at all renewable energy sources, China is by far the largest energy producer, both in terms of installed capacity and actual electricity generation. In terms of installed capacity in 2022, China was ahead of the U.S., Brazil, India, Germany, Japan, Canada, Spain, France, and Italy, while in terms of electricity generation, China was followed by the U.S., Brazil, Canada, India, Germany, Japan, Russia, Norway, and Turkey. As for newly installed capacity, Asia led the way with a dominating two thirds (IRENA, 2024).

Let us say a few words about the global trend we are seeing in renewable energies: As the range of renewable sources has expanded, the pattern of renewables is changing. While hydropower continues to account for the largest share of electricity generation, the share of intermittent renewables (wind and solar) in the global energy mix has increased from 1.1% in 2000 to 40.2% in 2022. Hydropower remained the largest renewable source of electricity in 2022, recording a modest increase of 0.8% compared to 2021, followed by wind energy, which recorded an increase of 14% in just one year. Solar energy was the fastest growing RES, with an increase of 25.6% in 2022 compared to the previous year. In 2023, solar energy made the largest contribution to renewable energy capacity with 36.7%, followed by hydropower with 32.7%, wind energy with 26.3%, bioenergy with 3.9% and geothermal and ocean energy with minor shares. The share of intermittent renewables (wind energy and solar energy) rose to 63% of renewable capacity, indicating a shift towards intermittent energy sources (IRENA, 2024). The intermittency of renewable energy sources and their increasing shares call for a more efficient solution to store them and thus stabilise the operation of energy systems. Solutions are also being sought for the production of renewable hydrogen (which is also key to the green transition of the industry that is difficult to adapt).

According to IRENA, solar energy is likely to remain the most important source of capacity in the coming years, preserving its dominance in the expansion of renewable capacity additions (providing 347 GW of the total 473 GW of renewable capacity additions in 2023). The installation of new RES capacity has increased significantly over the last 23 years, reaching a peak of 473 GW of new capacity in 2023 (IRENA, 2024).

Global electricity generation from renewables accounted for 29.1% in 2022, while the remaining 70.9% came from fossil fuels, nuclear energy, pumped storage, and other non renewable sources. Since 2011, total global electricity generation has increased by 2.4% compared to the previous year—renewable energies have grown by 6.1%, while the growth rate for non-renewable energies was 1.3% (IRENA, 2024).

The International Energy Agency (IEA) expects that solar energy alone will meet around half of the increase in global electricity demand in 2024 and 2025.

# *EU targets for renewable energies*

The EU has binding targets for the share of energy from renewable energy sources (RES). The EU countries have agreed to jointly achieve an EU-wide target of 20% renewable energy in the energy supply (i.e. in their energy mix) by the end of 2020, with each country having its own national target. The EU Member States have even exceeded this target with a 22% share of renewable energy in gross final energy consumption in 2020.

The targets for 2030 were gradually increased. First, building on the 20% target for 2020, the 2018 Renewable Energy Directive set a new binding target for the EU for 2030 of at least 32%. Then, in 2019, the EU emphasised in the European Green Deal that renewables will be central to the transition to clean energy, and in July 2021, the European Commission presented new climate targets for Europe in 2030, proposing to raise the target for the share of renewables in the overall energy mix to at least 40% instead of 32%. In May 2022, the Commission published its REPowerEU plan, in which it proposes a series of measures to reduce the EU's dependency on Russian fossil fuels by 2030 by accelerating the transition to clean energy. The REPowerEU plan is based on three pillars: energy saving, clean energy production, and diversification of the EU's energy supply. As part of efforts to increase the share of renewable energy in electricity generation, industry, buildings and transport, the Commission has proposed increasing the target in the Directive to 45% by 2030. Finally, in September 2023, the European Parliament approved the agreement with the Council, which sets a new target of **42.5% RES by 2030. Member States are obliged to work towards achieving the 45% target.**

The updated Renewable Energy Directive 2023/2413 therefore raises the EU's binding RES target to at least 42.5% by 2030, which is almost double the current share.

***In 2022, the share of renewable energy in the EU was 23%, which increased in 2023 to 24.5%.***

*Table 1: The share of renewable energy in gross final energy consumption in the EU (%)*

| | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|
| EU | 9.6 | 10.2 | 10.8 | 11.7 | 12.6 | 13.9 | 14.4 | 14.5 | 16.0 |
| Belgium | 1.9 | 2.3 | 2.7 | 3.1 | 3.6 | 4.7 | 6.0 | 6.3 | 7.1 |
| Bulgaria | 9.2 | 9.2 | 9.4 | 9.1 | 10.3 | 12.0 | 13.9 | 14.2 | 15.8 |
| Czech Republic | 6.8 | 7.1 | 7.4 | 7.9 | 8.7 | 10.0 | 10.5 | 10.9 | 12.8 |
| Denmark | 14.8 | 16.0 | 16.3 | 17.7 | 18.5 | 19.9 | 21.9 | 23.4 | 25.5 |
| Germany | 6.2 | 7.2 | 8.5 | 10.0 | 10.1 | 10.9 | 11.7 | 12.5 | 13.5 |
| Estonia | 18.4 | 17.5 | 16.0 | 17.1 | 18.8 | 23.0 | 24.6 | 25.5 | 25.6 |
| Ireland | 2.4 | 2.8 | 3.1 | 3.5 | 4.0 | 5.2 | 5.8 | 6.6 | 7.0 |
| Greece | 7.2 | 7.3 | 7.5 | 8.2 | 8.2 | 8.7 | 10.1 | 11.2 | 13.7 |
| Spain | 8.3 | 8.4 | 9.2 | 9.7 | 10.7 | 13.0 | 13.8 | 13.2 | 14.2 |
| France | 9.3 | 9.3 | 8.9 | 9.4 | 11.2 | 12.2 | 12.7 | 10.8 | 13.2 |
| Croatia | 23.4 | 23.7 | 22.7 | 22.2 | 22.0 | 23.6 | 25.1 | 25.4 | 26.8 |
| Italy | 6.3 | 7.5 | 8.3 | 9.8 | 11.5 | 12.8 | 13.0 | 12.9 | 15.4 |
| Cyprus | 3.1 | 3.1 | 3.3 | 4.0 | 5.1 | 5.9 | 6.2 | 6.2 | 7.1 |
| Latvia | 32.8 | 32.3 | 31.1 | 29.6 | 29.8 | 34.3 | 30.4 | 33.5 | 35.7 |
| Lithuania | 17.2 | 16.8 | 16.9 | 16.5 | 17.8 | 19.8 | 19.6 | 19.9 | 21.4 |
| Luxembourg | 0.0 | 1.4 | 1.5 | 2.7 | 2.8 | 2.9 | 2.9 | 2.9 | 3.1 |
| Hungary | 4.4 | 6.9 | 7.4 | 8.6 | 8.6 | 11.7 | 12.7 | 14.0 | 15.5 |
| Malta | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 2.9 |
| Netherlands | 2.0 | 2.5 | 2.8 | 3.3 | 3.6 | 4.3 | 3.9 | 4.5 | 4.7 |
| Austria | 22.6 | 24.4 | 26.3 | 28.1 | 28.8 | 31.0 | 31.2 | 31.6 | 32.7 |
| Poland | 6.9 | 6.9 | 6.9 | 6.9 | 7.7 | 8.7 | 9.3 | 10.3 | 11.0 |
| Portugal | 19.2 | 19.5 | 20.8 | 21.9 | 22.9 | 24.4 | 24.2 | 24.6 | 24.6 |
| Romania | 16.8 | 17.6 | 17.1 | 18.2 | 20.2 | 22.2 | 22.8 | 21.7 | 22.8 |
| Slovenia | 18.4 | 19.8 | 18.4 | 19.7 | 18.6 | 20.8 | 21.1 | 20.9 | 21.6 |
| Slovakia | 6.4 | 6.4 | 6.6 | 7.8 | 7.7 | 9.4 | 9.1 | 10.3 | 10.5 |
| Finland | 29.2 | 28.8 | 30.0 | 29.6 | 31.1 | 31.0 | 32.2 | 32.5 | 34.2 |
| Sweden | 38.4 | 40.0 | 41.7 | 43.2 | 43.9 | 47.0 | 46.1 | 47.6 | 49.4 |
| Iceland | 58.9 | 60.3 | 60.9 | 71.9 | 68.0 | 70.2 | 70.9 | 72.3 | 73.7 |
| Norway | 58.4 | 60.1 | 60.5 | 60.4 | 62.0 | 65.1 | 61.9 | 64.6 | 64.9 |
| Montenegro | 0.0 | 35.7 | 34.8 | 32.9 | 32.3 | 39.4 | 40.6 | 40.6 | 41.5 |
| Serbia | 12.7 | 14.3 | 14.5 | 14.3 | 15.9 | 21.0 | 19.8 | 19.1 | 20.8 |
| BiH | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Albania | 29.6 | 31.4 | 32.1 | 32.7 | 32.4 | 31.4 | 31.9 | 31.2 | 35.2 |
| North Macedonia | 15.7 | 16.5 | 16.5 | 15.0 | 15.6 | 17.2 | 16.5 | 16.4 | 18.1 |
| Kosovo* | 20.5 | 19.8 | 19.5 | 18.8 | 18.4 | 18.2 | 18.2 | 17.6 | 18.6 |
| Moldova | 7.5 | 6.4 | 7.0 | 6.4 | 7.0 | 7.9 | 21.4 | 22.1 | 24.3 |
| Georgia | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

*Source: Eurostat (2025)*

| 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|
| 16.7 | 17.4 | 17.8 | 18.0 | 18.4 | 19.1 | 19.9 | 22.0 | 21.9 | 23.0 |
| 7.7 | 8.0 | 8.1 | 8.7 | 9.1 | 9.5 | 9.9 | 13.0 | 13.0 | 13.8 |
| 18.9 | 18.1 | 18.3 | 18.8 | 18.7 | 20.6 | 21.5 | 23.3 | 19.4 | 19.1 |
| 13.9 | 15.1 | 15.1 | 14.9 | 14.8 | 15.1 | 16.2 | 17.3 | 17.7 | 18.2 |
| 27.2 | 29.3 | 30.5 | 31.7 | 34.4 | 35.2 | 37.0 | 31.7 | 41.0 | 41.6 |
| 13.8 | 14.4 | 14.9 | 14.9 | 15.5 | 16.7 | 17.3 | 19.1 | 19.4 | 20.8 |
| 25.4 | 26.1 | 29.0 | 29.2 | 29.5 | 30.0 | 31.7 | 30.1 | 37.4 | 38.5 |
| 7.5 | 8.5 | 9.1 | 9.2 | 10.5 | 10.9 | 12.0 | 16.2 | 12.4 | 13.1 |
| 15.3 | 15.7 | 15.7 | 15.4 | 17.3 | 18.0 | 19.6 | 21.7 | 22.0 | 22.7 |
| 15.1 | 15.9 | 16.2 | 17.0 | 17.1 | 17.0 | 17.9 | 21.2 | 20.7 | 22.1 |
| 13.9 | 14.4 | 14.8 | 15.5 | 15.8 | 16.4 | 17.2 | 19.1 | 19.2 | 20.3 |
| 28.0 | 27.8 | 29.0 | 28.3 | 27.3 | 28.0 | 28.5 | 31.0 | 31.3 | 29.4 |
| 16.7 | 17.1 | 17.5 | 17.4 | 18.3 | 17.8 | 18.2 | 20.4 | 18.9 | 19.1 |
| 8.4 | 9.1 | 9.9 | 9.8 | 10.5 | 13.9 | 13.8 | 16.9 | 19.1 | 19.4 |
| 37.0 | 38.6 | 37.5 | 37.1 | 39.0 | 40.0 | 40.9 | 42.1 | 42.1 | 43.3 |
| 22.7 | 23.6 | 25.7 | 25.6 | 26.0 | 24.7 | 25.5 | 26.8 | 28.2 | 29.6 |
| 3.5 | 4.5 | 5.0 | 5.4 | 6.2 | 8.9 | 7.0 | 11.7 | 11.7 | 14.4 |
| 16.2 | 14.6 | 14.5 | 14.4 | 13.6 | 12.5 | 12.6 | 13.9 | 14.1 | 15.2 |
| 3.8 | 4.7 | 5.1 | 6.2 | 7.2 | 7.9 | 8.2 | 10.7 | 12.7 | 13.4 |
| 4.7 | 5.4 | 5.7 | 5.8 | 6.5 | 7.4 | 8.9 | 14.0 | 13.0 | 15.0 |
| 32.7 | 33.6 | 33.5 | 33.4 | 33.1 | 33.8 | 33.8 | 36.5 | 34.6 | 33.8 |
| 11.5 | 11.6 | 11.9 | 11.4 | 11.1 | 14.9 | 15.4 | 16.1 | 15.6 | 16.9 |
| 25.7 | 29.5 | 30.5 | 30.9 | 30.6 | 30.2 | 30.6 | 34.0 | 34.0 | 34.7 |
| 23.9 | 24.8 | 24.8 | 25.0 | 24.5 | 23.9 | 24.3 | 24.5 | 23.9 | 24.1 |
| 23.2 | 22.5 | 22.9 | 22.0 | 21.7 | 21.4 | 22.0 | 25.0 | 25.0 | 25.0 |
| 10.1 | 11.7 | 12.9 | 12.0 | 11.5 | 11.9 | 16.9 | 17.3 | 17.4 | 17.5 |
| 36.6 | 38.6 | 39.2 | 38.9 | 40.9 | 41.2 | 42.8 | 43.9 | 42.9 | 47.9 |
| 50.2 | 51.2 | 52.2 | 52.6 | 53.4 | 53.9 | 55.8 | 60.1 | 62.7 | 66.0 |
| 73.8 | 73.0 | 71.9 | 75.3 | 74.1 | 77.2 | 78.6 | 83.7 | 80.2 | 79.5 |
| 66.5 | 68.4 | 68.5 | 69.2 | 70.0 | 71.6 | 74.4 | 77.4 | 74.0 | 75.8 |
| 43.7 | 44.1 | 43.1 | 41.5 | 39.7 | 38.8 | 37.7 | 43.8 | 39.9 | 39.9 |
| 21.1 | 22.9 | 22.0 | 21.1 | 20.3 | 20.3 | 21.4 | 26.3 | 25.3 | 24.7 |
| 0.0 | 24.9 | 26.6 | 25.4 | 23.2 | 36.0 | 37.5 | 39.8 | 36.6 | 0.0 |
| 33.2 | 31.9 | 34.9 | 37.0 | 35.8 | 36.6 | 38.0 | 45.0 | 41.4 | 44.1 |
| 18.5 | 19.6 | 19.5 | 18.0 | 19.6 | 18.2 | 17.5 | 19.2 | 17.5 | 18.7 |
| 18.8 | 19.5 | 18.5 | 24.5 | 23.1 | 24.6 | 24.2 | 24.4 | 22.1 | 18.8 |
| 24.4 | 26.2 | 26.2 | 26.9 | 27.8 | 27.5 | 23.8 | 25.1 | 22.2 | 21.5 |
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 22.3 | 21.2 |

*Note: * This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.*

In 2022, the share of RES in gross final energy consumption in the EU was 23%, in 2021 21.9%, and in 2020 22%. Sweden is by far the country with the highest share of renewables in gross final energy consumption (66%), followed by Finland (47.9%), Latvia (43.3%), Denmark (41.6%), Estonia (38.5%), Portugal (34.7%), and Austria (33.8%). The lowest shares are in Ireland (13.1%), Malta (13.4%), Belgium (13.8%), Luxembourg (14.4%), and the Netherlands (15%) (Eurostat, 2023).

In 2023, the share of renewable energies in gross final energy consumption in the EU increased further to 24.5 %. This share is 18 percentage points below the target for 2030 (42.5%), which means that an average annual increase of 2.6 percentage points will be required from 2024 to 2030 (Eurostat, 2024).

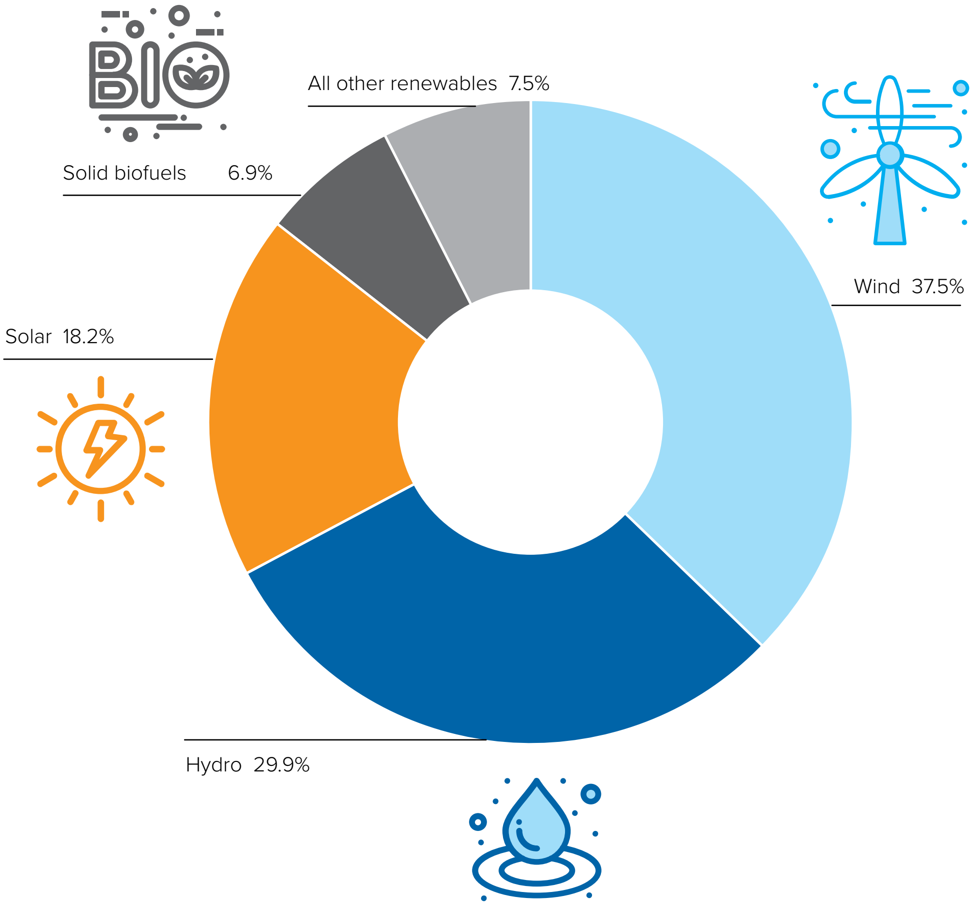
## *The share of RES in gross electricity consumption in the EU was 41.2% in 2022 and 45,3% in 2023.*

In 2022, the share of renewables in gross electricity consumption in the EU was 41.2%. This is 3.4 percentage points more than in 2021 (37.8%) and a clear lead over other energy sources used to generate electricity, such as nuclear energy (less than 22%), gas (less than 20%) or coal (less than 17%). Overall, renewable energy sources increased by 5.7% from 2021 to 2022 (Eurostat, 2024).

Wind and hydropower combined accounted for more than two thirds of total electricity generation from renewable sources (37.5% and 29.9% respectively). The remaining third of electricity was generated from solar energy (18.2%), solid biofuels (6.9%), and other renewable sources (7.5%). Solar energy is the fastest growing source—in 2008 it accounted for only 1% of electricity consumption in the EU (Eurostat, 2024).

Electricity from renewable sources is the most widespread in Sweden. Most of Swedish electricity consumed in 2022 came from renewables (83.3%, mainly hydro and wind power). A similar situation was seen in Denmark (77.2%, mainly wind power) and Austria (74.7%, mainly hydro power). Other countries with RES shares above 50% included Portugal (61%), Croatia (55.5%), Latvia (53.3%), and Spain (50.9%) (Eurostat, 2024).

*Figure 5: Sources of renewable energy in gross electricity consumption in the EU, 2022*




*Source: Eurostat (2024)*

In 2023, renewable energy sources accounted for 45.3% of gross electricity consumption in the EU, an increase of 4.1 percentage points (pp) compared to 2022. This marks the largest annual increase in the share of renewables in gross electricity consumption since the start of the time series in 2004. In addition, the annual increases in 2022 (3.5 percentage points) and 2020 (3.3 percentage points) were among the largest annual increases to date (Eurostat, 2025).

# 5

# THERMAL ENERGY WORLDWIDE

Some vital human activities, such as cooking and heating are related to heat. Heat is the energy that we as humanity discovered long before any other kind of energy. Humans learned to understand the correlation between cold and the sun's rays, but with the use of fire, heat took on a whole new meaning.

Thermal energy or heat refers to the absorption and emission of heat: a substance can be heated by fire (absorbing the heat of the fire) and cooled in ice, for example (releasing heat). A substance can also change in fire: it can melt, it can boil. Heat is therefore a special form of energy; it is part of the internal energy of the components (atoms, molecules) that flow through matter. Internal energy is the energy that a body possesses due to its thermal state, i.e. its pressure and temperature, but also due to its aggregate state and its chemical state.

Although in the current era of electrification—where fossil fuels are being replaced by electricity—much of the discussion about the future of energy centres on electricity alone, the importance of thermal energy is obvious to everyone just by thinking about cold winters. Fuels (coal, wood, natural gas, petrol, heating oil, fuel oil, etc.) are a very important source of heat, and when a substance burns, (combustion) heat is released. The indicator of the total energy released as heat when 1 kg of a specific substance, i.e. a fuel, is burnt is called the calorific value or heating value.

The heating value of fossil fuels—coal, oil, and natural gas—varies considerably due to their different hydrocarbon composition. Crude oil has a heating value of between 42 and 47 MJ/kg (or GJ/t), while the heating value of fuel oil, which is obtained by crude oil distillation, is 45 MJ/kg. Natural gas, which consists mainly of methane, has a heating value of 56 MJ/kg. In the case of coal, the older it is, the higher its carbon content and therefore its heating value (Aleksić, 2023). Lignite is the youngest type of coal with the lowest energy content and a heating value of between 10 and 20 MJ/kg. According to the annual reports of the Velenje Coal Mine, its lignite has a heating value of around 11 MJ/kg (Premogovnik Velenje). Brown coal, with a carbon content of around 70% and a heating value of between 19 and 27 MJ/kg, is more energy-rich, while bituminous coal, with a carbon content of around 80% and a heating value of almost 25 MJ/kg, is of even higher quality, which is why it is widely used. The highest quality coal is anthracite with a carbon content of up to 98% and a heating value of up to 33 MJ/kg (Aleksić, 2023).

Renewable heat sources such as solar energy (solar thermal collectors), geothermal and ambient energy, biomass and biofuels of various origins (landfills, sewage, etc.) are becoming increasingly important and are already successfully replacing fossil fuels in many areas. At a time when energy efficiency is crucial, the utilisation of surplus heat is also gaining in significance. This refers to heat that is generated as a by-product of technical processes, e.g. in industry, in the cooling of commercial or data centres, etc., but which cannot be used for the needs of the technical process itself due to inappropriate temperature or for other reasons.

Energy for heating and cooling accounts for around half of the EU's total gross final energy consumption and will be a key sector in decarbonisation efforts. In 2022, the share of renewable energy sources (RES) for heating and cooling continued to increase, reaching an EU average of 24.8%. This is 1.8 percentage points more than the previous year and 6.2 percentage points more than a decade ago, when the share was 18.6% (2012). The gross final consumption of renewable energy for heating and cooling in the EU has increased over time, mainly due to biomass, and heat pumps. Despite this progress, additional impetus is needed to achieve the higher targets of EU Directive 2023/2413 on the promotion of the use of energy from renewable sources (RED III), which requires Member States to increase the annual average share of renewable energy in heating and cooling by at least 0.8% in the period 2021-2025 and by at least 1.1% in the period 2026 2030 (Eurostat, 2024).

The heating sector is very diverse in terms of the intended use of heat and the required temperature levels. A wide range of technological solutions are used for heat generation and distribution, for heating, and for heat storage. As far as energy storage is concerned, heat has several important advantages over electricity, including significantly lower costs per unit of energy stored and a longer period of effective storage of large amounts of energy.

# *District heating*

Special attention is paid to district heating, as there is a District Heating Section operating within EICS. In Slovenia, 50 heat distributors supplied heat from district heating systems in 2023 and distribution took place in 67 municipalities using 110 distribution systems. District heating accounts for about 12% of the total heat supply. District heating is widely used in all three largest cities—Ljubljana, Maribor and Celje—and is also available in a number of other cities such as Velenje, Trbovlje, Jesenice, Ptuj, Slovenj Gradec, Nova Gorica, Murska Sobota, Kočevje, Slovenske Konjice, Metlika, Lendava, Piran, Ravne na Koroškem, Črnomelj, Kamnik, Kidričevo, Postojna, Ivančna Gorica, Kranjska Gora, Oplotnica, Hrastnik, Ribnica, Šentilj, and Bled.

District heating is a method of heat supply (heating of buildings), which brings heat to consumers from a central source via a network of pipes, usually using water as the transfer medium. The heat is supplied to homes and other consumers through a hot water network and transferred to the building's internal heating system via a heating station. District heating replaces smaller boiler rooms in buildings. The special feature and major advantage of district heating is the ability to utilise different energy sources and technologies for heat generation or heat recovery, which makes the system highly flexible.

Coal, natural gas, biomass, ambient energy can serve as primary energy sources, as can municipal waste (through incineration), all types of renewable energy sources, and surplus heat, which can be utilised either directly or with the help of heat pumps. The most important energy sources for heat generation in district heating systems in Slovenia are coal and natural gas, which together accounted for 77% of primary energy sources in 2023, followed by biomass with just under 19% and waste with just over 3%. Geothermal energy and excess heat from industry together accounted for only 0.4% (Agencija za energijo 2024, p. 333).

Other advantages of district heating include efficient emission control and significantly lower air pollution compared to individual combustion appliances, high reliability of supply and safe operation, professional management, efficient energy utilisation and space saving. In addition, the specific investment costs per unit of energy are significantly lower and the costs for heat supply are controlled. District heating and cooling is an important infrastructure for decarbonisation as it enables the integration of various energy-efficient solutions, such as the use of local renewable sources and excess heat or cold that would otherwise remain unused.

A district heating or cooling system also offers flexibility on the electricity market through power-to-heat or combined heat and power (CHP). The great and underutilised potential of district heating and cooling therefore lies in its ability to integrate sectors—in particular electricity, CHP, heat pumps and energy storage.

Despite its advantages, this particular heating system only accounts for 12% of the heating market for households and the service sector in the EU (European Commission: Joint Research Centre, 2022, p. 6).

# The connection between cooking, women's education and political priorities

Almost a third of the world's population—an estimated 2.3 billion people in 128 countries, most of which in the world's poorest regions, according to the IEA—do not have access to clean cooking equipment, which has significant consequences for public health, the local environment, and socio-economic development. The IEA estimates that almost 4 million people die prematurely every year because they breathe in the dangerous smoke from traditional cookstoves and open fires, with women and children disproportionately affected (IEA, 2023).

Countries such as China, India, and Indonesia have made commendable progress in the spread of clean cooking technologies. However, in sub-Saharan Africa, more and more people do not have access to cleaner cookers and fuels. Almost four out of five Africans still cook their food over open fires and on traditional cookers, using wood, charcoal, animal dung, and other polluting fuels.

The strenuous labour of collecting firewood also hinders educational and employment opportunities. The lack of cleaner cooking methods not only has a negative impact on health—particularly that of women and children (in Africa alone, women and children account for 60% of early deaths due to smoke inhalation and indoor air pollution), but also prevents many girls and women from accessing education, earning an income, or starting a business that would give them financial independence. In many parts of the world, they tend to have little influence on household consumption as other purchases take priority over clean cooking appliances. The under-representation of women in executive institutions also means that the issue of clean cooking plays only a minor role on the political agenda. As the IEA emphasises, clean cooking must become a political priority. Even the simplest and most widely used cooking appliances, such as LPG camping stoves and electric hobs, could improve the situation for women.

# 6

# ENERGY CONSUMPTION WORLDWIDE

HOW MUCH ENERGY DO COUNTRIES CONSUME AND WHICH IS THE MOST ENERGY-INTENSIVE?

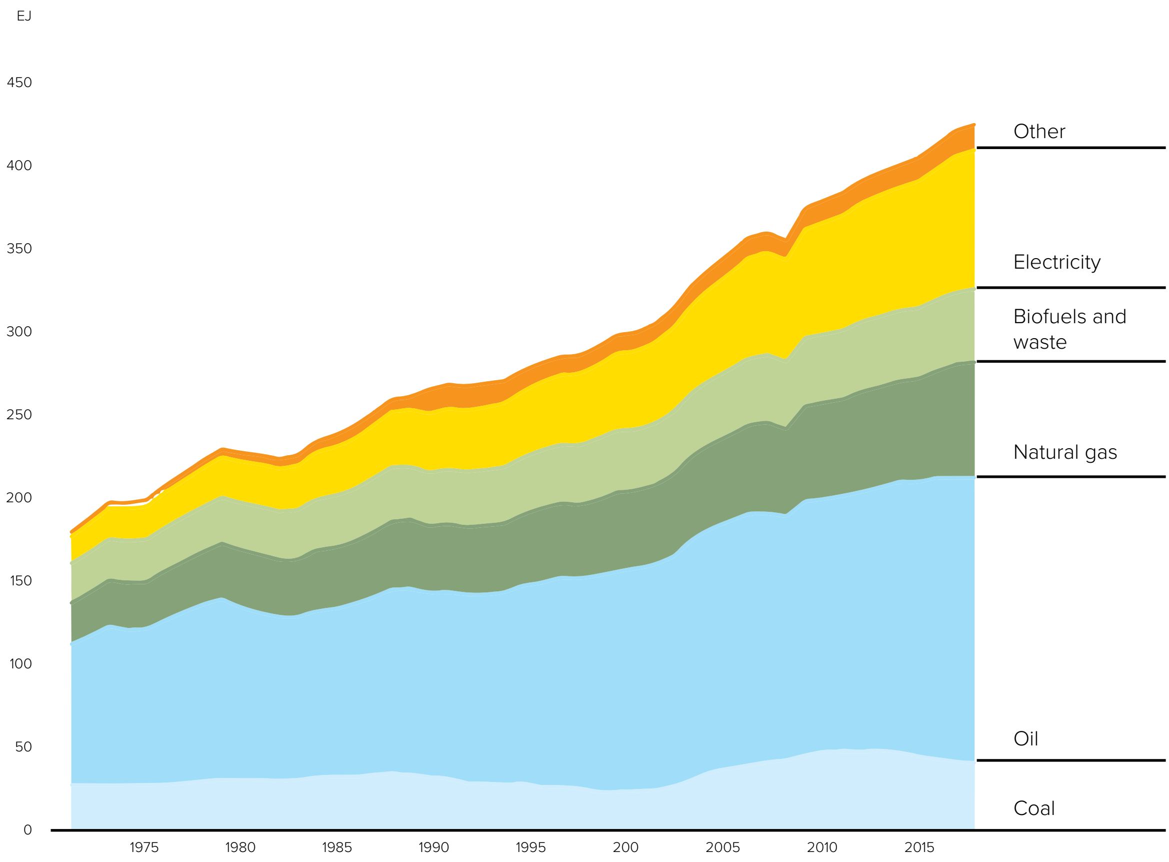
# *Every country consumes a certain amount of energy*

Just as people or countries utilise primary energy resources and produce various energy sources, they also consume them. Energy is consumed by people (households), by businesses (the economy), and by public institutions in various forms.

It is first necessary to define the term final energy consumption, which according to Eurostat is the total energy consumed by end users such as households, industry, and agriculture. This comprises the energy that reaches end users and not the one consumed by the energy sector itself. So, final energy consumption excludes the energy consumed by the energy sector, including its supply and conversion.

Total global final consumption has been rising steadily over the last 50 years. Population has also increased. In 1971, 3.8 billion people lived in the world; in 2019, this figure already rose to 7.8 billion. The figures presented by the International Energy Agency (IEA) for the period 1971-2019 show that final consumption in 2019 was around 420 exajoules (EJ; 1018 J) of energy. Oil and electricity are by far the most consumed fuels today, whereas five decades ago, the most consumed fuels were oil and coal (IEA, 2021).

*Figure 6: World total final energy consumption, 1971–2019*




*Source: IEA (2021)*

Final coal consumption rose from 26.6 EJ in 1971 to 39.8 EJ in 2019, an increase of almost 50% in 50 years.

Final oil consumption climbed from 83.6 EJ in 1971 to 169 EJ in 2019. That is an increase of 202%, a doubling of the consumption of black gold in merely half a century.

Final consumption of natural gas jumped from 24.4 EJ in 1971 to 68.4 EJ in 2019. That is an increase of 280%, which means that we are consuming almost three times as much gas as we did 50 years ago.

Final consumption of biofuels and waste rose from 23.5 EJ in 1971 to 43.4 EJ in 2019, an increase of 85%.

Final electricity consumption rose from 15.8 EJ in 1971 to 82.3 EJ in 2019. This means that global electricity consumption increased by more than 520% in just half a century. In 2019, we consumed five times as much as we did five decades ago.

The final consumption of other energy sources climbed from 2.9 EJ in 1971 to 15.1 EJ in 2019, which, similar to electricity growth, represents an increase of just over 520%.

Even though consumption has been rising since 1971, the shares of energy sources in the overall consumption mix have changed. Fifty years ago, coal accounted for almost 14% of total consumption, whereas in 2019, it was only 9.5%. The share of oil has also dropped, from 44% to just over 40%, as has the share of biofuels and waste from just over 13% to just over 10%. The share of gas has risen from just under 13% to over 16%, and that of electricity from just over 8% to almost 20%.

So we can see that global energy consumption has increased continuously, with the exception of the periods following the first and second oil crises (after 1973 and in the early 1980s) and in the years following the financial crisis (after 2008). Global energy consumption is still increasing today, but appears to be slowing down.

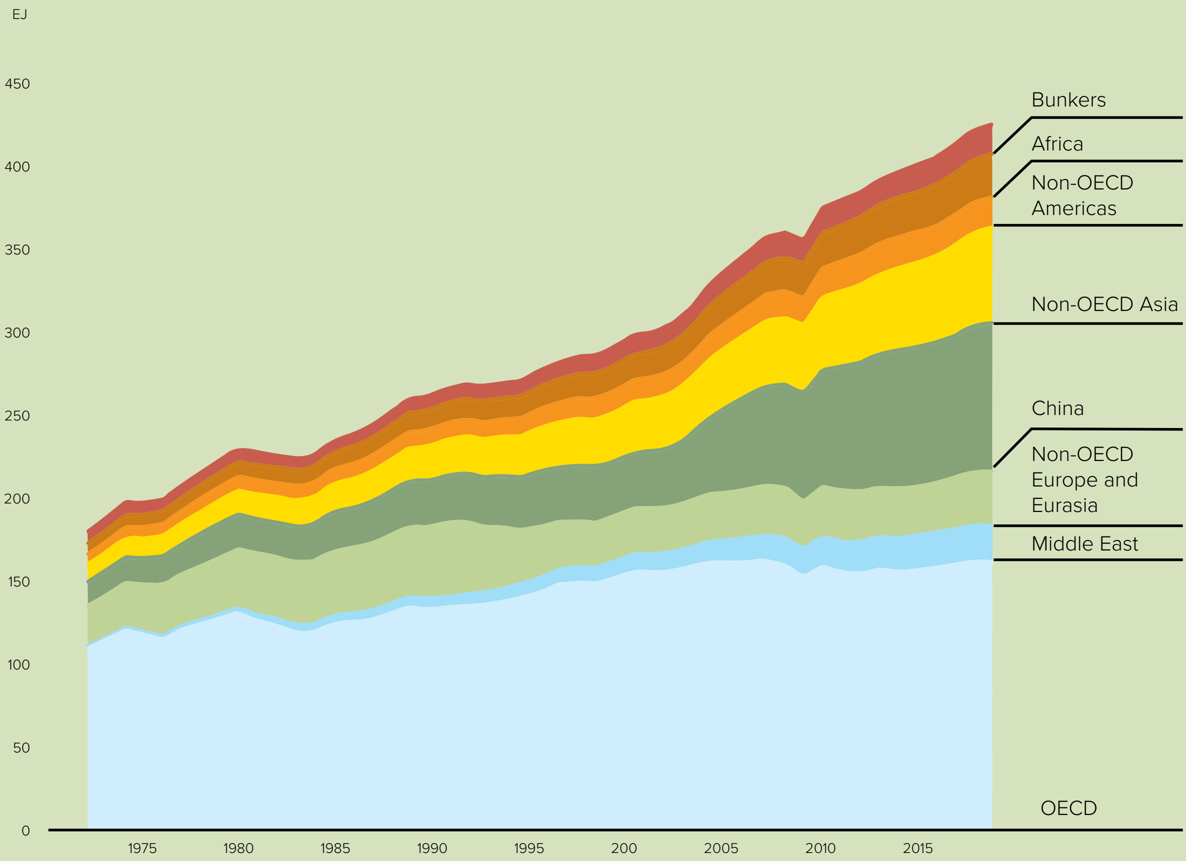
# *Consumption in OECD countries and China by far the highest*

Where in the world is final consumption highest? Consumption is by far the highest in the member countries of the OECD. As more and more countries have joined the organisation over the years, it should be noted that the OECD had 23 members in 1971 and 36 in 2019 (the statistics we cite refer to these two years). Slovenia joined the OECD in 2010 and today the organisation has 38 members.

In 1971, OECD countries consumed 107.8 EJ of energy, which was around three-fifths of the world total. In OECD member countries, consumption has increased by 47% to 158.6 EJ in the last half century and still accounted for 38% of total world consumption in 2019. Note: The second largest consumer is China, which has increased its consumption from 14.2 EJ in 1971 to 88 EJ, an increase of 620% (IEA, 2021).

Consumption in the non-OECD parts of Europe and Eurasia increased by just over 35%, in the non-OECD parts of Asia by just under 54%, and in the non-OECD parts of the Americas by 30%. Africa doubled its consumption to 25.7 EJ, while consumption in the Middle East increased twenty-fold to 21.4 EJ, almost equalling total consumption in Africa (IEA, 2021).

*Figure 7: World total final energy consumption by region, 1971-2019*




*Source: IEA (2021)*

Consumption by economic sector shows the following picture: The iron and steel industry consumes the most coal, followed by the chemical and petrochemical industry, non-metallic materials, and other industries. By far the most oil is consumed in the road transport sector, followed by aviation, industry, and water bound transport. Gas is mainly used in industry and households, but also in transport and the service sector. A similar pattern emerges for electricity: Industry and households consume the most, followed by services.

## *Global demand for electricity has grown the fastest in recent years*

We are living in an era of electrification, which is closely linked to decarbonisation—we are shifting towards using more electricity in more and more sectors, at the expense of reducing the share of fossil fuels used (but not the actual amount of fossil fuels). As we have seen, final electricity consumption increased more than fivefold between 1971 and 2019. The IEA's own analyses show that global electricity demand has grown at the fastest rate in recent years, driven by sustained economic growth, intense heatwaves, and the increasing deployment of electricity-powered technologies, such as electric vehicles and heat pumps.

Global electricity demand is expected to increase by around 4% in 2024, compared to 2.5% in 2023, according to the IEA's mid-year electricity report. This would be the highest annual growth rate since 2007, excluding the exceptional spikes following the global financial crisis and the COVID-19 pandemic. The strong increase in global electricity consumption is expected to continue in 2025, with growth of around 4% again (IEA, 2024).

## The top five by supply and consumption: China, the U.S., India, Russia, Japan

According to the IEA, the top five countries in the world by total energy supply by energy source (coal, oil, gas, renewables, and others), but also by industrial energy consumption (iron and steel, chemical and petrochemical industry, non-metallic minerals, paper, pulp and printing, other industrial sectors, and other) and total final consumption (industry, transport, households, and other) are China, the U.S., India, Russia, and Japan.

## Consumption is associated with greenhouse gas emissions

In the age of electrification, we are experiencing an accelerated expansion of various renewable energy sources. The IEA states that renewable energies are growing so rapidly that the amount of electricity generated worldwide from renewable energies will eclipse the amount of electricity from coal for the first time in 2025. Photovoltaics alone are expected to cover around half of the growth in global electricity demand in 2024 and 2025.

Despite the strong increase in renewable energies, the IEA report stated that global electricity generation from coal was unlikely to decline in 2024 due to the strong growth in demand, particularly in China and India. As a result, carbon dioxide emissions from the global electricity sector have peaked. A slight increase was expected in 2024, followed by a decline in 2025, but the IEA pointed out considerable uncertainties: China's hydropower generation recovered strongly in the first half of 2024 from an absolute low in 2023. If this trend continued in the second half of the year, it could curb coal-based power generation, which would lead to a slight decrease rather than a small increase in global emissions from the power sector in 2024.

At the same time, the IEA (2024) notes that global coal demand is expected to remain largely unchanged in 2024 and 2025, as rising electricity demand in some of the world's major economies offsets the impact of a gradual recovery in hydropower and the rapid expansion of solar and wind energy.

Global coal consumption increased by 2.6% in 2023, reaching an all-time high, fuelled by strong growth in China and India, the world's two largest coal consumers. While coal demand increased in both the power and industrial sectors, the main drivers for coal consumption were low hydropower generation and rapidly growing electricity demand (IEA, 2024).

According to Eurostat (2024), final energy consumption in the EU totalled 37,771 petajoules (PJ) in 2022, a decrease of 3.9% compared to 2021. Petroleum products accounted for more than a third (36.8%) of total final energy consumption in the EU, with electricity (23%) and natural gas (20.6%) accounting for relatively high shares. The total volume of energy consumed in the EU in 2022 was 0.5% lower than in 1990. However, the fuel structure shifted significantly over this period—away from solid fuels and petroleum products towards renewables and biofuels and also towards electricity. In 2022, industry accounted for a quarter (25.1%) of energy consumption in the EU, transport for 31%, and other sectors (households and services) for 43.9%. European households consume the most energy for heating, which accounts for 63.5% of final energy consumption in the household sector. In 2022, almost four fifths of final energy consumption in the EU household sector was covered by three main sources: natural gas (30.9%), electricity (25.1%), and renewables and biofuels (22.6%).

# *Energy intensity around the globe*

Energy use is the greatest burden on the environment, but on the other hand, energy is also essential for the existence and development of mankind. A reduction in energy consumption can be achieved by reducing energy-consuming activities (reducing passenger kilometres, reducing heating demand, etc.) or by improving energy efficiency.

Total energy intensity is calculated as units of total energy used per gross domestic product (GDP). Energy intensity decreases when GDP growth surpasses the growth in energy consumption, while environmental impacts decrease when energy consumption decreases.

Institutions around the world measure energy intensity in terms of different indicators and in different units. For example, the U.S. EIA measures energy intensity as energy consumption per person or per capita in million British thermal units (MMBtu) per person. In the U.S., primary energy consumption per capita in 2022 was 284 MMBtu, while the global average was just over 70 MMBtu per capita or 72.2 MMBtu to be exact (US EIA, 2024). On average, a U.S. citizen consumes nearly four times as much energy per year as the average inhabitant of the Earth.

Among the earlier mentioned top five in supply and consumption (China, the U.S., India, Russia, Japan), all except India are well above the global average in terms of energy intensity. At the head of the top five is the U.S. (the earlier mentioned 284 MMBtu per capita), followed by Russia (227 MMBtu per capita), and, with a significant gap in between, Japan (132 MMBtu per capita) and China (108 MMBtu per capita). In 2022, the average energy intensity per capita in India was 23 MMBtu, which means that the average person in India consumes three times less energy in a year than the average inhabitant of the Earth (US EIA, 2025).

According to these data, the most energy-intensive countries per capita in the world are Qatar (728), Singapore (642), Bahrain (544), the United Arab Emirates (443), Brunei (402), Kuwait (379), Saudi Arabia (353), and Canada (315), followed by Oman (300), Turkmenistan (250), Malta (242), Luxembourg (239), South Korea (231), Australia (230), Norway (208), and Taiwan (200) (US EIA, 2025).

An energy intensity of 113 MMBtu per capita was measured for Slovenia in 2022 (US EIA, 2025). The calculation shows that the average person in Slovenia consumes 1.5 times as much energy as the average inhabitant of the Earth.

The data of the International Energy Agency (IEA) and those of the World Bank use a different unit to refer to intensity, as energy intensity of a country's primary energy consumption (and not the per capita consumption of that country) is represented as a ratio between energy supply and GDP measured at purchasing power parity (PPP). This indicator defines energy intensity as the ratio of energy consumption per unit of GDP generated in a country. More energy consumed and less GDP generated means higher energy intensity. Less energy consumed per unit of GDP means lower energy intensity or possibly higher energy efficiency.

The rate of improvement in global primary energy intensity—defined as the percentage decrease in the ratio of total global energy supply per unit of GDP—is the indicator used to monitor progress in global energy efficiency.

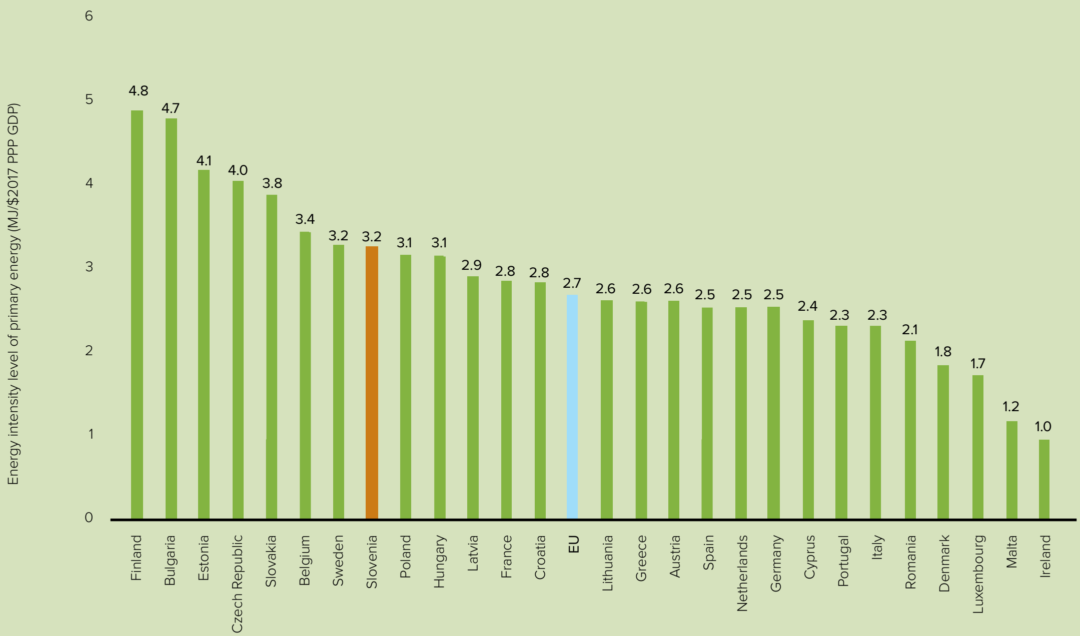
## *Energy efficiency ≠ energy intensity*

Energy intensity is often used to measure energy efficiency as it represents the energy consumed for a given activity or output at the sub-industrial or sub-sectoral level and at the level of final consumption. However, energy intensity and improvements in energy intensity are not necessarily the result of improvements in energy efficiency, as the two categories (i.e. energy efficiency and energy intensity) cannot be equated. Energy intensity depends on many factors, not just economic efficiency. These factors include the structure of the economy or economic sectors, the type of industrial production, the exchange rate, the availability of energy services, the size of the economy or country, the climate, and consumer behaviour. Changes in these factors have an impact on energy consumption per unit of output and thus on energy intensity, without necessarily changing energy consumption itself. Energy efficiency can therefore be influenced by many non-energy-related factors, which is why using energy intensity to measure energy efficiency can lead to misleading conclusions (Hrovatin and Zorić, 2017, p. 5).

The data shows that energy intensity is decreasing around the world. However, the pace of energy efficiency improvements slowed to 0.8% in 2021, down from an average of 1.8% in the previous decade, according to IEA calculations. This is due to the COVID-19 pandemic and significant changes in the global economy that coincided with the initial lockdowns and travel restrictions due to the pandemic. In 2021, there was no major shift towards improved energy efficiency, but improvements have been expected from 2022 onwards due to new policies and measures to increase energy security. The IEA even predicts that energy intensity will improve at a rate of 2% above historical levels in the future (IEA, 2024).

According to the World Bank, the energy intensity indicator in the EU countries is between 1 and 4.8, with the lowest in Ireland at exactly 1 MJ/$2017 PPP GDP, followed by Malta (1.2), Luxembourg (1.7), and Denmark (1.8). At the other end of the scale are Finland (4.8), Bulgaria (4.7), Estonia (4.1), and the Czech Republic (4). In other EU Member States, energy intensity, measured as the units of energy consumed per unit of GDP, is between 2.1 and 3.8. The EU average is 2.7. For Slovenia, this ratio is 3.2, which means that our country's energy intensity is well above the EU average—Slovenia consumes more than the EU average (World Bank Group, 2023).

*Figure 8: Energy intensity in EU countries, 2022*



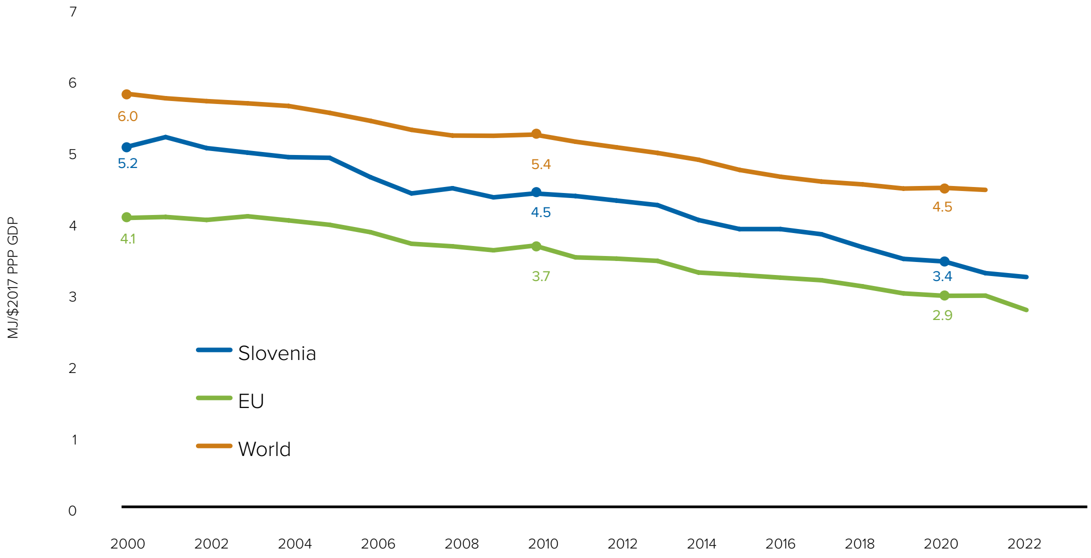

*Source: World Bank Group (2023)*

Slovenia's energy intensity fell significantly from 5.2 to 3.2 MJ/$2017 PPP GDP between 2000 and 2022. This decline means that Slovenia consumes less energy per unit of GDP generated and has therefore improved its energy efficiency.

Energy intensity in the EU and worldwide shows a similar trend. In the EU, it fell from 4.1 MJ/$2017 PPP GDP in 2000 to 2.7 MJ/$2017 PPP GDP in 2022 (World Bank Group, 2023).

Global energy intensity also decreased from 6.04 MJ/$2017 PPP GDP in 2000 to 4.53 MJ/$2017 PPP GDP in 2021 (World Bank Group, 2023). Of course, the decline was not the same in all countries of the world but it should be noted that the indicator for the world was still at 7.4 in 1990 (IEA, 2025).

*Figure 9: Energy intensity of Slovenia, EU and the world*




*Source: World Bank Group (2023)*

# *Dilemmas and the question of the Anthropocene*

TWe conclude this chapter on increasing global energy consumption and the consequences for the environment and climate with the question of the Anthropocene, which scientists have been discussing for many years and was finally voted on in 2024. It should be the period in which man became the main factor in changing the environment—it is no longer possible to consider nature as something completely independent of mankind, because man acts as a geological force that influences everything natural, from the heights of the atmosphere to the depths of the oceans. All this is said to have happened sometime after the industrial revolution, i.e. after 1800.

The Anthropocene has been proposed as the new, most recent geological time unit, with the Industrial Revolution or nuclear testing possibly being the milestones marking its beginning. There has been a proposal to place the beginning of the new geological epoch, whose main feature is the global impact of humanity on the planet, at around 1950. The beginning of the Anthropocene, which should still be visible in the rock structure millions of years from now, would thus be set at the time of the atmospheric nuclear tests immediately after the Second World War, which left a distinctive trace of radioactive isotopes on the planet. Scientists under the auspices of the International Union of Geological Sciences (IUGS) did not support the proposal in early 2024 and rejected it. The working group that proposed ratifying the Anthropocene as an epoch had spent 15 years drafting the report, which was then rejected by a majority of scientists.

IUGS recognises that the concept of the Anthropocene will continue to be used not only in the context of Earth science research, but also in the social sciences, in politics and economics, and, of course, by the general public. It is therefore not recognised as an official geological term, although according to the IUGS "it will more usefully be employed informally in future discussions of the anthropogenic impacts on Earth's climatic and environmental systems" (IUGS, 2024).

We agree with this assessment, particularly in relation to the discussions on the green transition. There are dilemmas with every energy source, including renewables. There are many examples: the use of biomass for heating (increasing particulate pollution in the air, especially in urban areas in winter), the construction of hydroelectric plants on certain rivers (which contradicts the concept of free-flowing rivers or the preservation of biodiversity), wind farms affecting the landscape, the recycling of solar panels, the link between biofuel and food production, the incineration of waste, and so on. We need to pay close attention to these complex issues and discuss them openly, because people need to protect the planet so that we, our descendants, and the entire living world can survive on it.

One of the dilemmas regarding energy is the treatment of renewable energy in relation to fossil fuels. If we are only interested in which sources are more environmentally friendly, the answer is probably renewable energy. However, if we do not make a comparison and only focus on renewable energy, it becomes clear that the use of renewable technologies also has an impact on the environment. Almost everything humans do affects the environment. This is why the term Anthropocene has been introduced for the age we live in, because it is characterised by the impact of humans on the planet. The problem is comprehensive in nature and goes beyond a single sector such as energy.

7

# HOW MUCH DO WE PAY FOR ENERGY?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The energy price has been the number one topic in both the general and specialised public in recent years. EICS would like to contribute to open communication on this topic through its articles and expositions on current developments, the formation of energy prices (especially those of electricity and natural gas), and the composition of prices, quoting only official data sourced from SURS and Eurostat.

Additional information on prices are available here:

https: //ezs. si/en/energy-transition/

Prices are also monitored by regulatory authorities, in our case the Energy Agency. Below are some highlights from their bi-annual reviews of the wholesale gas and electricity markets over the last three years.

The second half of 2021 saw an exceptional rise in global energy prices, with all regions, not just the EU, facing the same challenge. Electricity prices reached historic highs in Europe in the second half of 2021, and natural gas prices continued the positive price trend of the first half of the year, reaching new record levels in the second half of 2021.

In the first half of 2022, prices for natural gas and electricity also rose for the most part, with prices for both energy products in Europe once again reaching new historic highs. The price increase was triggered by unforeseeable events—the Russian invasion of Ukraine and the sanctions imposed in response to Russia—which caused additional volatility and unpredictability on the wholesale energy markets. The heightened geopolitical situation also resulted in natural gas imports from Russia to the EU falling by around 38% year on year in the first half of the year, while LNG imports increased by more than 55% year on year in the same period. In the second half of 2022, geopolitical tensions and unforeseeable events once again led to new phases of price volatility and record prices on the wholesale energy markets. In August 2022, gas prices in the EU reached an all-time high and were 1000% higher than in previous decades. In the first half of 2023, prices on the wholesale markets for natural gas and electricity moved away from the record levels reached in 2022.

Wholesale prices of natural gas and electricity gradually fell in the first half of 2023. The fall in prices was the result of above-average natural gas storage levels, a decline in natural gas and electricity consumption, the successful substitution of Russian gas imports, and increased electricity generation from renewable energies. The gradual fall in prices of coal and emission allowances also contributed to the decline in electricity prices. In the second half of 2023, prices of energy-generating products on the wholesale markets fell for the most part. Although wholesale prices of natural gas and electricity were well below the record levels reached at the time of the energy crisis, they were still higher than in the period before the crisis.

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In 2024, EICS commissioned a comparative analysis of electricity and gas price trends for the 2019-2023 period in Slovenia and the EU countries from the Analysis Department (sl. Analitika) of the Chamber of Commerce and Industry of. Slovenia (CCIS). The analysis is based on Eurostat databases.

When comparing energy prices, it is important to bear in mind that the final price of electricity or gas paid by the consumer (customer) is made up of several components. In the world of energy, it is important to understand that the cost of electricity and gas varies from country to country and that these costs are broken down into different components: energy product and supply costs, network tariffs, and taxes, fees and charges. In some places the cost of the energy product is higher, in some the network tariffs are lower, and in others the taxes are higher or lower. When we speak of a “price”, we must specify whether it is only the “price of the energy product” or the “price including network tariffs” or the “price including taxes” or the “final price”. The latter comprises all price components. It is also necessary to define whether the price applies to a household or a non-household customer (in the latter case, it is sometimes also necessary to distinguish between a small business or an industry).

Follow the links to the price analyses for electricity and natural gas:


https: //ezs. si/wp-content/uploads/2024/08/Analiza-cen-zemeljskega-plina-v-2019-2023-maj-2024. pdf


https: //ezs. si/wp-content/uploads/2024/08/Analiza-cen-elektricne-energije-v-2019-2023-julij-2024. pdf

# *Gas and electricity prices in Slovenia in 2023*

The analysis of gas prices showed that the *average price of natural gas* (energy product) for **non-household consumers** in the average consumer group in 2023 was €59.4/MWh in the EU, €58.5/MWh in the eurozone and €59.1/MWh in Slovenia, which means that the difference was small. The highest price among the comparable neighbouring countries was reached in Hungary (€83.1/MWh). The *network tariffs* for non-household consumers in Slovenia were between 7% and 20% below the European average and totalled €5.7/MWh for the average non-household consumer group in Slovenia in 2023. The highest network charges among the neighbouring countries were recorded in Italy (€11.7/MWh) and the lowest in Austria (€4.9/MWh). In Slovenia, *costs and charges* (excluding VAT) for nonhousehold consumers in 2023 were generally 41-66% lower than the European average for all consumer groups. They amounted to €2.8/MWh, which is lower than in the EU (€6.4/MWh) and the eurozone (€7.1/MWh). In comparable countries, the differences in the level of charges were considerable and ranged from €0.6/MWh in Croatia to €1.4/MWh in Italy and striking €12.4/MWh in Germany. The reasons for these differences include different national policies and regulations, and differences in infrastructure and grid maintenance costs. The *final price of natural gas* excluding VAT for nonhousehold consumers in Slovenia was generally lower than the European average for all consumer groups, ranging between 0 and 13%. In 2023, the average price of natural gas excluding VAT for non-household consumers was €72.4/MWh in the EU-24, €72.2/MWh in the eurozone, and €67.6/MWh in Slovenia, which is below the EU and eurozone average. Croatia (€66.6/MWh) and Austria (€63.8/MWh) had the lowest natural gas prices excluding VAT among the comparable countries.

In 2023, the *average energy price* (natural gas) for **household consumers** in the average consumer group was € 73.4/MWh in the EU and € 79.9/MWh in the eurozone. In Slovenia, the price of the energy product was € 71.8/MWh, which is slightly below the EU average. In Austria, Italy, and Germany, the price for the energy product was higher than in Slovenia, while the price in Croatia and Hungary was lower. The network tariff and levies in Croatia were very low, while the network tariff in Hungary was slightly higher than in Slovenia, but their levies were 60% lower. In Italy, the network tariff was 97% higher than in Slovenia, but the levy was only €0.2/MWh. In 2023, the *network tariff*, which covers the costs of transmitting and distributing energy to end consumers, was €20.3/MWh in the EU24 and €21.7/MWh in the eurozone. In Slovenia, the network tariff was €13.3/MWh and thus below the EU and eurozone averages. Of the comparable neighbouring countries, only Croatia had a lower network tariff in 2023. *Taxes* (VAT, levies and fees) are an important part of energy costs. In 2023, the average taxes, fees, and levies in the EU amounted to €20.9/MWh, in the eurozone to €22.3/MWh, and in Slovenia to €17.6/MWh, which is lower than the EU and eurozone averages. Of the comparable neighbouring countries, taxes were lower in three countries (Italy, Croatia, Hungary), which is due to the reduced VAT rates in Italy and Croatia, and due to price regulation in Hungary. The *final price* is of course a combination of all the above components of the (final) price. In 2023, the *average final price* for natural gas in the EU-24, including VAT, was €114.6/MWh. In Slovenia, it was below the EU average at €102.7/ MWh, with only Hungary and Croatia even lower. In general, the price varies depending on the amount of energy consumed. For consumers using less than 20 GJ (D1 band), the total cost in Slovenia is €106.3/MWh, which is below the EU-24 average (€140.3/MWh). The same applies to consumers who consume between 20 GJ and 199 GJ. However, the comparative price difference is lower for household consumers with a consumption of 200 GJ of natural gas or more (D3 band).

The analysis of electricity prices showed that the *price of electricity* (energy product) for **non-household consumers** in the average consumer group in Slovenia was €176/MWh in 2023, which corresponds to an increase of 21.5% compared to 2022. In terms of absolute electricity price in 2023, Slovenia ranked 7th among the EU-27 (in descending order). Compared to the countries in the region, the price in Slovenia was 27.4% higher than in Germany and 13.7% lower than in Croatia. Compared to the EU-27 average, the price of electricity in Slovenia was one fifth higher in 2023, which is the largest difference in the last five-year period. The *network tariff* for the average consumer group in Slovenia was €22/MWh in 2023, 41% higher than in 2022. In terms of network tariff, Slovenia ranked 25th (in descending order) of the 27 EU Member States in 2023. Compared to the countries in the region, the network tariff in Slovenia was the lowest—two thirds lower than in Hungary and 47.7% lower than in Germany.

In 2023, the total charges, including levies, fees and costs (RES, CHP and EE contributions; excise duties; tax on capacity; other) for non-household consumers in the average consumer group in Slovenia amounted to €12.1/MWh, an increase of 12% compared to the previous year. Throughout the five-year observation period, Slovenia has maintained lower charges for non-household consumers compared to the EU-27, Germany, Italy and Croatia, with the exception of Hungary and, in 2023, Austria. In terms of charges, this put Slovenia in 11th place (in descending order) among the 27 countries in 2023. Compared to the countries in the region, Slovenia had 73.8% lower charges than Italy and 65.5% lower charges than Germany in 2023. Compared to the EU-27 average, charges in Slovenia were 45.7% lower. The electricity price for the average consumer group, including costs and charges before VAT, for non-household consumers in Slovenia was €210/MWh in 2023, 22.7% higher than in 2022. The electricity price in Slovenia was thus 2.5 times higher than in 2019. Compared to 2019, the price of electricity in Slovenia was 2.5 times higher in 2023, putting Slovenia in 11th place among the 27 EU countries (in descending order). Slovenia has thus significantly improved its ranking compared to 2019, when it was in 22nd place. Compared to the countries in the region, the price in Slovenia was lower throughout the period under review. In 2023, it was 18.6% lower than in Hungary and 16.4% lower than in Croatia. Compared to the average electricity price in the EU-27, the price in Slovenia was 3.1% higher.

The price of electricity (energy product) for **households** continued to rise throughout 2023. There are differences between the EU-27 countries in the intensity of regulation and the annual adjustment of the continuously rising retail electricity prices for consumers, which, however, are gradually returning to the pre-crisis price structure following the stabilisation of the energy markets. Network charges in particular are rising again. In 2023, the countries were tackling the transition out of the energy crisis by gradually easing the use of a variety of crisis measures such as energy price caps, transfers to households, or the regulation of excise duties, levies and VAT.

*The price of electricity* (energy product) for household consumers in the average consumer group in Slovenia in 2023 was €103.2/MWh, an increase of a quarter compared to 2022. All other selected comparable countries recorded increases ranging from 1.8% in Hungary to 81.2% in Austria. Compared to 2019, the price for the product in Slovenia was 78.2% higher. In terms of price, Slovenia thus ranks 19th (in descending order) among the 27 EU countries in 2023. Compared to other countries in the region, the price in Slovenia was 3.7 times higher than in Hungary and half as high as in Germany and Austria. Compared to the average price of the EU-27, however, it was 36.2% lower in Slovenia in 2023.

*The network charge* for household consumers in the average consumer group in Slovenia was €55.2/MWh in 2023, 37.7% higher than in 2022, which is the highest increase among the countries in the region. This put Slovenia in 20th place (in descending order) in terms of the level of network charges in 2023, placing it in the bottom third of the EU-27 countries (10th place in 2019). If we compare Slovenia with the selected countries in the region, its network charges were 43.6% lower than in Germany and 28.1% lower than in Austria, but 14.5% higher than in Croatia. Compared to the EU-27 average, the network charge in Slovenia was 23.7% lower.

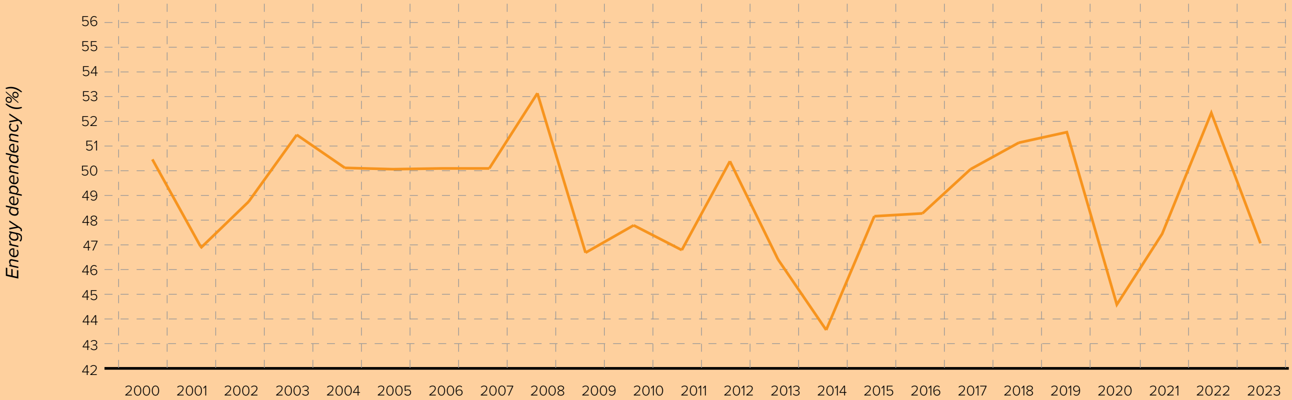
# 8

# SLOVENIA'S ENERGY DEPENDENCY

Slovenia does not have sufficient energy sources of its own to meet the energy needs of both households and industrial consumers and is therefore dependent on energy imports. Energy dependency is the ratio between net imports (import-export) and the country's total energy supply.

*Table 2 and Figure 10: Slovenia's energy import dependency, 2000-2023*

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Energy dependency (%)) | 50.4 | 46.9 | 48.8 | 51.4 | 50.3 | 50.1 | 50.2 | 50.2 | 53.1 | 46.8 | 47.9 | 46.9 | 50.4 | 46.4 | 43.6 | 48.0 | 48.1 | 50.0 | 50.9 | 51.4 | 44.4 | 47.3 | 52.2 | 47.5 |




*Source: SURS (2025)*

The table and chart on Slovenia's energy import dependency clearly show that the country's import dependency fluctuated between 43% and 53% over the last 23 years. In the first two decades of the century, Slovenia imported around half of the energy required by industry and households. With some energy sources, specifically natural gas and oil, Slovenia is exclusively dependent on imports.

Looking only at electricity, Slovenia's dependency on foreign countries is much lower, as the country produces most of its own electric energy. In Slovenia, electricity is generated in power plants, primarily in hydroelectric power plants (mainly on the Drava, Sava, and Soča rivers), in thermal power plants (coal-fired in Šoštanj and gas-fired or fuel oil-fired in Brestanica) and in the country's nuclear power plant (Krško).

Slovenia's dependency on imports for its electricity supply is therefore much lower and fluctuates considerably. Import dependency generally shows the relationship between domestic consumption and domestic production resources and is therefore subject to fluctuations in both production and consumption. Domestic generation covered 70% of electricity consumption in 2022 and 90.9% in 2023 (Agencija za energijo, 2024, p. 27).

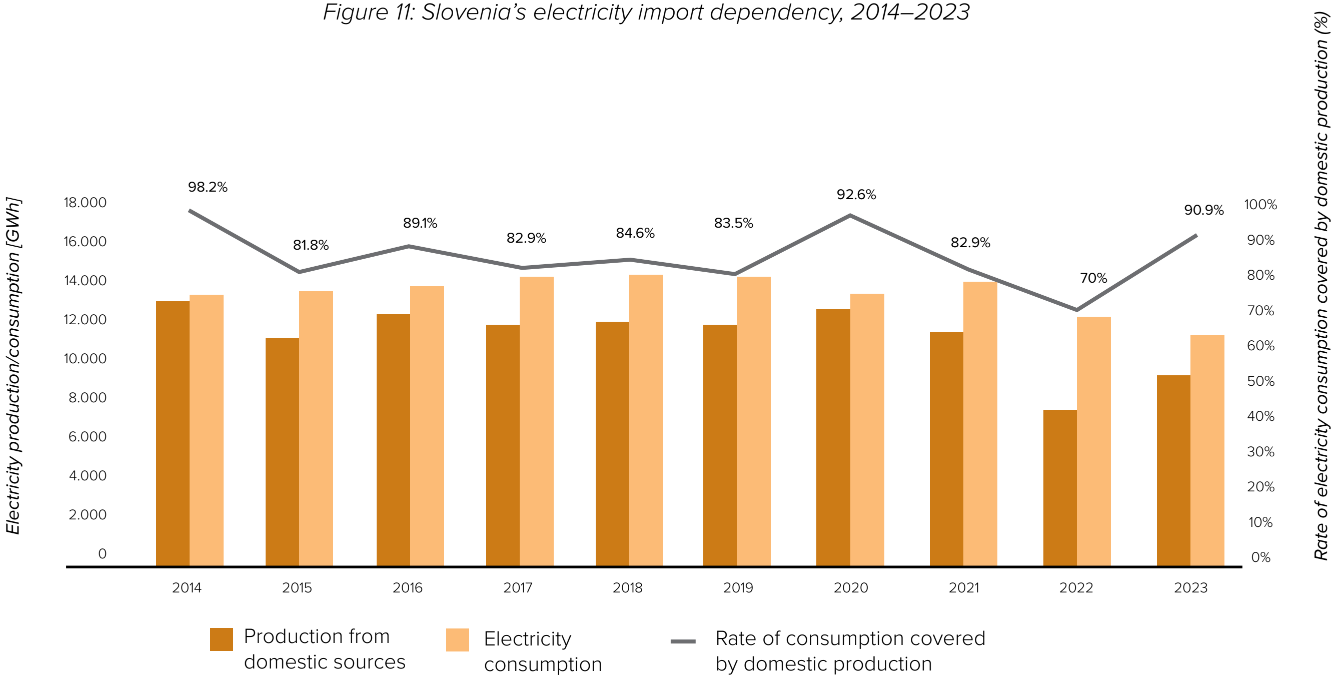
Every year, the national energy regulator—the Energy Agency (based in Maribor)—publishes a report on the state of the energy sector in Slovenia. Below you will find Table 3 and Figure 11, showing Slovenia's electricity import dependency from the report for the year 2023 (Agencija za energijo, 2024).

*Table 3: Proportions of electricity consumption covered by domestic electricity production, 2010-2023*

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Generation at the transmission level [GWh]** | **11,729** | **11,098** | **10,979** | **11,373** | **12,067** | **10,198** | **11,405** | **10,969** | **11,212** | **10,934** | **11,639** | **10,638** | **8,529** | **10,294** |
| – of which hydropower plants | 4,248 | 3,361 | 3,730 | 4,480 | 5,794 | 3,708 | 4,293 | 3,725 | 4,421 | 4,225 | 4,747 | 4,504 | 3,037 | 4,792 |
| – of which thermal power plants | 4,795 | 4,787 | 4,633 | 4,381 | 3,242 | 3,809 | 4,401 | 4,262 | 4,049 | 3,946 | 3,872 | 3,429 | 2,841 | 2,841 |
| – of which nuclear power plant (50% share) | 2,685 | 2,949 | 2,616 | 2,512 | 3,030 | 2,681 | 2,712 | 2,983 | 2,742 | 2,763 | 3,020 | 2,706 | 2,651 | 2,662 |
| **Generation at the distribution level [GWh]** | **849** | **833** | **951** | **1,070** | **1,185** | **1,075** | **1,116** | **1,032** | **1,050** | **1,044** | **1,088** | **1,079** | **1,012** | **1,238** |
| **Total domestic generation [GWh]** | **12,578** | **11,930** | **11,930** | **12,443** | **13,252** | **11,273** | **12,521** | **12,001** | **12,262** | **11,978** | **12,727** | **11,717** | **9,541** | **11,533** |
| **Total electricity consumption [GWh]** | **13,112** | **13,396** | **13,380** | **13,539** | **13,489** | **13,787** | **14,056** | **14,468** | **14,501** | **14,341** | **13,744** | **14,142** | **13,638** | **12,688** |
| – of which end user consumption | 12,158 | 12,682 | 12,631 | 12,816 | 12,719 | 13,041 | 13,297 | 13,665 | 13,736 | 13,564 | 12,897 | 13,336 | 12,793 | 11,848 |
| – of which network losses | 982 | 824 | 877 | 849 | 821 | 864 | 876 | 893 | 880 | 859 | 849 | 837 | 845 | 842 |
| – of which export to Italy via distribution system (via Vrtojba and Sežana substations) | -28 | -110 | -128 | -126 | -50 | -118 | -117 | -90 | -115 | -81 | -2 | -31 | -0,15 | -0,1 |
| **Share of electricity consumption met by domestic production** | **95.9%** | **89.1%** | **89.2%** | **91.9%** | **98.2%** | **81.8%** | **89.1%** | **82.9%** | **84.6%** | **83.5%** | **92.6%** | **82.9%** | **70.0%** | **90.9%** |

*Source: The Energy Agency (2024)*

*Figure 11: Slovenia's electricity import dependency, 2014–2023*




*Source: The Energy Agency (2024)*

We can see that the proportion of electricity consumption covered by domestic generation varies from year to year. The largest contribution to electricity production from domestic sources is made by large hydroelectric power plants, thermal power plants, and nuclear power plants connected to the electricity transmission grid in Slovenia. A minor part of production from domestic sources is connected to the electricity distribution system. Due to the high share of hydropower in electricity production, the total production from domestic sources is highly dependent on the hydrology of a given period, according to the Report on the state of the energy sector in Slovenia.

For the calculation of import dependency, the gross electricity consumption takes into account not only the consumption of end consumers in the transmission and distribution system but also the losses throughout the electric power system, whereby the electricity exported to Italy via the distribution system from the Vrtojba and Sežana substations is deducted (i.e. the quantities of electricity distributed to Italy via the distribution system from the Vrtojba and Sežana substations are not included in Slovenia's final consumption).

Electricity import dependency is defined based on the ratio of domestic electricity generation from domestic sources to gross domestic consumption of electricity.

Import dependency fluctuated considerably in the 2010-2019 decade, influenced not only by changes in domestic electricity generation but also by changes in electricity consumption. In the decade under consideration, import dependency reached its lowest value in 2014 (1.8%) on account of high electricity generation from hydropower plants resulting from extremely favourable hydrological conditions but also on account of lower gross consumption compared to the previous year. In 2017, import dependency increased significantly (17.1%) due to lower domestic production (mainly by hydropower plants) and an increase in electricity consumption (Agencija za energijo, 2018, p. 23).

The last five-year period 2019-2023 was also characterised by fluctuations in the share of consumption covered by domestic production. It was highest in 2020 (92.6%) and lowest in 2022 (70%), mainly due to significantly lower electricity generation from hydropower due to the drought and the temporary shutdown of Šoštanj thermal power plant (TEŠ6) to save coal (Agencija za energijo, 2018, p. 45). In 2023, the share of electricity consumption covered by domestic generation nearly reached the five-year high at 90.9%, mainly due to the good hydrology and the resulting hydropower production (Agencija za energijo, 2024, p. 27).

Solid availability of domestic power plants, greater integration of dispersed sources, and excellent international interconnection of Slovenia's electric power system contribute to an extremely high level of reliability of electricity supply in the country.

9

# ENERGY IN SLOVENIA: RENEWABLES, FOSSIL FUELS, NUCLEAR ENERGY

IMPORTS, GENERATION AND CONSUMPTION

# *Energy supply in Slovenia: Half of the energy sources are imported, but most of the electricity is generated domestically*

In sections two and three it has already been established that countries generally have a certain amount of their own energy sources, that they produce energy from domestic and/or imported sources, and that they import some of the energy they need. If we add the imported energy to the domestically produced energy, we get the total annual amount of energy used for conversion to other forms of energy (electricity and heat) or final consumption (fuelling cars), which also includes the heat losses that occur on the way to consumers (via transmission lines or heat pipes). Approximately half of Slovenia's domestic energy demand is covered by energy imports.

According to the Statistical Office of the Republic of Slovenia, Slovenia's energy dependency in 2023 was 47.5%, which means that 52.5% of the total energy demand was sourced locally (SURS, 2025). The supply of petroleum products is entirely based on imports, and the country also imports natural gas. Coal is mined locally at the Velenje Coal Mine, while the two main renewable energy sources are wood biomass (mainly used for heating in single-family homes) and water (hydropower) from Slovenian rivers.

- Slovenia's total primary energy supply in 2023 was 6.1 million tonnes of oil equivalent (Mtoe), which corresponds to 257 PJ (4.2% less than in 2022 and 6.4% less than in 2021).
- The total volume of domestic energy sources in Slovenia in 2023 was 3.4 million toe (Mtoe), which corresponds to 141 PJ (7.3% more than in 2022 and 1.4% less than in 2021).
- In terms of the structure of energy supply, petroleum products dominated the energy mix with 33.9%, followed by nuclear energy with 23.3%, renewable energy sources (including hydropower) with 20.8%, coal with 11.6%, and natural gas with 10.5%.

# Electricity supply: One third from coal, one third from water, one third from nuclear power

In Slovenia, the three main players in electricity generation from domestic sources are large hydropower plants (HPP), thermal power plants (TPP), and the nuclear power plant—they are all connected to the electricity transmission system, while only a small part is connected to the distribution system.

**What electricity generation plants are there in Slovenia and who operates them?**

Electricity generation in Slovenia is managed by two holding companies: Holding Slovenske elektrarne (HSE) and the GEN Group.

**The following companies belong to HSE:**

- Dravske elektrarne Maribor (DEM): HPP Dravograd, HPP Vuzenica, HPP Vuhred, HPP Ožbalt, HPP Fala, HPP Mariborski otok, HPP Zlatoličje, and HPP Formin.
- Soške elektrarne Nova Gorica (SENG): HPP Tolmin, HPP Doblar 1 and 2, PSPP Avče, and HPP Plave 1 and 2.
- HSE Energetska družba Trbovlje (HSE edT): two gas-fired units.

*Note: Termoelektrarna Šoštanj (TEŠ) and Premogovnik Velenje (PV) were part of HSE until the end of 2024.*

**The companies that belong to the GEN Group are:**

- Hidroelektrarne na spodnji Savi (HESS): HPP Boštanj, HPP Arto-Blanca, HPP Krško, HPP Brežice, and HPP Mokrice.
- Savske elektrarne Ljubljana (SEL): HPP Moste, HPP Mavčiče, HPP Medvode, and HPP Vrhovo.
- Nuklearna elektrarna Krško (NEK).
- Termoelektrarna Brestanica (TEB).

**• One third from RES**

The proportion of electricity generated from renewable energies (in hydropower plants and other power plants using renewable energies) has been changing from year to year. And why? Because the pattern of renewable energy has been changing (*see section* 4). We have been seeing diverse environmental conditions in terms of hydrology and solar radiation. However, the share of electricity from renewables also depends on the level of investment in renewable energy installations. In general, investment in renewable energy is increasing.

In 2023, the share of electricity from renewable energy sources in total production in Slovenia was 41.6%, while in 2013 it was only 33.5%, which means an increase of 8.1 percentage points in ten years. This share, i.e. the share of renewable energies in electricity generation, is therefore higher than the share of renewable energies in the total supply or in the energy mix.

**• One third from coal**

Fossil-fired power plants—in particular TPP Šoštanj (coal) and TPP Brestanica (gas/fuel oil)—accounted for 23% of Slovenia's total electricity generation in 2023 and 33.5% in 2013, a decrease of 10.5 percentage points.

The most important pillar of the Slovenian coal industry is the Velenje Coal Mine, which used to produce around 3.5 million tonnes of coal per year, which now decreased to only between 2 and 2.5 million tonnes destined for the nearby TPP Šoštanj.

In the past, coal was also mined in the Trbovlje-Hrastnik coal mine, which is no longer in operation. Next to it is the Trbovlje Thermal Power Plant (TET), which has been operating under the new name HSE Energetska družba Trbovlje (HSE edT) since the beginning of 2018. The coal-fired unit was shut down, while two gas-fired units are still in operation. The Brestanica TPP also includes gas-fired units.

**• One third from nuclear**

In 2023, the Krško Nuclear Power Plant (NEK) contributed a 35.3% share to Slovenia's total electricity generation, which is 2.4 percentage points lower than in 2013, when the share was 32.9%.

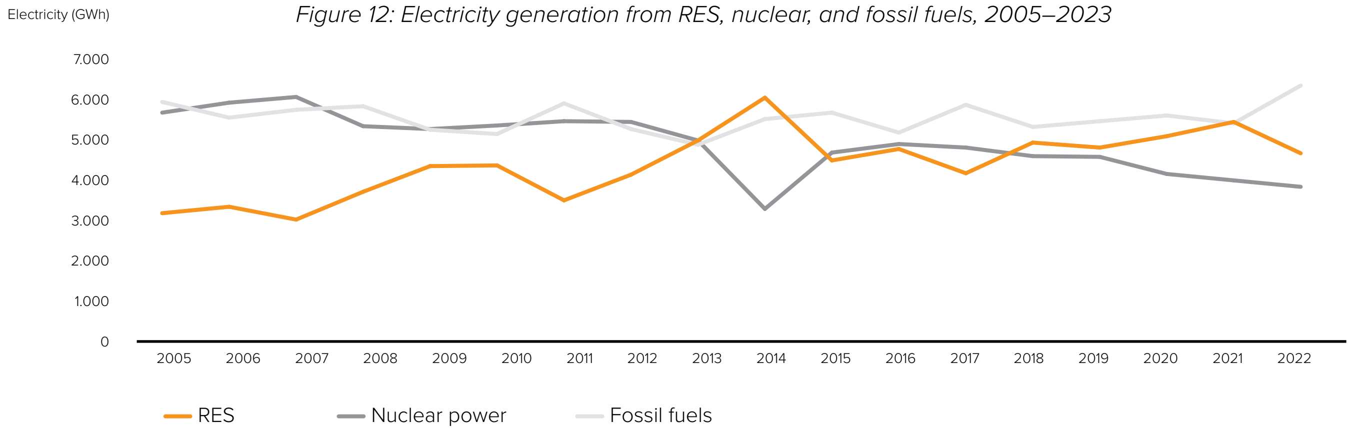
It is important to emphasise that NEK is co-owned by the Slovenian state-owned company GEN energija and the Croatian state-owned Hrvatska elektroprivreda – HEP, which means that it produces and supplies electricity only for the benefit of its two shareholders who have rights and obligations to 50% of the available energy and net production each. What does this mean? This means that NEK only contributes half of its total output to Slovenia's electricity production, as the other half is exported to Croatia

*Table 4: Gross electricity production by energy source (%)*

| | RES | NUCLEAR | FOSSIL | OTHER* |
|---|---|---|---|---|
| 2005 | 23.3 | 38.9 | 37.4 | 0.4 |
| 2006 | 24.2 | 36.7 | 38.8 | 0.3 |
| 2007 | 22.4 | 37.9 | 39.7 | 0.1 |
| 2008 | 26.3 | 38.3 | 35.5 | 0.0 |
| 2009 | 29.9 | 35.0 | 35.1 | 0.0 |
| 2010 | 30.0 | 34.4 | 35.6 | 0.0 |
| 2011 | 25.1 | 38.7 | 36.2 | 0.0 |
| 2012 | 28.7 | 35.1 | 36.1 | 0.0 |
| 2013 | 33.5 | 32.9 | 33.5 | 0.0 |
| 2014 | 39.5 | 36.5 | 23.9 | 0.1 |
| 2015 | 30.7 | 37.4 | 31.8 | 0.1 |
| 2016 | 32.3 | 34.6 | 33.0 | 0.1 |
| 2017 | 28.9 | 38.5 | 32.5 | 0.1 |
| 2018 | 33.2 | 35.4 | 31.3 | 0.1 |
| 2019 | 32.5 | 36.2 | 31.2 | 0.1 |
| 2020 | 34.1 | 37.0 | 28.8 | 0.1 |
| 2021 | 36.1 | 35.9 | 27.9 | 0.1 |
| 2022 | 31.7 | 41.2 | 27.0 | 0.2 |
| 2023 | 41.6 | 35.3 | 23.0 | 0.1 |

*Note: *Other sources include electricity generation in thermal power plants from other renewable and non-renewable sources, including waste.*
*Source: SURS (2025)*

*Figure 12: Electricity generation from RES, nuclear, and fossil fuels, 2005–2023*




*Source: SURS (2025)*

# The first third from RES

The share of energy generated from renewable energy sources (RES) has been set as a binding target for each Member State. All EU Member States have agreed on a common share of renewable energy sources in the EU energy mix of 20% by the end of 2020, with each Member State pursuing its own predetermined renewable energy target. For Slovenia, this meant that the share of renewable energy in the country's energy mix was to be increased to 25% by the end of 2020 and to 27% by 2030. The country has achieved the target so far, albeit only through statistical transfer.

*Table 5: Renewables share in the gross final energy consumption in Slovenia (%)*

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Share | 20.94 | 21.55 | 23.16 | 22.46 | 22.88 | 21.97 | 21.66 | 21.38 | 21.97 | 25 | 25 | 25 | 25.7 |

*Source: SURS (2025)*

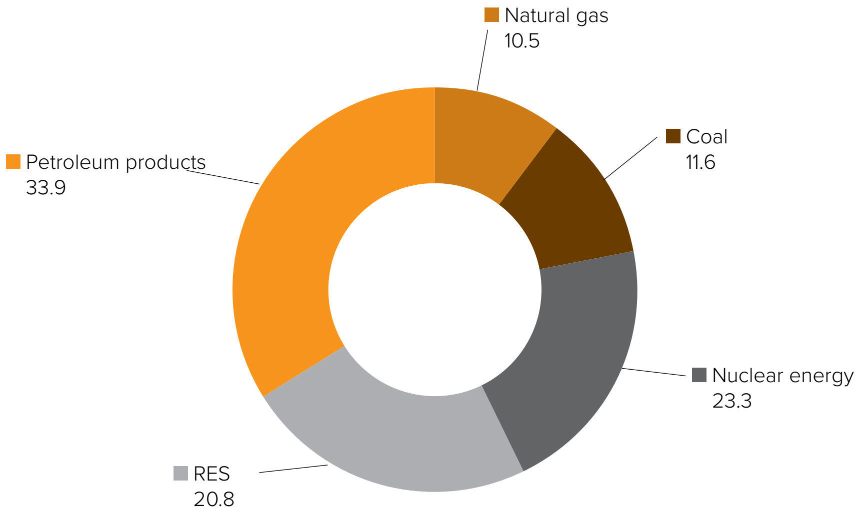
The statistical transfer of renewable energy sources is a mechanism that allows EU Member States to meet their national RES targets by buying and selling the missing shares. Member States can make arrangements for statistical transfer of agreed amounts of renewable energy from one Member State to another, with the transferred amount being deducted from the renewable energy of the country making the transfer and added to the renewable energy of the country receiving the transfer. The latter is made possible by Directive 2009/28/EC on the promotion of the use of energy from renewable sources for the 2020 framework and EU Directive 2018/2001 for the 2030 framework. The transfer agreement may be valid for one or more years and must include the quantity and price of the energy in question.

The table shows that the share of RES has remained the same in recent years—exactly 25%. The country has not reached its target for 2020-2021-2022, but has utilised the statistical transfer mechanism.

In 2022, the actual share of renewable energy in Slovenia was 22.94%. The country had to make up for the missing part of the 25% target through the statistical transfer mechanism based on an agreement with Croatia. In accordance with this agreement, Slovenia carried out a transfer of 1,193 GWh of energy at a price of €9.1/MWh and paid €10.9 million from the RES support funds managed by Borzen in its capacity as a support centre. In 2021, the RES target of 25% was also not achieved (it was actually 24.61%) and the missing share (less than one percentage point or 208 GWh) was purchased from the Czech Republic at a price of €9.80/MWh, totalling just over €2 million. A year before that, in 2020, Slovenia was also short of the 25% RES target with 24.1%, so around €5 million were paid for the statistical transfer of 465 GWh of energy to the Czech Republic.

The good news from November 2024 is that Slovenia managed to achieve 25.07% of RES in 2023, which means that the target has finally been reached.

*Figure 13: Energy supply in Slovenia, 2023 (%)*



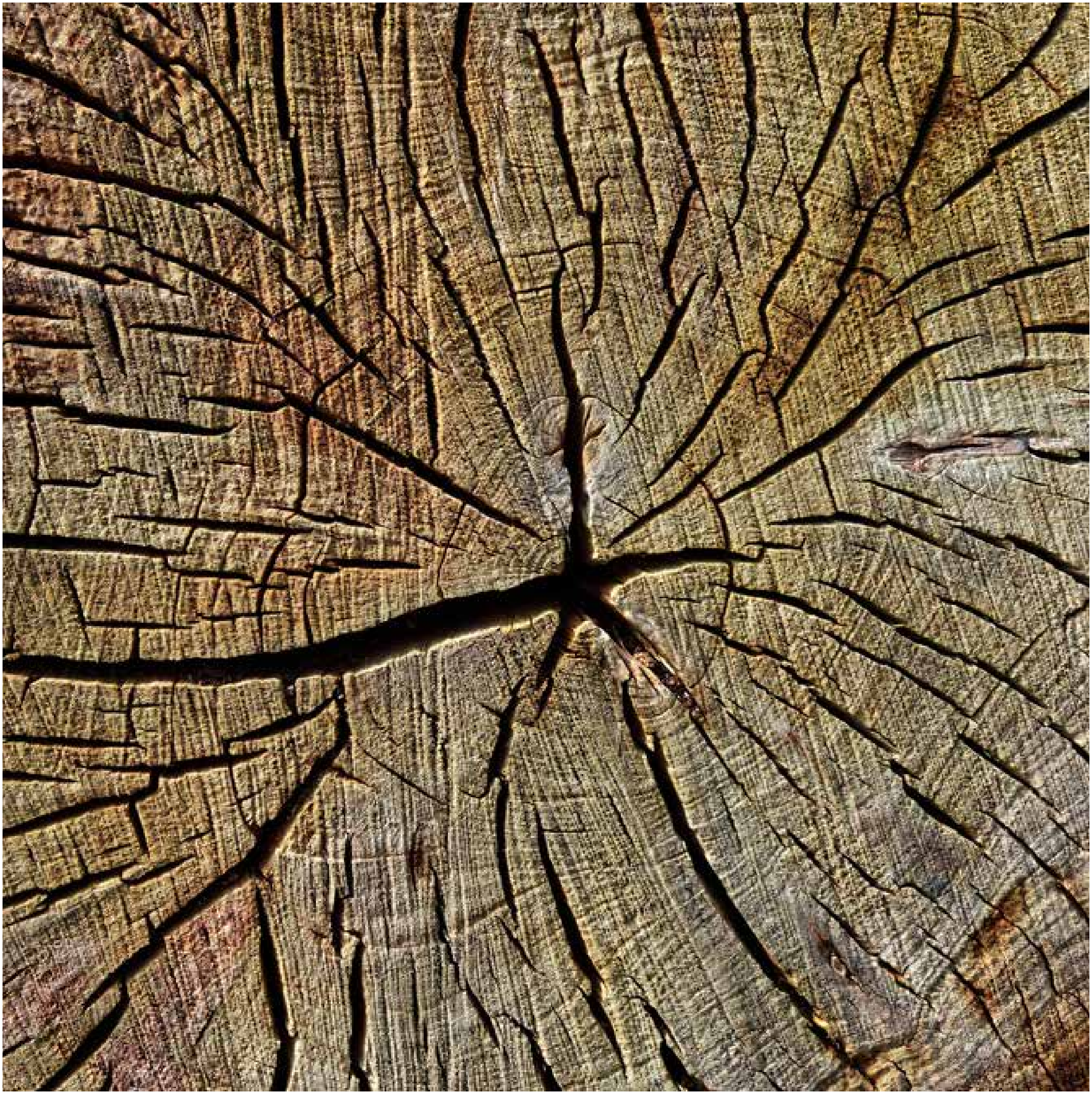

*Source: SURS (2025)*

*Table 6: The shares of RES in Slovenia's energy supply, 2023 (%)*

| RES | (%) |
|---|---:|
| Wood and other solid biomass resources | 8.4 |
| Hydropower | 6.9 |
| Solar energy (solar power plants) | 1.3 |
| Liquid biofuels (biodiesel and biopetrol) | 1.5 |
| Geothermal energy and ambient heat | 1.2 |
| Biogases (landfill gas, gas from wastewater treatment plants, etc.) | 0.4 |
| Solar thermal energy (solar thermal collectors) | 0.1 |
| Wind energy | 0.01 |

*Source: SURS (2025)*

In Slovenia, wood is the most important renewable energy source, which in 2023 had a 42% share in the country's energy mix. As much as 68% of the total wood biomass consumed in 2023 was used by households, mainly for heating. Hydropower was in second place with 35%. Other renewable energies had smaller shares in the energy mix, although the use of all renewable energies has been generally increasing.



# *The second third from coal*

In Slovenia, electricity is generated from coal at the Šoštanj thermal power plant (TEŠ). The most important operator of coal mining in Slovenia is the Velenje coal mine (Premogovnik Velenje or PV), which supplies its coal to the nearby Šoštanj thermal power plant. The second third of coal-fired power generation must therefore take into consideration both companies—PV and TEŠ. The companies are interdependent and were both managed under the umbrella of a single group, HSE, until the end of 2024. With the adoption of the law on transitional financing of the accelerated and fair coal phase-out (passed by the National Assembly in December 2024), ownership of TEŠ and PV was transferred from HSE to the state as of 1 January 2025, with management being taken over by the Slovenian Sovereign Holding (SSH).

How has coal production in Slovenia developed over the course of history? Starting from an initial 3,500 tonnes in 1887, PV achieved its biggest breakthrough in production after 1955, when it reached an annual production of one million tonnes of coal for the first time. The most important development of the coal mine took place after 1972 with the introduction of mechanised mining, which led to a significant increase in coal production: Between 1981 and 1986, PV mined over 5 million tonnes of coal a year. While PV used to produce an average of around 3.5 million tonnes of coal per year, annual production is now between 2 and 2.5 million tonnes. PV employs more than 1,000 people and its production depends mainly on the consumption of its sole customer, TEŠ.

The main activity of TEŠ, which is located in the immediate vicinity of PV, is the production of electricity and also district heating in the Šalek Valley, where Velenje is the largest town. With an installed capacity of 1,029 MW, it produces on average a third of the country's electricity. In times of crisis, it can cover even more than half of electricity consumption. The average annual electricity production is between 3,500 and 4,200 GWh, and the average annual production of thermal energy for district heating is between 300 and 350 GWh. To produce this amount of electricity and heat a year, TEŠ consumes between 2.8 and 3.2 million tonnes of coal. TEŠ also offers a wide range of system services (primary, secondary, and tertiary reserve) and employs around 300 people.

In view of the energy transition as part of the European Green Deal (*see chapter 3*), with which the EU aims to become a climate-neutral society by 2050, i.e. to achieve net-zero greenhouse gas emissions, it will be necessary to move away from coal. This means the coal mines throughout the EU, including in Slovenia, will be closed, which is referred to as the coal exit.

In January 2022, the Slovenian government adopted the national strategy for coal phase out and restructuring of coal regions in line with the principles of just transition. This is the foundation for the energy transformation of Slovenia but also that of the Savinja-Šalek (SAŠA) and Zasavje coal regions, and for all those involved in the coal industry, the objective of which is to ensure a just transition as quickly and comprehensively as possible, especially for all affected workers and their families.

According to this strategy, 2033 is the year in which Slovenia will stop generating electricity from coal at the latest, which means that an earlier phase-out of coal is also possible.

By setting a timeframe for the coal phase-out, the country has secured access to the Just Transition Fund, from which it will receive just over €248 million for the period 2021-2027. Of the nearly quarter of a billion euros, €174 million are earmarked for the Savinja-Šalek region, and €75 million for the Zasavje region. The majority of the funds, around €140 million, must be utilised by the end of 2026, which means that the projects must be completed by mid-2026. The remaining €109 million can be spent before the end of 2029, just like the rest of the cohesion funds.

There are two important milestones for the Velenje coal mine, namely the period before and the period after the year of the coal phase-out. Until the target year, production will continue as planned, which will primarily require the personnel engaged in the production process, while after the cessation of mining, some personnel will be needed for another 15 years for the activities related to mine closure. The proposed year 2033 therefore means that mining operations will continue for at least another 20 years.

The question of what to do after the year of the closure of PV and TEŠ is one of the biggest challenges for the country, which generates a third of its electricity through these two entities. On the one hand, the existing local energy site and employees must be taken care of, and on the other hand, an alternative source of electricity generation must be secured at national level. A green transition to a carbon-free society is probably one of the biggest challenges facing the country. The Šalek Valley is an important energy site and it is planned to maintain this type of activity there, but in a different way. The people at PV believe the future could lie in using the existing high value-added expertise, such as expertise in mining, electrical engineering, and mechanical engineering. They are also considering opportunities in construction, design, electronics, refurbishment, and manufacturing of mining and construction machinery and equipment. TEŠ believes that maintaining the energy centre combined with the knowledge and technology accumulated in the Šalek Valley will enable further development and the introduction of new technologies and related jobs with high added value. HSE will focus primarily on investments in the use of technologies to reduce greenhouse gas emissions and strengthen the circular economy. The aim is to preserve existing jobs and create new ones, to complete the transition to a climate-neutral economy by 2050 at the latest, and to ensure security of supply and energy self-sufficiency.

In September 2024, HSE and the Ministry of Environment, Climate and Energy announced that TEŠ was in a serious financial situation that was leading to insolvency. HSE's continued financial support for TEŠ (and PV) or the absorption of losses was no longer possible due to EU state aid rules. On 1 January 2025, the HSE Group was restructured by dissolving its “thermal division” (the companies Premogovnik Velenje and Termoelektrarna Šoštanj) and transferring it to the state (under the direct management of SSH).

TEŠ's primary task would thus be to provide heat for the district heating system of Šoštanj and Velenje (for around 35,000 people), the industry, and the infrastructure of the Savinja-Šalek region. In the short term, it is not possible to completely replace TEŠ as a heat producer with alternative producers.

In order to ensure a continued supply of heat in the Šalek Valley, one possible solution is the adoption of an emergency law that would make TEŠ a public utility company with heat production as its main activity. The Šoštanj thermal power plant is the only producer that supplies thermal energy for the Šalek Valley to the Velenje municipal utility under a contract valid until mid-September 2031. This contract stipulates that TEŠ must continuously supply heat for heating the Šalek Valley every day of the year.

# *The third third from nuclear*

Slovenia is one of 32 countries in the world that operate nuclear power plants. It has one nuclear power plant—the Krško Nuclear Power Plant (NEK)—which has been in operation for 40 years. The country imports the fuel for the NPP and exports half of the electricity produced by NEK to Croatia (50% owner of NEK).

The investors in the first nuclear power plant were the energy companies Savske elektrarne Ljubljana and Elektroprivreda Zagreb, which, in cooperation with the investment team, carried out the preparatory work, the tender and the selection of the most favourable bidder. In August 1974, the investors signed a contract for the supply of equipment and construction of a 632 MW nuclear power plant with the American company Westinghouse Electric Corporation, with Gilbert Associates Inc. as the designer, Gradis and Hidroelektra as the construction contractors, and Hidromontaža and Đuro Đaković as the installers. The foundation stone for the Krško nuclear power plant was laid on 1 December 1974. In January 1984, the NPP was granted a licence for regular operation. After the originally planned operating period of 40 years expired, an environmental licence to extend the operating period to 60 years was issued by the responsible ministry in January 2023. The extension of the NEK's operating life to 2043 was based on a preliminary environmental impact assessment and an environmental approval.

In addition to extending the operating life of NEK, Slovenia is planning to build a second nuclear power plant unit (JEK2). While the first unit had an original operating life of 40 years, which was extended by 20 years and can be extended further to 80 years in 2043, the planned operating life for JEK2 is 60 years, with the possibility of being extended to 100 years.

Slovenia is opting for a second nuclear power plant unit because, on the one hand, it has been moving away from fossil fuels and coal (so the second third must be replaced in some way) and, on the other hand, the trend towards electrification (heat pumps, electromobility, the needs of digitalisation and new technologies) is likely to lead to a (significant) increase in electricity consumption. According to some forecasts, annual electricity consumption in Slovenia will more than double by 2050 compared to current consumption.

Another important reason for building a second nuclear power plant is the country's energy self-sufficiency. Slovenia covered around 70% of its electricity needs in 2022 and 90.9% in 2023 from domestic sources (Agencija za energijo, 2024). Without the Šoštanj thermal power plant (TEŠ), this share would certainly be significantly lower, which will actually be the case after the closure of TEŠ and the Velenje coal mine. Energy experts agree that the expected further increase in Slovenia's dependency on imports is strategically unacceptable. If we want to be self-sufficient in electricity, we need new, reliable, and carbon-free sources of electricity. Energy self-sufficiency is the key to energy security, which we will look at in more detail in the next chapter.

Despite the fact that Slovenia has lived with nuclear energy for 40 years, it is still a source of controversy. It is important that this debate is based on credible data and information. GEN energija, a major investor in JEK2, has offered answers to questions about the second nuclear power plant project. The question of nuclear energy is also a political issue, so a wider public debate on it is to be expected.

# *People consume energy through their activities*

Tips for saving energy:

https: //ezs. si/en/energy-transition/

Energy is consumed by people (households) and companies (the economy) in different forms.

In recent years, final energy consumption in Slovenia was around 5,000,000 toe (5 Mtoe). In 2023, Slovenia is estimated to have consumed 2,120,577 toe of petroleum products, 1,071,025 toe of electricity, 598,680 toe of renewable energy and waste, 527,643 toe of natural gas, 147,042 toe of heat, 83,513 toe of geothermal, solar and wind energy, and 24,359 toe of solid fuels (4,572,840 toe in total).

*Table 7: Energy balance (toe), Slovenia*

| | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|
| End consumption | 4,503,537 | 4,825,484 | 4,819,028 | 4,572,840 |

*Source: SURS (2025)*

In the period between 2000 and 2023, consumption peaked in the year 2008 at 5,674,200 toe and bottomed out in 2020 at 4,503,537 toe.

Consumption in the energy sector fell from around 18,000 toe to just under 10,000 toe between 2000 and 2023. In the manufacturing and construction sectors, it fell from around 1,400,000 toe to around 1,100,000 toe. In the transport sector, it rose from 1,200,000 toe to 1,900,000 toe. Consumption by private households has fluctuated and was around 1,200,000 toe in 2000, rose to over 1,400,000 toe in 2005, and has not exceeded 1,200,000 toe since 2014 (totalling 1,040,000 toe in 2023). In agriculture and forestry, consumption remained more or less constant at around 75,000 toe (SURS, 2025).

Looking only at electricity, total electricity consumption in Slovenia in 2023 was 12,688 GWh, or 11,847 GWh excluding losses in the transmission and distribution systems. Compared to 2022, it was 950 GWh or 7% lower. In 2023, households consumed 3,386 GWh of electricity or 3.1% less than in 2022. As can be seen from the table, electricity consumption in Slovenia was in decline in the period 2021–2023.

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*Table 8: : Electricity consumption, 2021–2023*

| ELECTRICITY CONSUMPTION [GWh] | 2021 | 2022 | 2023 |
|---|---|---|---|
| Business consumption in the transmission system | 134 | 96 | 66 |
| Business consumption in the distribution system | 7,803 | 7,660 | 7,137 |
| Business consumption in closed transmission systems | 1,350 | 1,203 | 852 |
| **TOTAL BUSINESS CONSUMPTION** | **9,287** | **8,959** | **8,056** |
| **HOUSEHOLD CONSUMPTION** | **3,665** | **3,493** | **3,386** |
| • Single-tariff metering | 916 | 863 | 854 |
| • Double-tariff metering | 2,748 | 2,629 | 2,532 |
| **Total end-consumer consumption** | **12,952** | **12,452** | **11,442** |
| Consumption of Avče PSPP in the pumping mode | 384 | 341 | 406 |
| Losses in transmission and distribution system | 837 | 845 | 841 |
| **Total electricity consumption** | **14,173** | **13,638** | **12,688** |

*Source: The Energy Agency (2024)*

# 10

# ENERGY SECURITY


WT1

## Import dependency in several contexts

All parts of the world are interdependent—some more, some less—but in terms of trade, the world is now more interconnected than ever. When it comes to energy, countries or regions that are rich in natural resources—in addition to coal, oil and gas, for example, also water and rare metals—have an advantage. It was mentioned at the beginning of this publication that crude oil is now the world's most important export commodity.

Interaction strengthens integration, but increased co-operation also means interdependence. Dependency can be a binding force—at least that was the premise behind the founding of the European Union. In 1950, five years after the Second World War, European nations were still in the process of alleviating the terrible consequences of the Second World War. On 9 May of the same year, French Foreign Minister Robert Schuman presented a declaration in which he proposed the creation of a European Coal and Steel Community. The European heads of state and government were determined to prevent another war. They believed that by pooling steel and coal production, a war between historical rivals France and Germany would be, as the declaration put it, "not merely unthinkable, but materially impossible". The European Coal and Steel Community was founded in 1951 by the Treaty of Paris with Belgium, France, Italy, Luxembourg, the Netherlands, and West Germany as signatories. In fact, to date there have been no military conflicts between these countries or, subsequently, between the growing community of EU members.

## Sanctions against Russia and falling EU gas consumption

The above does not mean that there have been no conflicts in the European neighbourhood. Slovenia witnessed the disintegration of the former Yugoslavia and the years of war in some of the former republics have left deep scars in many places. In 2022, Europe also experienced Russia's attack on Ukraine, the country through which many of the energy routes for Russian energy products pass to European consumers. Ukraine is not a member of the EU, but the EU has sided strongly with it and imposed unprecedented sanctions against Russia.

The sanctions, which complement existing measures against Russia imposed since 2014 over the annexation of Crimea and non-compliance with the Minsk agreements include targeted restrictive measures (individual sanctions), economic sanctions, diplomatic measures, and visarelated measures. The economic sanctions are designed to seriously damage Russia's actions while effectively hampering Russia's ability to continue its aggression.

Sanctions have been imposed on companies in the energy sector. Products that cannot be imported into the EU from Russia include crude oil and refined petroleum products; coal and other solid fossil fuels; steel, iron and crude iron; cement and asphalt; copper and aluminium wire and tubes; wood, paper, synthetic rubber and plastics; helium; seafood, alcoholic beverages, cigarettes and cosmetics; diamonds and gold, including jewellery; other goods that contribute to strengthening Russia's industrial and defence capabilities. Goods that cannot be exported from the EU to Russia include advanced technologies (e.g. quantum computers and advanced semiconductors, electronic components and software); certain types of machinery and transport equipment; special goods and technologies required for oil refining; and equipment, technologies and services for the energy industry.

Russia and the EU used to rely on each other's imports, and the sanctions have naturally affected this cooperation or trade. Between the first quarter of 2021 and the first quarter of 2024, the value of EU imports from Russia fell by 85%, according to Eurostat calculations. From 2021 to 2023, crude oil and petroleum products imported directly from Russia to the EU alone fell by 86.5%—from 171,302,000 tonnes in 2021 to 23,107,000 tonnes in 2023. Russia's share in oil import of non-EU countries fell from 30% in the first quarter of 2022 to 3% in the first quarter of 2024. Russia used to export around half of its oil to the EU. The ban on coal imports from Russia has affected around a quarter of all Russian coal exports. So, in this case, interdependence has not improved the situation and of course both the EU and Russia have started to look for new sources of imports and exports, respectively (Eurostat, 2025).

As for gas, no sanctions were imposed, but the EU decided that countries should reduce their gas consumption. The EU has succeeded in doing so: In 2023, the EU recorded its lowest consumption of natural gas since 2019. While lower consumption of a foreign energy source naturally strengthens a country's own energy security, simply replacing one energy source with another or using a different supply route from the same source would still mean dependency.

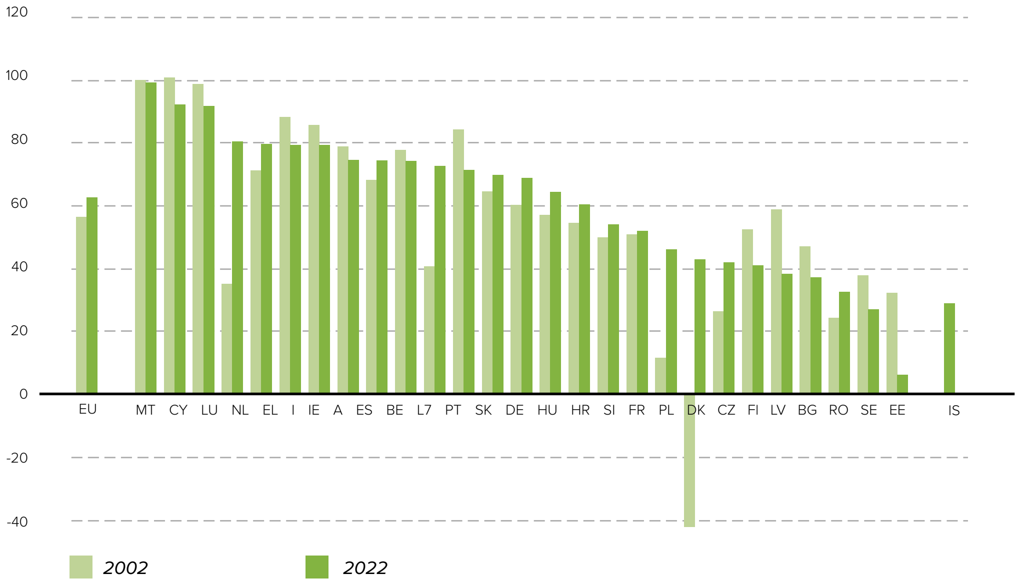
# *The EU's energy dependency is already almost two thirds*

The degree of dependency on energy imports shows the extent to which an economy relies on imports to cover its energy needs. It is defined as the share of net imports (imports minus exports) in gross domestic energy consumption (which is the sum of energy produced and net imports).

While the EU's energy import dependency was 56% in 2002, 58% in 2020, and 56% again in 2021, it was already 63% in 2022, which means that 63% of the EU's energy needs were covered by net imports. The differences between the individual countries are enormous, ranging from 99% dependency in Malta, 92% in Cyprus and 91% in Luxembourg to 6% in Estonia. More than half (15) of the EU countries have increased their energy dependency on foreign countries between 2002 and 2022, i.e. in two decades, including Germany, Austria, the Netherlands, Greece, Hungary, Croatia, and Slovenia. On the other hand, 11 EU Member States including France, Spain, Italy, Finland, Estonia, and Latvia have managed to reduce their dependency (Eurostat, 2024).

In 2022, when the EU imported 63% of its energy, more than half of imports of oil and petroleum products from non-EU countries came from five countries: Russia (21%), the U.S. (11%), Norway (10%), Saudi Arabia and the UK (both 7%). Similarly, the analysis shows that more than half of the EU's natural gas imports come from Russia (23%), Norway (17%), the U.S. (14%), and Algeria (11%), while the largest imports of solid fossil fuels (mainly coal) come from Russia (23%), followed by the U.S. (18%), Australia (16%), South Africa (14%), and Colombia (13%) (Eurostat, 2024).

*Figure 14: Energy import dependency of EU countries*




*Source: Eurostat (2024)*

Oil products make up the largest share of the EU's energy mix. In 2022, the EU's energy mix was mainly made up of five different sources: crude oil and petroleum products (37%), natural gas (21%), renewables (18%), solid fossil fuels (13%), and nuclear energy (11%). Russia has long been the main supplier of crude oil and petroleum products, natural gas, and solid fossil fuels to the EU, but this could change now due to the sanctions imposed on the country.

# *European Energy Union*

Energy security is one of the most important dimensions of the European Energy Union. In February 2015, the EU adopted a strategy for the Energy Union. It comprises five dimensions: energy security (energy reliability, solidarity, and trust), the internal energy market, energy efficiency, climate action, and decarbonisation of the economy, along with research, innovation, and competitiveness. As the world's largest energy importer, the EU must reduce its dependency on external markets. The Energy Union should help the EU reduce its dependency on energy imports, so its strategy aims to provide Europe with affordable, secure, and sustainable energy.

The completion of the internal energy market and a more efficient use of energy are key factors for energy security. This requires more transparency, more solidarity, and more trust among Member States, with countries in the neighbourhood, such as Ukraine, being undoubtedly important as well.

Every year, Brussels produces a report on the state of the Energy Union. The report from October 2023, states that Russia has used energy supply as a weapon to cut off Europe's supply of fossil fuels thereby damaging its economy. The EU has managed to prevent energy supply disruptions, reduce pressure on energy markets, and increase the supply of clean renewable energy—after all, in May 2023, the EU generated more energy from wind and solar than from fossil fuels for the first time in history (European Commission, 2023).

But such shake-ups among long-standing partners are not easy and have consequences. Energy markets are (still) vulnerable, critical infrastructure needs to be protected, including from sabotage, and the impact of the crisis highlights the risks of dependency on unreliable sources. If the Union wants to be a major global player, it must provide affordable, reliable and accessible energy in the long term—both for households and for the economy, as the Union's industrial/economic competitiveness is essential for its prosperity and further development. The energy crisis and supply chain disruptions of the last two years show how important it is to increase the production capacity of the EU's net-zero industry while strengthening its competitiveness. The State of the Energy Union Report 2024, issued in September 2024, already shows the progress the EU is making in providing reliable, competitive, and affordable energy for all (European Commission, 2024).

Chapters 8 and 9 have already pointed out that Slovenia does not have sufficient energy sources to meet the needs of all household and industrial consumers, so the country is dependent on imports. In fact, Slovenia has to import about half of the country's energy needs. Slovenia is completely dependent on oil imports. This means that the country is very vulnerable to disruptions in oil supply. As this is generally true for a large part of the EU, the EU has imposed an obligation on its Member States to maintain minimum stocks of crude oil and petroleum products that they could use in the event of an oil supply disruption. Member States have generally recognised the increasing importance and imperative for the EU as a community, to develop an integrated energy policy combining measures at European and Member State levels.

The availability of oil stocks and the security of energy supply are fundamental elements of public security for the Member States and for the EU as a whole. To ensure security of oil supply, Council Directive 2009/119/EC, which obliges Member States to maintain minimum stocks of crude oil and/or petroleum products, requires that Member States, including Slovenia, should maintain at all times oil stocks equivalent to at least 90 days of average daily net imports or 61 days of average daily domestic consumption, whichever is the greater. Member States may set up central stockholding entities (CSEs). Slovenia has decided to entrust the task of building up and managing compulsory stocks of crude oil and petroleum products to the Agency of the Republic of Slovenia for Commodity Reserves, which is owned by the Republic of Slovenia. Slovenia began building up compulsory stocks of petroleum products in 1999. By 2005, it had reached the required 90 days of compulsory stocks and has since complied with the provisions of the Directive. The largest part of the compulsory stocks of petroleum products is held in the form of physical—real—stocks, and a smaller part in the form of delegated stocks.

Slovenia does not import crude oil because it has no refineries of its own. Petrol, the largest petroleum company in Slovenia, imports only petroleum products, i.e. diesel fuel, unleaded petrol, and liquefied petroleum gas (LPG). Petrol imports most of its liquid fuels from EU refineries in the Mediterranean and north-west Europe, mainly because they guarantee adequate product quality. Petrol's purchasing strategy is centred on maritime supply, although inland refineries in South-East Europe are equally important, as they complete the supply chain and improve supply stability, especially for products that are typical of local demand.

Slovenia is also fully dependent on natural gas imports. It does not have its own natural gas wells, natural gas storage facilities, or liquefied natural gas terminals, so the natural gas available on the Slovenian wholesale market is imported from neighbouring countries and delivered via transmission pipelines. The wholesale market is therefore supplied with gas from Austria, Italy, and Croatia. The transmission network is connected to the natural gas transmission networks of Austria (Ceršak metering and regulating station), Italy (Šempeter pri Gorici metering and regulating station), and Croatia (Rogatec metering and regulating station). At the border crossings with Italy and Croatia, natural gas can be transported in both directions, while at the border crossing with Austria, it can only be transported in one direction to Slovenia.

In recent years, an additional transmission route through Slovenia via Italy has been established and the proportion of capacity leased at individual border crossing points has changed, both of which indicate a change in the gas import routes to Slovenia. All of this is a consequence of the energy crisis and the changed geopolitical situation in the eastern supply corridors. While gas suppliers from Austria provided 84% of total gas imports in 2022, with Italy supplying the rest, the western supply route became stronger in 2023, supplying 37% of total gas imports.

The natural gas market in Europe underwent a complete transformation of the supply side following the Russia-Ukraine conflict in 2022. The eastern supply corridor, through which Europe sourced over 40% of its natural gas in the past, accounted for 25.1 bcm or 8.7% of total natural gas imports in 2023. Most European suppliers terminated their long-term Russian gas supply contracts in 2022, with the exception of the central EU countries, which had no suitable alternative at that time. The EU Member States have compensated for the shortfall in Russian gas by increasing imports via pipelines from the north and south and through deliveries to European LNG terminals.

An increase in the otherwise fully utilised export capacity of the northern supply route, through which the EU imported around 30% of its total gas imports in 2023, would only be possible by optimising maintenance work. The ambitious plans were thwarted by unplanned outages in the Norwegian gas infrastructure, which led to even lower export volumes.

In contrast to the northern supply route, the southern one offers more opportunities to expand import capacities and secure natural gas from Algeria, Libya, and Azerbaijan. The commissioning of the Trans Adriatic Pipeline (TAP) on 15 November 2020, which supplies Azerbaijani natural gas from the Caspian Basin via the South Caucasus and Turkey, was therefore an important contribution to improving the security and diversification of natural gas supply routes to the EU. The TAP pipeline transported 11.4 billion cubic metres and 11.8 billion cubic metres of gas in 2022 and 2023, respectively, representing 3.4% and 3.5% of the EU's total gas imports. Italian diplomacy was very active in 2023 to ensure a stable energy supply. An important factor is the encouraging plans of Algeria and Libya to expand production capacity, which could offer the opportunity to further increase import capacity along the southern supply corridor. If these plans are realised, the annual capacity of natural gas exports via pipelines from North Africa to Italy could be increased from just over 40 bcm at present to around 60 bcm, enough to cover 80% of Italy's total annual gas consumption or 10% of the EU's total gas consumption in 2021.

To ensure the diversification and security of natural gas supply, the EU has increased its imports of liquefied natural gas (LNG) to compensate for the loss of Russian supplies, with imports of more than 120 billion cubic metres in 2023. This volume is due to the expansion of existing terminals and the accelerated construction of new LNG import terminals.

Geoplin, Slovenia's largest natural gas wholesaler, was forced to terminate its existing longterm supply contract for Russian gas at the end of 2022. Under a natural gas framework agreement with Algeria's Sonatrach, which came into force at the beginning of 2023, Geoplin imports the majority of the natural gas for the country's needs in Europe via the Mediterranean pipeline network. In addition, Geoplin signed a cooperation memorandum with the Azerbaijani state oil company SOCAR in 2024 and has already concluded its first natural gas supply deal, which could be the first step towards long-term cooperation in natural gas supply between Geoplin and SOCAR. The capacity expansions of the TAP pipeline and the pipelines from North Africa were announced some time ago. Of the two options, the second seems more viable if Algeria, the largest exporter of natural gas from North Africa, realises its ambitious plans to expand production. In this case, or in the event of the expansion of TAP capacity, it is realistic to expect increased liquidity at the Italian virtual trading point, which would further strengthen the role of the southern supply corridor. The latter is an advantage for Slovenia due to its geographical proximity. The nearby LNG terminal on the island of Krk also offers additional security for Slovenia's natural gas supply.

As we have already established, Slovenia is much less dependent on imports for electricity than for oil and gas. However, the import dependency of Slovenia's electricity supply fluctuates considerably depending on the state of precipitation (hydrology), as this has an impact on electricity generation from hydropower plants.

Although one of Slovenia's options for reducing its dependency on oil and gas is "simply" to reduce consumption—given that the country has no production capacities—Slovenia could also reduce its dependency on electricity by expanding its own production capacities. Even if electricity consumption were to be reduced through energy efficiency measures, electrification in all areas of society is expected to increase electricity consumption. Slovenia currently uses both renewable and fossil fuels to generate electricity, but in the future, fossil fuels will have to be replaced by cleaner alternatives in all EU countries and in most countries around the world. Slovenia must therefore start today to prepare for the construction of major energy plants in the future.

Every country, every economy, and every household need energy, and it has to come from somewhere. Energy dependency on imports, i.e. on other countries, signifies less security, more vulnerability, and unpredictable prices. In September 2024, Mario Draghi, the former President of the European Central Bank (ECB), shared the same idea in his report *The future of European competitiveness*, where he stated that "EU companies still face electricity prices that are 2-3 times those in the U.S. Natural gas prices paid are 4-5 times higher. This price gap is primarily driven by Europe's lack of natural resources, but also by fundamental issues with our common energy market. Market rules prevent industries and households from capturing the full benefits of clean energy in their bills. High taxes and rents captured by financial traders raise energy costs for our economy".

And also: "Over the medium term, decarbonisation will help shift power generation towards secure, low-cost clean energy sources. But fossil fuels will continue to play a central role in energy pricing at least for the remainder of this decade. Without a plan to transfer the benefits of decarbonisation to end-users, energy prices will continue to weigh on growth".

The obligations arising from international treaties and agreements, particularly in relation to the energy market, investments, energy and energy transmission, integration into international energy systems, and climate change mitigation, are an integral part of Slovenia's energy policy and plans for the development of energy activities. In this context, the Energy Act (EZ-2) prescribes the country's energy policy with measures for the transition to non-fossil energy sources, including incentives for the use of renewable energy sources, energy efficiency, and investments to support a fair, green transition of carbondependent regions and areas (restructuring of coal regions).

In the Energy Act (EZ-2), energy security is implied also in the provisions on crisis situations in energy supply, with measures being defined specifically for such situations. It also creates a systematic basis for temporary energy price control in the event that major market disruptions or prolonged periods of significant fluctuations in energy prices beyond normal seasonal fluctuations occur or can reasonably be expected.

The updated Integrated National Energy and Climate Plan (NEPN) of Slovenia (adopted in December 2024) composed by NEPN Consortium (2024) also defines goals for energy security, namely:

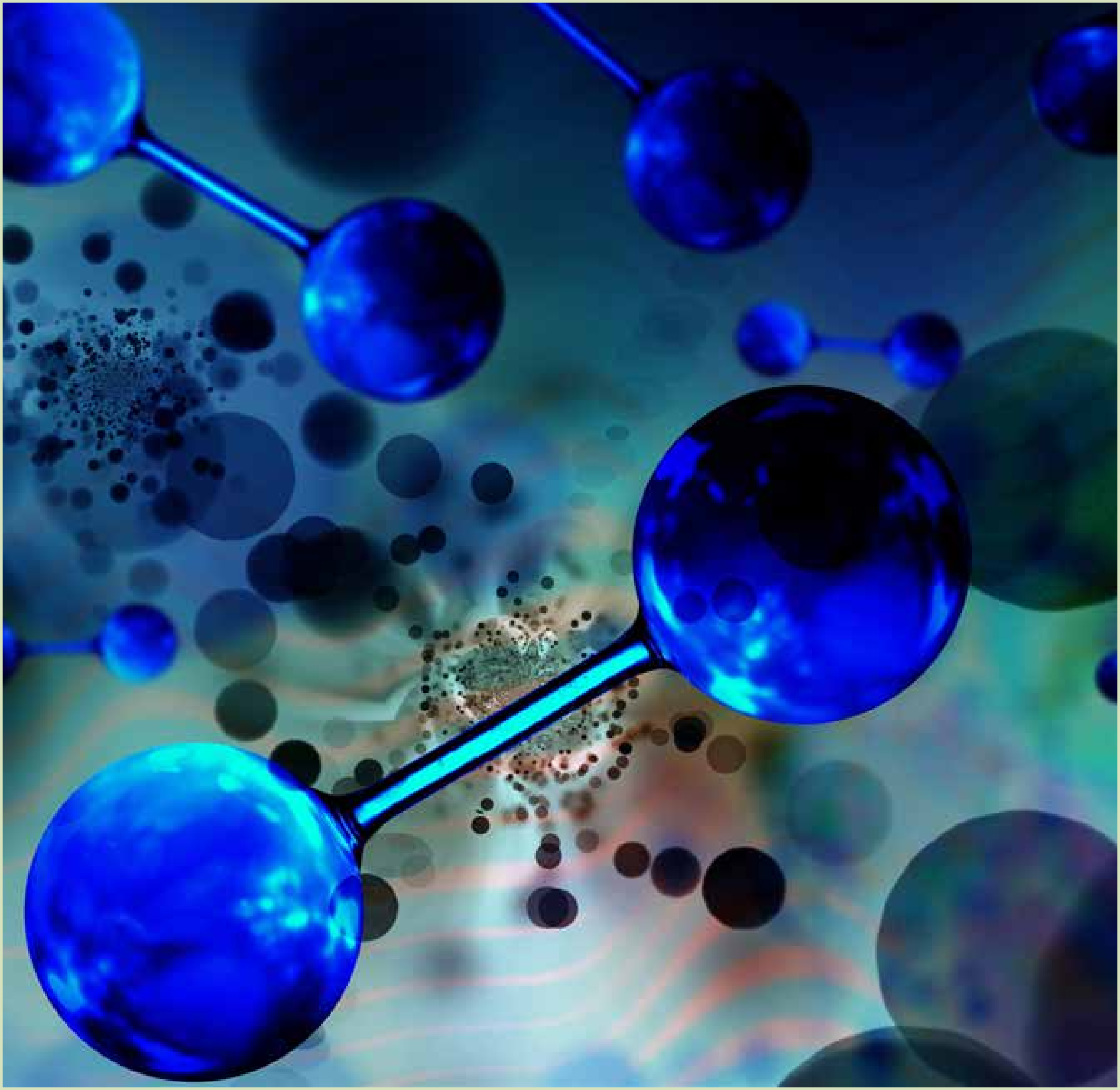
- Ensuring a secure and competitive energy supply.

- Diversifying energy supply sources and routes, production capacities, locations, technologies, and energy products.

- Ensuring an adequate level of security of electricity supply (maintaining a high level of electricity interconnection with neighbouring countries—the target is more than 80%; ensuring at least 85% of electricity supply from Slovenian power plants by 2030 and 100% by 2040; ensuring sufficient generation capacity—the ability to meet the electricity and energy needs of customers in all situations, taking into account the planned and unplanned availability of all elements; continuing the use of nuclear energy and maintaining excellence in the operation of nuclear power plants in Slovenia and making an informed and transparent decision on the construction of a new nuclear power plant as soon as possible but no later than 2028; increasing the resilience of the electricity distribution network to disruptions and reducing possible impacts on the natural environment (fires)—increasing all the while the share of the underground medium-voltage network from the current 35% to at least 50%; accelerating the development of system services and the active role of consumers of electricity, district heating, and other goods; and ensuring that at least a minimum level of system services is mandatorily leased within the Republic of Slovenia).

- Ensuring a reliable and competitive gas supply (upgrading interconnections with neighbouring countries and preparing for new renewable and low-carbon gases; reducing import dependency on fossil fuels also through domestic production of renewable and low-carbon gaseous and liquid fuels—the goal is to produce at least 5% of renewable and low-carbon gaseous fuels and 1% of liquid fuels from Slovenian sources by 2030).

- Accelerated development of energy storage technologies, infrastructures, and services (by accelerating the construction of pumped storage hydropower plants and battery-based electricity storage systems).



# The role of hydrogen and renewable gases

Hydrogen can be used as a renewable energy storage that stabilises the entire energy system and contributes to the decarbonisation of the energy system, especially in the industrial and transport sectors (Saha et al., 2023). Although hydrogen ($H_2$) is invisible, colourful descriptions are used in connection with the way it is produced (Zemeljski plin, 2023). "Green" hydrogen is described as the clean energy source of the future, as it is the only type of hydrogen that is produced in a climate-neutral way (World Economic Forum, 2021).

Hydrogen emits only water when burned. However, its creation can be carbon intensive. Various methods have therefore been developed to lessen this impact, and scientists label the different types of hydrogen with colours to distinguish them from each other. Depending on how it is produced, hydrogen can be **grey, blue, turquoise, or green**, and sometimes pink or yellow, with naming conventions varying from country to country and over time (World Economic Forum, 2021).

**Grey hydrogen** is the most common form and is produced by steam reforming from natural gas or methane, whereby the resulting $CO_2$ escapes into the atmosphere and increases the greenhouse effect. **Blue hydrogen** is actually grey hydrogen, the difference being that the $CO_2$ produced during steam reforming is captured and stored underground (Carbon Capture and Storage or CSS) and does not escape into the atmosphere. For this reason, this method of hydrogen production can be considered $CO_2$-neutral in terms of its environmental footprint. **Turquoise hydrogen** is produced from methane by pyrolysis, producing solid carbon instead of $CO_2$. This eliminates the need for carbon capture and storage, and the carbon can be used, for example, in tyre production or as a soil conditioner (Zemeljski plin, 2021). **Green hydrogen**—also known as "pure hydrogen"—is produced by electrolysis of water (splitting water into two hydrogen atoms and one oxygen atom). Only electricity from renewable sources is used, so no $CO_2$ is produced in this way (World Economic Forum, 2021).

Green hydrogen is at an early stage of development. One of the biggest challenges is its production cost. Some expect the price to fall as the technology develops and economies of scale are achieved, others remain sceptical. Hydrogen enables the seasonal storage of energy in large underground storage facilities. This means that hydrogen could be used to store solar and wind energy generated in times of abundance (summer, spring, autumn) and use it when it is most needed (winter). The IEA report on hydrogen (Global Hydrogen Review 2024) shows that the production of green and low-carbon hydrogen increased by almost 50% worldwide in the period 2021-2024, with green hydrogen accounting for almost all of the increase. Electrolyser production capacity has also increased significantly, quadrupling to be precise, which means that the increase in electrolyser production will enable additional production of green hydrogen (IEA, 2024).

Let us also mention another renewable gas that has been in use for a long time, namely biomethane. The combined production of biogas and biomethane amounted to 22 billion cubic metres in 2023, which is about 7% of European gas consumption (roughly the amount consumed by Belgium, Ireland, and Denmark combined). In Denmark, biomethane, which is largely produced domestically, accounts for around 40% of the gas in the Danish gas system. The growth of biomethane in the EU and in Europe as a whole has been significant in recent years, increasing almost tenfold (from 0.5 bcm in 2011 in the EU to 4.9 bcm in 2023 across Europe—of which 4.1 bcm in the EU alone and a further 0.8 bcm in European non-EU countries) (European Biogas Association, 2024).

## *World energy trilemma*

EICS is a member of the World Energy Council (WEC) whose reports also emphasise the importance of energy security. The analysis entitled World Energy Trilemma Report assesses countries' energy policies on the basis of three key dimensions: energy security (reliable and uninterrupted energy supply), energy equity (access to affordable energy), and environmental sustainability (minimising the impact of energy on the environment). The WEC report on challenges and opportunities in the energy sector, the so-called World Energy Issues Monitor, emphasises the importance of energy security for economic stability. The 2024 report mentions extreme weather events that can threaten energy generation and distribution infrastructure, which in turn affects energy security. To improve the situation, incentives are needed to strengthen the energy system and improve energy efficiency. The integration of renewable energy sources and the use of new technologies are also important challenges that can contribute to greater energy independence and therefore security. In addition, the report mentions the need to accelerate the implementation of the National Energy and Climate Plan (NEPN), which is a challenge in itself (World Energy Council, 2024).

## *Unforeseen events*

We live in a time in which changes in society are rapid and unpredictable. Responding to changing circumstances is a challenging, sometimes very arduous task. Everything is easier when our environment is more stable. The key to coping with change is our ability to adapt. It enables us to be more resilient. This applies equally to an individual, a company, a country, or a region. The better prepared one is for change, the better one can deal with the unforeseen events that come with it.

Even a simple fire can change things drastically and have consequences. Not to mention massive, unforeseeable events that we may not even have thought of. However, if we do consider them, we can be properly prepared. Some companies employ experts in special departments, dedicated to analysing developments and trends, based on which they attempt to make systematic predictions about future developments and opportunities—these forecasting experts are called futurologists.

However, there are also events that are difficult to prepare for—such as an epidemic. Even if scientists are sometimes able to predict such events, the reality when they actually occur is a challenge and leaves us only partially prepared notwithstanding our predictions.

Unforeseen events are mentioned here for a reason—because they can change lives.

### Natural disasters

Fires, earthquakes, floods, severe storms, landslides, avalanches, freezing rain, heat waves—we have experienced all of these in Slovenia and they are not that rare. In 2014, for example, freezing rain hit the whole of Slovenia and not only caused massive damage to forests, but also millions in damage to the energy infrastructure. In 2023, a large part of Slovenia was hit by flooding—from houses to energy infrastructure, the damage was measured in the billions for the entire country and in the tens of millions for the energy infrastructure.

### Epidemic

Throughout its history, mankind has repeatedly had to contend with epidemics of infectious diseases. The epidemics always claimed many lives and undermined the structured world and society. The last COVID-19 pandemic affected the whole world and naturally impacted the energy sector on many levels: Energy consumption in households and industry changed due to people's restricted movement, fuel supplies decreased, energy investments dropped either due to lockdowns or supply disruptions. But even in such situations, it is crucial that the operation of critical infrastructure is not interrupted despite a shortage of specialised personnel.

### Cyberattacks

On the one hand, rapid technological development can help people to overcome many a challenge, but on the other hand, it also brings with it many risks. Cyberattacks can be either deliberate (attacks, espionage, criminal acts) or accidental (technical errors) cyber security threats. In any case, it is important that the critical energy infrastructure is protected against cyberattacks.

**Military attacks (wars)**

In the first edition of this publication, wars were not mentioned among contingencies. However, in the year following the publication, the conflict in Ukraine took place, which had a significant impact on the European energy sector, and thus also on the Slovenian energy sector. In war, the usual rules and norms no longer apply and profound changes can occur. Relationships that were previously partnerships can turn into something completely different. For example, oil imports from Russia to the EU fell drastically after the military conflict in Ukraine, and the EU began to look for gas from other suppliers.

## *The military and its influence on climate change*

When we talk about security, even if it is "only" energy security, we cannot ignore the role of national militaries. The military is one of the largest consumers of fuel in the world. It is estimated that the military is responsible for 5.5% of global greenhouse gas emissions. The British organisations Scientists for Global Responsibility (SGR) and the Conflict and Environment Observatory (CEOBS) published a report in November 2022 comparing the scale of these emissions with the size of countries around the world: If the world's military were a country, it would have the fourth largest national carbon footprint in the world. China is in first place, followed by the U.S. and India. The next place would be taken by the military, followed by Russia and Japan.

It is also worth noting that for decades, analysts of climate change and its security implications have focused on how an increasingly unstable climate affects or undermines national security. Few have asked the reverse question: How national security decisions—such as spending on military or warfare—can affect the climate and thus undermine our collective security.

# 11

# DIGITALISATION

# *What is digitalisation?*

Digitalisation represents a fundamental change in the way the energy industry (and all other sectors) operates. It introduces digital technologies into business processes to improve efficiency and productivity. Digitalisation enables centralised data collection, which promotes transparency, simplifies information processing, and optimises processes. These are key factors for precise, real-time management of energy generation and distribution. At the same time, faults can be quickly recognised and rectified, which reduces outages and increases security of supply. This is crucial for the economy as an electricity consumer.

The energy sector is facing challenges such as climate change on the one hand and the increase in energy demand and the resulting need for greater energy efficiency on the other. Digitalisation can play an important role in this context, as it enables optimisation of energy generation and distribution, easier integration of variable renewable energies, improved grid reliability and, above all, data-driven decision-making.

For end users, including businesses, digitalisation enables greater energy efficiency and thus contributes to reduced emissions. Analyses of mass data can reveal patterns in energy consumption, which can then be used to develop customised energy solutions for different customer segments.

# *Important applications of digitalisation in the energy sector*

**Smart grids**

Digitalisation is the basis for the development of smart grids. By optimising energy generation, distribution, and consumption and by involving all users, smart grids enable better and more flexible energy management, which is key to ensuring a reliable and efficient energy supply. Smart grids enable real-time monitoring of energy system performance through advanced algorithms, sensors, and IoT (Internet of Things) devices. This enables dynamic adjustment of energy supply and demand and rapid response to faults or outages, reducing downtime and increasing the chances of restoring grid operation.

Smart grids incorporate a wide range of digital technologies, such as advanced metering systems, communication networks, and analytics tools, which enable not only the monitoring of energy consumption and generation, but also the prediction of future demand based on past patterns. This allows for more accurate coordination of consumption and generation and avoids excessive strain on the grid, resulting in greater energy efficiency and reliability.

**Integration of renewable energies**

Digitalisation is the key to successfully integrating renewable energy sources such as solar, wind, and hydropower into electricity systems. Since renewables are highly weatherdependent and their generation cannot be precisely controlled or predicted, it is a real challenge to integrate these sources into existing energy grids which have been designed for stable and predictable sources such as coal, gas, or nuclear power. Digital technologies make it possible to better address this challenge through advanced analytical tools, forecasting models, and real-time monitoring. They enable more accurate forecasting of renewable energy generation and better coordination with the existing energy infrastructure. By analysing large amounts of data coming from various sources, such as sensors on energy devices, weather data, and forecasts, we can more accurately predict renewable energy production.

### Data-driven decision-making

Collecting and analysing large amounts of data generated by digital systems has become an important tool for better decision-making in the energy sector. With the help of advanced data processing and analysis technologies, energy companies can gain a deeper insight into the performance of their systems and thus better predict future needs and challenges.

Digital systems generate large amounts of data in real time, including information on grid status, energy generation and consumption, temperatures, voltages, grid loads, etc. With advanced data analysis tools such as machine learning algorithms and artificial intelligence, these data can be processed quickly to recognise patterns, trends, or even anomalies that would otherwise be overlooked. A very important role of AI is predictive maintenance, where the operation of energy infrastructure is continuously monitored and analysed to detect potential faults in advance. This enables quick action and identification of potential problems, which is basically process optimisation.

As a result, decisions are made based on factual rather than theoretical information, which increases the accuracy and speed of decision-making at all levels of the energy sector—from operational to strategic planning.

### Improving energy efficiency

Among other things, digitalisation enables end consumers to closely monitor and optimise their energy consumption, which contributes significantly to reducing overall consumption and costs. With smart metres that enable real-time consumption monitoring, users can better understand their energy habits and make informed decisions to optimise consumption. In addition, energy management systems in buildings enable consumption to be automatically adjusted to demand and also to price signals, thus helping to increase energy efficiency in buildings, industry, and other sectors. Various digital platforms and applications for consumption monitoring propose adjustments that can help reduce unnecessary consumption and optimise the performance of appliances. In this way, consumers can play an active role in reducing costs and increasing energy efficiency while contributing to the overarching goals of sustainable development and reduced carbon emissions.

**Investments**

Digitalisation improves the efficiency of grid investments and ensures the sustainability of investments in view of the high investment needs in the electricity grids resulting from electrification and the green transition. In this context, the role and implementation of artificial intelligence in the business processes of energy companies is important.

**Cyber security**

Increasing digitalisation also increases the vulnerability of energy systems to cyberattacks. Energy systems are increasingly dependent on digital technologies, which opens up new opportunities for hacks and malicious activities. Protecting critical infrastructure in the energy sector from such attacks is therefore crucial for the reliable operation of the entire sector.

This protection also means significant resources for this purpose, because to protect themselves effectively, companies need to invest in advanced security systems, i.e. stateof-the-art software and hardware to detect and prevent cyber threats, in addition to their existing investments in digitalisation. They must also invest in employee training. Employees need to be familiarised with the different types of cyber threats and the best methods for preventing attacks. This includes a secure use of passwords, recognising suspicious emails and websites, and knowing protocols for reporting incidents. In the event of a successful cyberattack, the consequences can be very serious, including power outages, disruption to energy supplies, and financial damages. Cyber security in the energy sector is important not only to protect infrastructure, but also to ensure public confidence.

# *Opportunities for the future*

Digitalisation is opening the door to new business models, innovative services, and solutions that will shape the future of the energy industry. Some key opportunities:

**Development of advanced energy trading platforms:** One of the most common applications of AI in the energy sector is improving supply and demand forecasting. Digital platforms enable a more efficient connection between energy producers and consumers and facilitate renewable energy trading. Such platforms can contribute to a more dynamic and flexible energy market.

**Creating new services for consumers:** Digitalisation enables the development of new services that offer consumers better control over their energy consumption, optimised costs, and an active role in the energy market. Smart apps, energy management systems for households, and platforms for exchanging energy between consumers are just a few examples.

**Promoting innovation and the development of new technologies:** Digitalisation is driving research and development in the energy sector and leading to more advanced systems for energy generation, storage, and distribution.

Successful implementation of the digital transformation in the energy sector requires cooperation of all stakeholders—government, regulators, businesses, and consumers. Clear regulation, incentives for innovation, and raising public awareness of the importance of digitalisation are key factors for a successful transition to the digital energy era. Slovenian energy companies are working intensively on smart grids and digitalisation and are adapting to global trends in these areas.

## Data centres “devour” energy

According to IEA estimates, data centres, which are mentioned separately here, currently account for around 1-1.5% of global electricity consumption and contribute around 1% of greenhouse gas emissions. The cryptocurrency Bitcoin is estimated to have consumed 110 TWh of energy in 2022 (IEA, 2023).

The demand for digital services—streaming, cloud gaming, blockchain, artificial intelligence, machine learning, and virtual reality—is growing rapidly (according to the IEA, the number of Internet users worldwide has more than doubled and global Internet traffic has increased 25-fold since 2010—in just over a decade), which leads to increased energy consumption of data centres and data networks that support this digitalisation. These are buildings or any space dedicated to housing computer equipment, which includes powerful servers, large amounts of storage space for various data, and a suitable network infrastructure.

The IEA estimates that the combination of increasing machine learning models and computing requirements is likely to be enough to outstrip any improvements in energy efficiency (even if AI alone can help reduce energy consumption in data centres), so a net increase in overall AI-related energy consumption is expected in the coming years.

12

# LONG-TERM GLOBAL, EU AND SLOVENIAN ENVIRONMENTAL AND CLIMATE POLICY


THE WORLD
BELONGS TO THE
ENERGETIC

# *Everything is interwoven*

Climate change affects us all, all regions, the whole planet.

The way people do things and the way they live has an impact on the local and global environment and therefore on the whole world.

We need energy and it comes from the earth (coal, ore, oil, gas, water), the sun, and the wind. In other words, it comes from everywhere. And by using energy, we produce emissions.

A large proportion of these emissions are greenhouse gases. Our planet is facing climate change caused by greenhouse gases from human activities.

And what are these activities? Practically everything: our breathing, our living in buildings (heating, electricity), our journeys to work and everywhere else (passenger transport), the transport of goods by road, rail, sea or air, and the functioning of the economy and public administration (healthcare, education, etc.).

# *The set goals and policies*

**THE WORLD** ▸ Paris Agreement (2015; action plan to curb global warming)

**THE EU** ▸ Energy Union, 2015 + European Green Deal, 2019 (climate neutrality) + Fit for 55 & REPowerEU: energy policy within the framework of EU Member States for recovery and resilience

**SLOVENIA** ▸ Slovenian Development Strategy 2030 (low-carbon circular economy) + Long-term Climate Strategy by 2050 + Updated Integrated National Energy and Climate Plan (NEPN)

# *What is the world doing? Trying to curb temperature rise*

Due to its global nature, climate change requires the co-operation of all countries around the world. For this reason, world leaders agreed in 2015 on a series of new ambitious goals to combat climate change. The Paris Agreement represents an action plan to limit global warming, supported by the majority of countries worldwide. In order to achieve this goal, special support will be given to developing countries.

**Paris Agreement**

https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:22016A1019(01)

Its long-term goal is to limit global warming to well below 2°C compared to pre-industrial levels or at least to prevent the temperature rise from exceeding 1.5°C. And why do we need to curb global warming? The consequences of climate change can be seen in all corners of the world: The perpetual ice at both poles is melting and sea levels are rising. Together, these two effects are leading to flooding and erosion in coastal and lowland areas. In some parts of the world, extreme weather events and rainfall are becoming more frequent, while other parts are suffering from extreme heatwaves and droughts.

Climate changes are expected to intensify in the coming decades. And they are happening at such a rapid pace that many animals and plants are finding it difficult to adapt. Several terrestrial, freshwater, and marine species have already migrated to new areas. If global average temperatures continue to rise uncontrollably, a growing number of species will be threatened with extinction.

**The Paris Agreement** entered into force on 4 November 2016 after the condition of ratification by at least 55 countries accounting for at least 55% of global greenhouse gas emissions had been met. The agreement was ratified by all EU Member States, with Slovenia following suit towards the end of 2016.

# *What is Europe doing? Investing in RES and EE*

**The European Union** wants to take the lead in the fight against climate change. This is reflected in the increasingly ambitious (in other words, stringent) targets it is setting itself. These targets must be met by the EU Member States, otherwise sanctions may be imposed. The EU sees the transition to a net-zero emissions economy as a solution to the climate crisis and as an opportunity for technological development and economic growth (increasing competitiveness) but also for social balance and justice.

The EU adopted the **20-20-20** climate and energy targets back in 2007 and the necessary legislation to achieve these targets by 2020 followed in 2009: 1) To reduce GHG emissions by 20% compared to 1990, 2) To increase the share of renewable energy sources (RES) to 20%, 3) To improve energy efficiency by 20%.

In October 2014, the EU set new targets for 2030, which were further tightened in 2018 with the Clean Energy Package to 403232.5. In order to achieve the set targets, the EU adopted the **Energy Union** strategy in February 2015. This focuses on five dimensions: energy security, internal energy market, energy efficiency, climate action with decarbonisation of the economy, along with research, innovation, and competitiveness.

In December 2019, the European heads of state and government signed the **European Green Deal**, which supports the goal of making the EU the first climate-neutral continent by 2050, in line with the goals of the Paris Agreement. On this basis, in March 2020, the EU Council adopted a *Long-term low greenhouse gas emission development strategy of the EU and its Member States – a contribution to the United Nations Framework Convention on Climate Change (UNFCCC) on behalf of the European Union and its Member States*. The EU and its Member States are fully committed to the Paris Agreement and its longterm goals and call for an urgent increase in global ambition in the light of the latest scientific evidence, including the latest reports of the Intergovernmental Panel on Climate Change (IPCC).

In July 2021, the European Commission proposed a multi-legislative package entitled **"Fit for 55"**. By October 2023, a number of legislative acts were adopted at EU level as part of this package (many were also renewed), including Regulation (EU) 2021/1119 establishing a framework for achieving climate neutrality, which significantly increased the EU's climate and energy targets for 2030. EU Member States are now legally obliged to reduce their emissions by at least 55% by 2030. The 2030 target is an intermediate step on the way to net zero emissions by 2050. Another intermediate step is the 2040 target: In 2024, the European Commission recommended a 90% reduction in net greenhouse gas emissions by 2040 compared to 1990 levels. At the time, the European Commission also wanted to increase the target for renewable energy to 40% as part of the same package, however, the subsequent roadmap increased this share even further.

## *Why "Fit for 55"?*

"Fit for 55" refers to the **EU's target of reducing net greenhouse gas emissions by at least 55% by 2030**. The proposed package should align the EU legislation with the target for 2030.

In response to the Russian invasion of Ukraine in early 2022 and the use of energy resources as an economic weapon, the European Commission presented the **REPowerEU** plan in May 2022. The main objectives of the plan were to save energy, diversify the energy supply, and increase clean energy production in the EU. This was followed by negotiations at EU level and the adoption of new laws in the years that followed.

Directive (EU) 2023/2413 on the promotion of energy from renewable sources stipulates that Member States shall jointly ensure that the share of renewable energy in the Union's gross final consumption of energy is at least 42.5% in 2030. At the same time, Member States are jointly aiming for a share of renewable energy in the EU's gross final energy consumption of at least 45% by 2030.

If we take a look at the energy efficiency target, it has been tightened as well. According to Directive (EU) 2023/1791 on energy efficiency, the Union's energy consumption by 2030 should be at least 11.7% lower compared to what was initially projected for 2030 according to the EU reference scenario based on the year 2020—1,124 Mtoe for primary energy consumption and 864 Mtoe for final energy consumption. Member States should therefore jointly ensure that energy consumption in 2030 is reduced by at least 11.7% compared to the projections of the EU reference scenario for 2020, leading to a maximum final energy consumption of the Union of 763 Mtoe in 2030. Member States shall use their best endeavours to contribute jointly to the Union's indicative target for primary energy consumption of a maximum of 992.5 Mtoe in 2030. Each Member State shall set an indicative national contribution to energy efficiency.

It should be added that the Directive defines "energy efficiency first" as a fundamental principle of EU energy policy, which has been given legal force for the first time. In practice, this means that EU countries must take energy efficiency into account in all major political decisions and major investments in the energy and non-energy sectors.

In May 2024, exactly two years after the **REPowerEU** plan was presented, the main achievements at EU level were as follows (European Commission, 2024):

- Natural gas consumption was reduced by 18% from August 2022 to March 2024.
- EU's dependency on Russian fossil fuels has been ended—the share of gas imports from Russia was reduced from 45% to 15% between 2021 and 2023.
- Access to secure and affordable energy is enabled.
- Electricity generated from wind and solar power in the EU surpassed that from gas for the first time since 2022.
- The share of renewable energy has increased rapidly—a record amount of almost 96 GW of new solar capacity has been installed since 2022, while wind capacity has increased by 33 GW.

# *Europeans see climate change as a very serious problem*

Europeans are concerned about climate change and believe that action is urgently needed. In the July 2023 Eurobarometer survey, respondents were asked which of the 11 listed problems they considered to be the most serious in the world. Europeans put “poverty, hunger, and lack of drinking water” in first place, “armed conflict” in second place, and “climate change” in third place.

More than three quarters (77%) of EU citizens currently consider climate change to be a very serious problem. One sixth (16%) of respondents consider climate change to be a fairly serious problem, while 7% do not consider climate change to be a serious problem. The proportion of respondents who consider climate change to be a very serious problem has remained relatively stable since 2019, when a similar Eurobarometer survey was conducted.

The majority of Europeans believe that the European Union (56%), national governments (56%), and business and industry (53%) are responsible for tackling climate change. A third (35%) of respondents believe that they are personally responsible. More than eight in ten respondents (86%) believe it is important that their national governments and the European Union (85%) take action to improve energy efficiency by 2030 (e. g. by encouraging people to insulate their homes, install solar panels, or buy electric cars). More than half (58%) of EU citizens also believe that the use of renewable energy should be expedited, energy efficiency should be improved, and the transition to a green economy should be accelerated.

**Eurobarometer**

https: //europa. eu/eurobarometer/surveys/detail/2954

Three quarters of respondents (75%) believe that measures to combat climate change will lead to innovations that will increase the competitiveness of companies in the EU. Almost as many respondents (73%) believe that the cost of the damage caused by climate change is much higher than the cost of investing in the green transition.

# *And what plans does Slovenia have?*

**From the more general …**

In December 2017, the Government of the **Republic of Slovenia adopted the Slovenian Development Strategy 2030 (SRS 2030)**, a comprehensive development framework that emphasises quality of life for all. In line with this strategy and taking into account the dimensions of the Energy Union, Slovenia's main priorities by 2030 will be the transition to a low-carbon circular economy and the sustainable management of natural resources. The strategy states: "A reliable, sustainable and competitive supply of energy is crucial for development, whereby giving priority to energy efficiency (EE) and renewable energy sources (RES) is one of the basic principles of the development of the energy sector. One of the key factors for increasing the use of RES is the development of technologies for storing energy and digitalisation of the electricity system (the introduction of the so-called smart network). The priority increase in EE and the increased proportion of RES will allow us to reduce emissions of greenhouse gases (GHG), which is also part of Slovenia's commitment within the EU's climate and energy package and the Paris Climate Agreement."

In December 2017, **Slovenia's Smart Specialisation Strategy (S4)** was adopted, which includes priority areas, such as smart cities and communities (energy conversion, distribution, and management), smart buildings and homes, including the wood chain, and networks for the transition to the circular economy (technologies for biomass conversion, energy production based on alternative sources).

**… to the more concrete**

The latest document on energy policy in Slovenia is the **Updated Integrated National Energy and Climate Plan of the Republic of Slovenia (NEPN)**, which was adopted by the government in December 2024. The updated NEPN was prepared taking into account significantly improved policies and the changed geopolitical situation in the field of energy and climate. It focuses on the need to advance climate action, accelerate the energy transition, improve energy security, achieve the goals of the REPowerEU plan, and increase the resilience of the Energy Union.

The targets of the NEPN are to reduce greenhouse gas (GHG) emissions by at least 55% by 2033 compared to 2005 (and by 35-45% by 2030), to increase the share of renewables in final energy consumption to at least 33% by 2030, and to improve energy efficiency by at least 35% by 2030 to at least meet the indicative plan set out in the last amendment of the Energy Efficiency Directive—final energy consumption should not exceed 50.2 TWh (4,320 ktoe) in 2030. Converted to the primary energy level, consumption in 2030 should not exceed 69.5 TWh (5,980 ktoe).

If we compare these targets with the 2020 NEPN version, we see that they are becoming stricter (more ambitious). Back in 2020, Slovenia set the target of reducing emissions by 36%, while now we are already at 55% compared to 2005. A few years ago, we considered a target of 27% for renewable energy by 2030 (now the target is at 33%). We also committed a few years ago to limit our national final energy consumption to 54.9 TWh or 4,717 ktoe in 2030.

*Figure 15: The most important goals of Slovenian and EU climate and energy policy*

| | Slovenia | | EU |
|---|---|---|---|
| **2030 TARGETS** | **NEPN 2020** | **Updated NEPN 2024** | |
| **CLIMATE** | | | |
| **Total GHG emissions**<br>Reduction from 2005 | **-36%** | **-55% 2033**<br>-35% - 45% 2030 | **-55%** |
| **Non-ETS GHG emissions** | **-20% (-15%)** | **28% (-27%)** | **-40%** |
| **RENEWABLE ENERGY SOURCES** | | | |
| **Share of RES in gross final consumption** | **27%** | **33%** | **>42,5%** |
| **ENERGY EFFICIENCY** | | | |
| **Final energy use** | **54,9 TWh** | **50,2 TWh**<br>**-11.1%** | **-11,7%** |

*Source: MOPE, IJS (2024)*

Slovenia also has a **National Strategy for Coal Exit and Restructuring of Coal Regions in Accordance with the Principles of a Just Transition**, which was adopted by the Government of the Republic of Slovenia in January 2022. The strategy stipulates Slovenia will cease using coal to generate electricity in 2033 at the latest, with decommissioning work to continue for 15 years after active mining has been terminated. For the Savinja-Šalek region (SAŠA), the strategy envisages a coal phase-out that includes the closure of production in TEŠ Unit 6 and the end of lignite mining by 2033 at the latest. The strategic and operational goals for a just transition of the SAŠA coal region are based on five pillars:

- A just energy transition for both Slovenia and the SAŠA region.
- Gradual rehabilitation and revitalisation of spatially and environmentally degraded areas.
- Additional regional connectivity and sustainable mobility.
- Sustainable, flexible, and diversified economic development.
- Jobs and qualifications for all.

The strategy for the Zasavje region envisages a balanced development scenario focusing on the coherent and targeted development of key areas that will enable the transition to be completed in accordance with the principles of a just transition, i. e. a high-quality living, natural and business environment. Again, the goals are built on five pillars:

- A quality living and natural environment.
- A highly motivated and skilled population.
- A diverse and resilient local economy.
- Realisation of the region’s renewable potential.
- Improved connectivity of the region.

The strategy defines the process of comprehensive social and economic restructuring of the two regions, identifies the appropriate financial resources at national and EU levels, and sets out how to manage a fair transition process.

In July 2021, the National Assembly adopted the **Resolution on Slovenia's Long-Term Climate Strategy 2050 (ReDPS50)**. Its main focus is on reducing greenhouse gas emissions. The horizontal guidelines, which apply to all sectors, include increasing material efficiency, promoting low-carbon energy sources, energy efficiency, sustainable spatial development, sustainable construction, and promoting digitalisation with public administration as a role model. It also states that Slovenia will not adopt policies and measures or invest resources in a way that would undermine the commitments of the Paris Agreement. The vision is as follows:

In 2050, Slovenia will be a climate-neutral and climate-resilient society based on sustainable development. It will manage energy and natural resources efficiently, while maintaining a high level of competitiveness of its low-carbon circular economy.

The society will be based on a preserved nature, a circular economy, renewable and lowcarbon energy sources, sustainable mobility, and locally produced healthy food.

It will be adapted and resilient to the effects of climate change. Slovenia will be a society with a high quality of life and security that seizes its opportunities in a changing climate. The transition to a climate-neutral society will be inclusive and take into account the principles of climate justice. The costs and benefits of the transition will be shared equitably, with mitigation and adaptation measures made available to the most vulnerable population groups.

The action plan for implementing the 2030 climate strategy is the NEPN. The adoption of a **Climate Policy Act** is planned for 2025.

Among other things, Slovenia has set itself the goal of curbing and reducing energy poverty. In November 2023, the Slovenian government adopted a three-year **action plan to reduce energy poverty**. The overarching goal regarding energy poverty is to reduce the proportion of energy-poor households to a maximum of 3.8-4.6% by 2030. The second goal is to make investments in energy efficiency and renewable energies in at least 8,000 energy-poor households.

The definition of these households is set out in the 2022 Decree on the criteria for defining and assessing the number of energy-poor households. Energy poverty is considered to be the condition of a household whose income is below the at-risk-of-poverty threshold and which is unable to meet its basic energy needs because (1) living conditions are inadequate or (2) these needs cannot be met at affordable prices or (3) the energy efficiency of the living space is low. Basic energy needs include, in particular, the costs of heating, sanitation, cooling, cooking, and lighting. Energy poverty is also a household condition in which the cost of energy use accounts for a large proportion of expenditure in relation to the household's disposable income.

The updated NEPN, together with the National Strategy for Coal Exit, significantly strengthens the just transition and helps to mitigate social impacts. Together with the action plan to reduce energy poverty, it significantly strengthens policy in this area by addressing measures to alleviate energy poverty. Equity and solidarity, the two main objectives that have guided the development of the National Strategy for Coal Exit and the action plan to reduce energy poverty, are therefore integral parts of the updated NEPN. All three documents are based on the premise, crucial to the green transition, that no person or place will be left to fend for themselves.

# 13

# ENERGY OF SLOVENIA, EUROPEAN UNION AND THE WORLD: ECONOMIC CONTEXT


PEPSI
СКОПСКО
ВИПС
BRAVO
PREMIUM

# *Decarbonisation and competitiveness*

The energy sector is one of the economic sectors that is more closely linked to all other sectors than any other. Specifically, industry cannot function without energy in the form of electricity or gas, there is no transport without fuel, agriculture needs energy in various forms, and the service sector also needs energy. At the same time, the sector as a whole is undergoing a transformation process (the so-called green transition). As part of this process, all sectors are striving for decarbonisation—for reduced and more efficient use of energy products and for more energy-efficient processes. The energy sector is itself a highemitting sector—especially in terms of fossil fuels—but also a sector that supplies a variety of energy products while it is itself undergoing a transformation process and is also under pressure to provide the best possible prices for the rest of the sectors.

Competitiveness is therefore key when we talk about the economic context, and the affordability of energy is directly linked to this.

In the first edition of Energy in Slovenia, we included in the broader context of Slovenian energy—which also applies to the world's energy—the issues of import dependency, transport, the closure of mines and thermal power plants, the further use of nuclear energy, the further use of renewables, and efficient use in industry and elsewhere. We could also have added energy storage, security of energy supply, hydrogen, and much more. We will not go into all these aspects here, as the reader can look them up for themselves, but we will address the issue of competitiveness and continued growth of economies.

## *The concept of degrowth*

The concept of degrowth challenges the traditional belief that endless economic growth is the only goal we should strive for as a society. Instead, it advocates a shift away from an economy based on continuous gross domestic product (GDP) growth towards a model where quality of life and human wellbeing—rather than ever-increasing production and consumption—are at the centre of what we do. The goal is not economic decline, but a more balanced economy and society that respects the ecological limits of the planet and ensures long-term well-being for all people.

Why is this important? Sustained economic growth often means higher consumption of natural resources, more waste, and more severe environmental problems, while deepening social inequalities. Higher GDP usually means more production, more energy consumption, and higher corporate profits, but this does not necessarily guarantee a better life for all.

Degrowth therefore encourages less material consumption, a fairer distribution of resources, and a change in values in society: more care for the community, more solidarity, and more sustainable solutions. It offers alternative indicators of progress that are not based on GDP but focus on the well-being of the population, environmental indicators, and quality of life. It encourages us to think deeply about how we can live in balance with nature and for the good of the community in the long term, rather than blindly following the path of constant growth and consumption.

Energy, as already mentioned, is crucial for progress, but at the same time regions—which may differ greatly in terms of energy resources (reserves)—compete with each other to maximise economic growth. However, the concept of growth is not the same as the concept of sustainable growth, which should be kept in mind when referring to global development goals and the fight against climate change.

When we talk about decarbonisation and competitiveness, two issues are intertwined, namely the pursuit of a cleaner environment on the one hand and energy prices on the other.

# *High prices of energy in the EU and carbon leakage issue*

In 2024, companies in the EU faced electricity prices that were 2-3 times higher than in the U.S. and natural gas prices that were 4-5 times higher than in the U.S. How can we compete with such price levels? How can European industry compete with its American or Chinese competitors when it has to fulfil more demanding environmental and social standards on the one hand and pay so much more for energy products on the other?

A few years ago, the term “carbon leakage” was coined in the EU to refer to the relocation of production from the EU to other parts of the world where environmental standards are less stringent. Carbon leakage can mean the actual relocation of production to third countries with less stringent emission reduction requirements, but it can also mean that EU products are replaced by imported products with a higher carbon footprint. The production is/will be jeopardised in those sectors of the economy with disproportionately high costs, including energy costs and of course $CO_2$ allowances, compared to their competitors. In fact, the largest emitters in the EU have to buy emission allowances—not only industry but also thermal power plants and heating plants (for the share of greenhouse gas emissions resulting from the use of fossil fuels to generate electricity). The EU has set up an EU-wide emissions trading system (EU ETS), which is expected to have a significant impact on reducing greenhouse gas emissions.

The industries most at risk of carbon leakage, i.e. the relocation of industry out of the EU or the replacement by non-EU products manufactured to lower environmental standards, are energy-intensive industries, including the production of aluminium, metallic and nonmetallic materials, paper, glass, chemicals, building materials, etc.

These are important industries that the EU recognises as key to its long-term development. In its Strategic Foresight Reports, the EU therefore emphasises the importance of ensuring carbon-free and affordable energy and strategically managing the supply of key materials and commodities by taking a long-term systemic approach to avoid a new dependency trap.

# *Carbon leakage in the case of the Slovenian aluminium manufacturer Talum*

Aluminium has been recognised by the EU as a strategic raw material. Nevertheless, the European Aluminium Association estimates that Europe lost more than 30% of its primary aluminium production between 2008 and 2022. This trend has even worsened in recent years. As the demand for materials is increasing—5-7% per year for aluminium—Europe has already lost a large part of its production due to high costs, while the production of other producers outside Europe has been increasing. It should also be noted that the carbon footprint of aluminium production in the EU is significantly lower than elsewhere, especially where production growth is strongest (4-7 kg $CO_2$/kg Al in Europe vs. 15-20 kg $CO_2$/kg Al in India and China).

Aluminium production in electrolysis cells began in Slovenia in 1954 at the Talum aluminium plant. With its production of primary aluminium, Talum was among the top 10% of world producers consuming the least electricity per tonne of aluminium produced. Nevertheless, the plant was forced to cease production of primary aluminium in 2023. We are talking about an energy-intensive industry that is at risk of relocating to countries outside the EU. Talum's electricity consumption accounted for 5.72% of Slovenia's total electricity consumption in 2020, around 4% in 2021, and less than 3% in 2022.

Talum is also one of the companies in the EU ETS that has managed to achieve and even exceed the target of reducing greenhouse gas emissions by 55% by 2030 compared to the reference year 1990 through a restructuring process—in fact they have managed to reduce their $CO_2$ emissions by 64%. However, due to the uncompetitive conditions (most European producers have been receiving compensation for the indirect costs of GHG emissions since 2013, while Slovenia has been receiving compensation only since 2023), Talum was forced to stop its production of primary aluminium in March 2023. Today, Talum's core business is no longer the production of primary aluminium. Now, more than half of the aluminium for the products is already recovered through recycling and reprocessing, whereas just two decades ago their production structure was entirely dependent on in-house production of primary aluminium. However, as they also need some primary aluminium for the production of aluminium products, they now import it—mainly from outside the EU, where the carbon footprint is higher. So, the carbon footprint of Talum products has also increased due to the import of the raw material.

The reason why the EU pays more for energy than its main competitors is primarily due to the scarcity of natural resources in Europe. But that is not the only reason. In his report, Draghi (2024) also points to fundamental problems in the common European energy market: “Market rules prevent industries and households from capturing the full benefits of clean energy in their bills. High taxes and rents captured by financial traders raise energy costs for our economy. Over the medium term, decarbonisation will help shift power generation towards secure, low-cost clean energy sources. But fossil fuels will continue to play a central role in energy pricing at least for the remainder of this decade. Without a plan to transfer the benefits of decarbonisation to end-users, energy prices will continue to weigh on growth”.

Successful innovation for the green transition requires among other things a global level playing field, as the EU recognises. At the same time, it recognises the growing Chinese competition in clean technologies and electric vehicles, enabled by a combination of China’s comprehensive industrial policy and subsidies, rapid innovation, control over raw materials, and ability to mass produce. Greater reliance on China may be the cheapest and most efficient way to achieve Europe’s decarbonisation goals, but at the same time it poses a threat to the very industries that make decarbonisation possible..

# *The EU is reducing emissions. It is also focussing on a clean industry.*

EU greenhouse gas emissions fell by 32.5% between 1990 and 2022, according to the State of the Energy Union 2024 report (some of the figures in this report are from 2022).

Significant progress has been made in the field of renewable energy. In 2022, 39% of electricity was generated from renewables (in May 2022, wind and solar energy surpassed fossil fuels in electricity generation in the EU for the first time), and in 2023 this figure rose to 44.7%. In the first half of 2024, renewable energy accounted for 50% of electricity generation in the EU, according to EU statistics.

2022 was a record year for new photovoltaic capacity (+41 GW), up 60% on 2021 (+26 GW). Newly installed onshore and offshore wind capacity was 45% higher than in 2021. Between 2021 and 2023, installed wind and solar capacity increased by 36%. With 56 GW of newly installed solar capacity in 2023, the EU set another record, surpassing the 2022 figure. These record figures are important steps in the right direction, but need to be further improved to achieve the REPowerEU targets of the EU Solar Strategy and reach a total capacity of at least 700 GW by 2030 (according to estimates, 263 GW were installed at the end of 2023).

As far as energy efficiency targets are concerned, primary energy consumption in the EU was again on a downward trend in 2022, falling by 4.1%. Nevertheless, the EU estimates that efforts need to be stepped up, particularly in relation to heating and the level of renovation of buildings (with the aim of achieving the EU target of an additional 11.7% reduction in final energy consumption by 2030).

At the same time, the Union recognises the need to continue to tackle the problem of high energy prices relentlessly. As mentioned above, these are key to improving the competitiveness of EU industry and accelerating investment in the integrated European infrastructure networks that are essential for the electrification of the European economy. We mention this here because many believe that the EU's "green" policy, with targets that are more stringent compared to some less developed parts of the world, for example, is undermining the EU's competitiveness.

In March 2024, the Council of the EU adopted the European Critical Raw Materials Act. Metals, minerals, and natural materials are part of our daily lives. Those that are economically most important and for which there is a high supply risk are known as critical raw materials. They are essential to the functioning of many industrial ecosystems and in turn are of key economic importance for the EU. The EU's demand for base metals, battery materials, rare earth elements, and other raw materials is expected to increase exponentially in the future as the EU moves away from fossil fuels and towards clean energy systems that require more minerals. The green transition will therefore require local production of batteries, solar panels, permanent magnets, and other clean technologies, forcing the EU to have access to a whole range of raw materials. Some sectors are of particular strategic importance for the EU's renewable energy goals, but also for its digital, space, and defence goals.

A list of strategic raw materials, selected from 34 identified critical commodities, has been drawn up and will be reviewed regularly. Without critical raw materials, most parts of society could not function, as these very materials are contained in many everyday devices and products that are essential to any country's economy. Examples include (The Council of the EU, 2025):

- Telephone vibration technology = tungsten.
- Electric vehicles = lithium, cobalt, and nickel.
- Wind turbines = boron.
- Semiconductors = silicon metal.
- Glass manufacturing and plant fertiliser production = borates.
- Aircraft construction and aviation = magnesium and scandium.

Critical raw materials are mostly sourced from outside the EU. The EU will never be selfsufficient, but is working to diversify its supply. At present, the EU is exclusively dependent on one country for some critical raw materials. China covers 100% of the EU's demand for heavy rare earth elements, Turkey supplies 98% of the EU's boron demand, and South Africa covers 71% of the EU's platinum demand.

In addition, the Council of the EU adopted the Net Zero Industry Act in May 2024 (European Commission, 2024). Its aim is to accelerate progress towards the EU's 2030 climate and energy targets and the transition to climate neutrality, while improving the competitiveness of EU industry and increasing its energy independence. Examples of strategic net-zero industries are:

- Photovoltaics and solar thermal: A target of more than 320 GW of newly installed photovoltaic capacity by 2025 and 600 GW by 2030 could generate an annual GDP of €60 billion in Europe and create 400,000 new jobs.
- Onshore wind and offshore renewables: Increasing capacity from 204 GW in 2022 to more than 500 GW in 2030, contributing to the target of at least 42.5% of energy coming from renewables by 2030.
- Batteries: The target for portable batteries is 63% in 2027 and 73% in 2030, the targets for batteries for light means of transport (LMT) are 51% in 2028 and 61% in 2030, the targets for recycling of lithium are 50% by 2027 and 80% by 2030.
- Heat pumps:
  - 2021: Existing buildings with heat pumps = 2 million units;
  - 2025: Existing buildings with heat pumps = 3 million units + new buildings = 1.2 million units;
  - 2030: Existing buildings with heat pumps = 5 million units + new buildings = 1.5 million units;
  - By 2030, heat pumps are expected to reduce European gas demand for heating in buildings by at least 21 billion cubic metres.

- Renewable hydrogen: Hydrogen accounts for about 2% of the EU's energy mix and could account for 20% by 2050, of which 20-50% for energy demand of the transport and 5-20% for energy demand of the industry.
- Biomethane and biogas: Biomethane production in the EU is expected to reach 35 billion cubic metres per year by 2030.
- $CO_2$ capture and storage: This should increase to 80 million tonnes by 2030 and at least 300 million tonnes by 2040.
- Grid technologies: By 2024, 77% of EU consumers should have smart metres for electricity and 44% for gas.

All these targets are to be achieved through faster permit granting procedures for the construction, expansion, modification, and operation of projects; a simple regulatory framework for EU-based net-zero industries; and the promotion of innovation and access to markets (including stimulating consumer demand and public procurement). The objective is that the Union's overall capacity to produce strategic net-zero technologies reaches or approaches at least 40% of the demand for such technologies by 2030.

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# SLOVENIA'S ENERGY CHALLENGE

| IDEAL TARGETS | REALITY |
|---|---|
| 100% ENERGY SELF-SUFFICIENCY | 50/50 |
| USING OWN SOURCES | PARTLY |
| DOMESTIC KNOW-HOW | EXTENSIVE |
| AWARENESS | GROWING |
| CONSENSUS | NONE (YET) |

THERE IS NO IDEAL SCENARIO!

It would be ideal if we were 100% energy self-sufficient in all areas. It would be ideal if we had inexhaustible resources and first-class local expertise in all areas of the energy industry. It would also be ideal if people were aware of all the possibilities and opportunities offered by the energy transition.

It would also be ideal if we did not have to deal with issues such as import dependency, transport issues, the closure of coal mines and thermal power plants, greenhouse gas emissions, measures to improve the environment, and so on. It would be ideal to live an ideal life where there is no great demand for energy, where we have no emissions, and where everyone is happy.

And yet, the ideal is also knowing that people have to keep coming together to overcome the challenges and find the best possible solutions. We have to look for compromises, which means that we have to take into account different situations, interest groups, and their particularities.

After all we have learnt so far in this publication about various aspects of energy in Slovenia, the pursuit of an ideal situation forces us to think about the next steps in the energy transition, which inevitably clash with the picture of reality. In this conflict between aspirations and the urgency to act as soon as possible, we must be able to find a common understanding as a society about Slovenia's energy future. Especially, of course, if we really want to achieve the climate neutrality targets for 2050. We are only 25 years away from what we sometimes consider to be a very very distant future!

What Slovenia's energy will look like “tomorrow” depends on which (compromise) path the country decides to take. It is really up to the country (and its citizens) to decide whether we will rely mainly or exclusively on renewable energy or continue with nuclear energy in the face of mine closures, the reorganisation of the electricity sector, different import patterns, and increasing demand for less and cleaner energy consumption all the while dealing with high energy prices in Europe compared to the rest of the world, which pose serious challenges for energy-intensive industries. It is a trade-off between different options, which are of course weighed up by all countries, not just Slovenia, and there is no scenario that is simple, unambiguous, without any dilemmas. There is no scenario that leads us into the future without any worries.

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# WORLD'S ENERGY CHALLENGE

| IDEAL TARGETS |
| --- |
| SUSTAINABLE USE OF SOURCES |
| CLIMATE NEUTRALITY |
| NO ENERGY POVERTY |
| KNOWLEDGE INTEGRATION |
| AWARENESS |
| PEACE |

If you put Slovenia' s energy policy challenges in a global context, everything suddenly looks different—as if we were looking at a different picture.

And yet, the path to climate neutrality requires efforts from all parts of society, and this applies to every country as well as to all communities around the world.

The ideal situation regarding world energy, that which we all aspire to, is linked to solving the problem of energy production and supply, but also energy use—in a sustainable way. We believe that this will not be possible without bringing together a wide range of expertise (interdisciplinarity!) from all parts of the world. This integration will also be a step towards greater awareness among professionals and then the general public.

Accessible (or in other words, affordable) and clean energy is one of the most important global development goals (the goals were adopted by the United Nations in 2015 as a universal call to action to eradicate poverty, protect the planet, and ensure that all people live in peace and prosperity by 2030). We deliberately mentioned other challenges related to the world' s energy supply earlier, as the pathways to affordable, clean energy for all are intertwined and interdependent. Draghi also recognises this in his report, in which he highlights the problem of high energy prices for European competitiveness. At the same time, he makes it clear that while Europe must reduce energy prices as part of its decarbonisation policy, this process towards a climate-neutral society will only be successful if all political measures are in line with the decarbonisation goals (Draghi, 2024).

Affordable energy for all people on Earth means ensuring universal access to affordable, reliable, and modern energy services by 2030. As it is not only about access to energy per se, but also about the affordability of energy, this of course also means reducing energy poverty.

There is no single definition of energy poverty, but it is associated with low-income households (particularly vulnerable groups such as the unemployed, low-income earners, and the elderly are the most affected), which are usually also characterised by inadequate living conditions and spend a large proportion of their disposable income on energy. In Slovenia, the regulation on the criteria for defining and assessing the number of energy-poor households sets the bar at 50% (meaning that to qualify for an energy-poor household, the share of energy expenditure exceeds at least 50% of the household's disposable income).

In order to reduce energy poverty and create prosperity, more attention must be paid to general awareness-raising. This implies awareness-raising for all—individuals, households, businesses, institutions, communities. People in the West generally consider themselves to be much “greener” than people in the East, but the data on energy consumption presented in Chapter 6 is not so clear-cut. Furthermore, the awareness-raising process in industrialised countries differs significantly in its content from that in less developed countries.

What will tomorrow's energy look like, or what will the ideal image of our planet look like in 2050 and beyond, is a question that encompasses all these aspects, plus many more that permeate every pore of our lives and which we cannot deal with here but have selected in Chapter 12. What is certain, the path to climate neutrality also paves the way to world peace. This is society's highest value and its greatest asset. This is indeed a goal that we must work towards with all our might, both as individuals and as a society.

The United Nations' fundamental Sustainable Development Goals to eradicate poverty, reduce inequality, and build more peaceful and prosperous societies by 2030 are therefore going in same the direction in which the world's energy challenges are being addressed. Working towards the sustainable use of all the planet's resources, not just energy, the prudent use of all resources, and the pursuit of climate neutrality, as well as the integration of knowledge from all walks of life, will contribute to a better society that is fairer and more just than the one we have today. And in such a society, where people are connected and listen to each other, peace will reign.

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# WHAT IS THE PATH TO A "GREEN" FUTURE? CLEANER PRODUCTION … LOWER CONSUMPTION

In general, the answer to the question of what we can do for a greener future is quite simple: Consume less and produce what we do consume in a cleaner way. So, consume less energy in all its forms and generate electricity and heat from as clean—renewable and low carbon—energy sources as possible.

Then we immediately ask ourselves how we can consume less. Drive less by car? Set the thermostat one degree lower? Maybe bake fewer pastries and do less laundry? Insulate our house or production hall better? Spend less time using electronic devices? Produce fewer appliances? It is immediately clear that these are multifaceted questions that affect society as a whole with all its subsystems. It is about the way we live and work; it is about the intertwining of private and business life.

If we were to give up travelling to work by car (less fuel consumption, less emissions, savings in our pockets, but also less income for the manufacturer of this fuel), the employer would have to agree. This immediately raises the question of trust and also the question of whether it is realistically possible to work from home (probably not in healthcare, nor in the operation and maintenance of energy infrastructure). But even if we were to switch to working from home, we would need to turn up to work at least occasionally. For this we would need efficient transport, well-maintained roads or railways, and also a well maintained energy infrastructure combined with alternative fuels.

The energy transition is a transition from an energy system based primarily on fossil fuels to a system based on renewable energy sources (RES).

It is clear that replacing coal and oil with cleaner alternatives contributes to a significant reduction in greenhouse gas emissions in economic sectors that are closely linked to electricity consumption in particular. As far as the transition from fossil fuel-based energy systems to those based on renewable energies is concerned, this also includes the substitution of fossil natural gas with renewable gases such as biomethane and green hydrogen. Indeed, this substitution has been contributing to the energy transition we are experiencing in Europe and elsewhere—a transition from an energy system based primarily on fossil fuels to one based on renewable energy sources. In other words, it is an energy transition towards a low carbon society.

# *Let us recap:*

**Everything is interwoven.** And all areas of action affect everything: people, climate, environment, energy, countries, regions, the world. Reducing energy consumption affects our entire way of working and living, because it has an impact on both the local and the global environment. If we only focus on finding solutions for one part of the system, we will only be partially successful. We need to think about how we can connect all areas, all of us as individuals, all levels of the economy, and even all nations.

This is also why the objectives, policies and measures set out in the National Energy and Climate Plan (NEPN) address several dimensions of the Energy Union: 1) decarbonisation (greenhouse gas emissions and renewables), 2) energy efficiency, 3) energy security, 4) the internal energy market, and 5) research, innovation and competitiveness.

Trends that define a green future:

- Decarbonisation through clean technologies
- Circular economy
- Digitalisation with artificial intelligence (AI)
- Decentralisation
- Electrification of all sectors
- Sustainable financing
- Awareness and demands for environmental justice

EICS ENERGY INDUSTRY CHAMBER OF SLOVENIA

## WHAT IS EICS POSITION ON KEY CLIMATE AND ENERGY ISSUES?

EICS supports the efforts of all stakeholders and in particular the efforts of countries, industries, civil society, and individuals in the fight against climate change. We support the Paris Agreement and the European Green Deal. We recognise that the transition to a low carbon and climate-neutral circular economy requires coordinated action by the Slovenian government and numerous stakeholders from all sectors and at all levels of government and society, including those who are members of EICS. For this reason, we advocate a harmonised approach to the adoption of various strategic documents of the Republic of Slovenia (climate-energy-space), as both the economy and the energy sector in Slovenia need a stable framework for action. Today we already have to make decisions on the construction of future energy facilities, because both the preparation of documents and the siting of plants are very lengthy procedures.

What we are striving for above all is to:

1. Pursue the goals of a resilient Energy Union, the aim of which is to ensure a reliable, sustainable, competitive, and affordable energy supply for consumers (households and industry) across the EU.
2. Support sustainable energy solutions, including through research and innovation, which will eventually make Slovenia an economically successful low-carbon society.
3. Raise awareness of energy-related issues among EICS members and the public.

# WHAT IS EICS POSITION ON LOW-CARBON SOCIETY?

Every country, every economy, and, most importantly, every household needs energy, which has to come from somewhere. Dependency on energy imports, i.e. dependency on foreign countries, means less security, greater vulnerability, and unpredictable prices, so it is necessary to strive to maximise the country's energy self-sufficiency.

We warn the public how difficult it is to achieve energy security and decarbonisation goals without new investments in renewable energy sources (RES). For this reason, we do not support decisions that do not lead to the construction of new renewable energy facilities, especially hydropower plants. We should also not ignore other renewable energy sources, including solar and wind energy, as Slovenia needs to increase the share of renewable energy in its energy mix.

We argue that society needs to take a position on all types of energy so that energy companies are able to prepare the basis for investment decisions affecting energy infrastructure today and in the future.

We recognise that the implementation of climate and energy policies and measures has an impact on both society and the environment. Therefore, we endeavour to improve the quality of the environment through careful and prudent use of natural resources in Slovenia.

In short, we are in favour of Slovenia achieving the highest possible degree of energy self sufficiency where possible, i.e. in electricity production; we are in favour of using the energy sources available to us; and finally, we are in favour of using domestic sources of knowledge.

# WHAT DOES EICS DO TO RAISE AWARENESS AND WHO ARE ITS PARTNERS?

EICS promotes the climate and energy debate at all levels, including the debate on the ambition of future targets, which should be based on a technical background. The future lies in close co-operation and integration. To this end, EICS maintains an energy dialogue with all its members within the Assembly, the Management Board, and its working groups. To inform and educate the public on energy issues, EICS has produced news and organised a variety of events. EICS members and representatives regularly participate in various events such as conferences, consultations, and seminars.

EICS takes positions and presents them to key decision-makers in Slovenia and abroad. In doing so, it takes into account the broader framework in which Slovenia is involved, including the Paris Agreement, the European Green Deal, and Slovenian development strategy. Through the networking of its members and through its specialised sections, EICS ensures that energy companies and other industries are informed about the most important energy-related developments. However, EICS is also open to the general public and the media and regularly publishes news on its website, in its e-newsletter, and on its LinkedIn page.

As one of the employers' associations in the Republic of Slovenia, EICS also participates in the economic and social dialogue in its home country. EICS is the employers' representative in the Economic and Social Committee for the Energy Sector (ESOE), a tripartite committee of social partners in Slovenia, which deals with issues and measures in the field of economic and social policy, as well as other issues concerning specific areas discussed between the social partners in the Republic of Slovenia in relation to companies in the energy sector and fuel supply. The party representing the state within ESOE is the Ministry responsible for energy, while the employees are represented by the Trade Union of Energy Sector Workers of Slovenia (SDE).

As the employers' representative, EICS has signed two collective labour agreements with the employees' party:

- The Collective Agreement for the Slovenian Electrical Industry (2017).
- The Collective Agreement for the Slovenian Coal Mining Industry (2019).

EICS ENERGY INDUSTRY CHAMBER OF SLOVENIA

# Energy transition

https: //ezs. si/en/energy-transition/

# Energy prices

https: //ezs. si/energetski-prehod/cene-energije/

# Diligent use of energy

https: //ezs. si/energetski-prehod/skrbno-z-energijo/

# Addendum:

## SLOVENIAN “GREEN” KNOWLEDGE

Slovenia has a wealth of expertise in the energy sector. For example, Slovenian companies have the knowhow to build hydropower plants themselves. We also have a lot of knowledge in the field of solar power plants, in the utilisation of geothermal energy, and a large number of people work in the field of district heating.

As Slovenia is one of the 30 or so countries that have their own nuclear reactors and one of the 50 or so countries that operate research reactors, it goes without saying that the country has many nuclear experts. These experts work at the Krško Nuclear Power Plant (NEK) and the TRIGA research reactor, which is part of the Jožef Stefan Institute (JSI). Both the JSI reactor centre and the TRIGA reactor play a key role in training personnel for the Krško nuclear power plant. Almost all nuclear experts in Slovenia, including all professors of reactor physics and nuclear engineering at the universities of Ljubljana and Maribor, as well as the most important experts from the Krško NPP, Slovenian Nuclear Safety Administration, and the Agency for Radwaste Management (ARAO), started their careers or received practical training at the TRIGA reactor.

While this mainly concerns the production sector, it should also be mentioned that Slovenia has a wealth of expertise in the field of energy consumption. Energy consumers include, as already mentioned, transport, industry, the energy sector itself, buildings, and households. There are a number of solutions for the efficient use of energy, we know how to make smart metres, and we know how to build energy-efficient buildings and use sustainably sourced materials

# *Research and development (R&D)*

The Jožef Stefan Institute (IJS) is the leading research organisation in Slovenia. Its mission is the creation, dissemination, and transfer of knowledge in natural sciences, engineering, and life sciences. The Institute focuses on cutting-edge research and development of technologies such as nanotechnologies, new materials, biotechnologies, production and control technologies, communication technologies, computer and knowledge technologies, environmental technologies, and nuclear engineering. The departments within the IJS include among others the Reactor Physics Division, and the Reactor Engineering Division. A department of the IJS that deals with energy is the Energy Efficiency Centre (EEC). It is a centre where knowledge on energy efficiency is collected and transferred at the junction of energy consumers, government, energy, service and equipment providers, and other stakeholders. At the same time, it deals with the environmental impact of energy utilisation and conversion.

The leading Slovenian engineering and scientific research organisation in the field of electrical power engineering and the energy industry in general is the Milan Vidmar Electric Power Research Institute (EIMV), which is also a member of EICS.

# *Education—formal and informal*

Various faculties in Slovenia offer energy-related degree programmes, including the Faculty of Electrical Engineering (FE) and the Faculty of Mechanical Engineering at the University of Ljubljana (UL), and the Faculty of Electrical Engineering and Computer Science (FERI) and the Faculty of Energy Technology at the University of Maribor (UM). In addition, the School of Economics and Business at the UL deals with the economic aspects of the energy sector, the two Slovenian law faculties deal with the legislation related to the energy sector and the Biotechnical Faculty at the UL deals with climate change issues. Study programmes for energy specialists are also offered by the University of Novo mesto at their Faculty of Mechanical Engineering.

In addition to university education, young people can choose from a range of energy-related training opportunities outside academia. With the aim of preserving and expanding knowledge, many Slovenian companies and organisations that are members of EICS take care of the youth.

For example, the company GEN energija has launched the World of Energy, an interactive multimedia centre that provides comprehensive and evidence-based information on the importance of energy and its use in daily life, on electricity generation technologies, and on the economic, social and environmental aspects of energy. The Sustainable Energy web portal, launched by Slovenian power market operator Borzen, is an online information centre that delivers information on energy efficiency and renewable energy sources in Slovenia. Elektro Maribor has launched the Distribution Academy, which aims to preserve and develop the knowledge accumulated in the company over many years, while providing an opportunity for integration within the environment and the society through informative and educational activities.

Many other members of EICS across Slovenia have taken different approaches to bringing energy and the energy industry closer to the public. The Slovenian transmission system operator ELES, the company GEN energija, and two research and educational organisations—the Milan Vidmar Electric Power Research Institute (EIMV) and the Faculty of Electrical Engineering at the University of Ljubljana—have joined forces to launch a scientific festival called Elektrofest, dedicated to promoting energy literacy among secondary school students.

We should not forget to mention iEnergija, which is an educational and research platform on flexibility and security of supply, providing a space where experts, e.g. from ELES, can present reliability of transmission system operation or advanced energy storage systems. The aim of the iEnergija platform is to give students of different study programmes or other people interested in energy an insight into the emerging interrelationships within the energy sector, with a focus on the importance of flexibility and the active role of energy consumers. iEnergija was launched as part of a project by EN-LITE, the Society for the Promotion of Energy Literacy.

## *The importance of human resources and interdisciplinary integration*

How we can secure sufficient and the best human resources for the energy transition is one of the fundamental questions, especially if we are talking about a successful green transition. This is related to the issue of a growing energy labour market and the fight for the best talent in the electricity industry and other related sectors, and of course also to the issue of education and encouraging young people to enrol in study programmes that humanity needs to replace fossil fuels with renewable energy sources.

In the Energy Economics Manifesto, prepared by the Slovenian Association for Energy Economics (SAEE Section of EICS) and published in March 2023, we emphasised the importance of developing strategic human resource management, with a particular focus on those who are crucial to the operation of critical infrastructure. We must constantly remind ourselves that people are an important source of creativity and commitment. It is people who work, decide, endeavour, and change the world. The more attention society pays to people, especially workers, the more success it will reap: The green transition will happen faster, business results will improve and our planet will be better cared for, while everyone involved will be happier.

Young people in general are attaching more and more importance to justice and an inclusive society. EICS learns about their aspirations for their education and future work through youth climate events. It turns out that young people want to acquire knowledge in different areas, they want to understand climate change and its impact on their lives and work. The integration of knowledge—the interdisciplinary nature of studies or the integration of science, technology, and social sciences in the context of the energy transition—is therefore becoming increasingly important. Young people have expressed the desire to experience more interdisciplinary integration in climate and energy issues during their studies, which can later be applied to concrete projects in practice. They would also like to be better acquainted with the opportunities in the energy and climate sector and the resulting employment opportunities, as they believe that these opportunities are neither sufficiently recognised nor adequately promoted. They emphasise the importance of linking formal and non-formal education and the need for the school system to include more interdisciplinary content on the green transition, which should be introduced earlier, at least in primary school, rather than at university.

EICS recognises the need to ensure a long-term pool of human resources for the energy sector in conjunction with the promotion of STEM (Science, Technology, Engineering, and Mathematics) professions. Engineering plays an important infrastructural and economic role in society and should be promoted in EICS member companies and beyond through various examples of good practice. Mentoring and co-operation with research institutions are encouraged. Energy is an interdisciplinary field with social, economic, and environmental implications, which is why EICS also promotes other professions that, together with engineering, will contribute to the successful development of the national energy sector and to sustainable development in general.

The future of the professions and the stability of the energy sector' s talent pool have never been more important. EICS is also aware, through social dialogue, of the challenge of finding, training, and retaining key personnel. This will also determine how successful each country will be in implementing its measures for a climate-neutral society.

EICS has contributed to two publications of the Institute of the Republic of Slovenia for Vocational Education and Training (CPI), from which we have picked out some of the highlights here.

# *COLLECTION OF SCIENTIFIC PAPERS—Contributions to the understanding of sustainability in vocational education and training*


This collection of scientific papers is a compilation of materials produced as part of two CPI development projects, Care 4 Climate and Climate Goals in Education and Training 2022 2023, which MSc. Ana Vučina Vršnak was involved in. The materials were developed to support the development activities in the field of vocational education and training (VET) with the aim of elaborating an integrated programme of awareness raising, education, and training on climate change in the context of education and training for sustainable development. The first part of the compendium contains ten descriptions of sustainability areas from an environmental, social, and economic perspective, which we have identified specifically for education and training in VET. The second part of the compendium contains additional supporting materials that were composed in the course of developing the content within both projects.

# *Qualification system for electrical engineering, electronics, automation, energy, and electronic communication*

The publication was prepared by the Institute of the Republic of Slovenia for Vocational Education and Training (CPI) with the aim of providing a comprehensive overview of the qualifications in question, the broader picture of the sectors concerned. and the position of the qualifications within them. The publication was intended for various groups of stakeholders who are in one way or another connected to the selected sectors: employers, chambers, trade unions, educational institutions, professional organisations, representatives of ministries, and the general public. EICS has contributed a section on the energy sector.

# SECTIONS WITHIN THE ENERGY INDUSTRY CHAMBER OF SLOVENIA (EICS):

**The Eurelectric Section** focuses on the development and competitiveness of the electric industry and promotes the role of low-carbon electricity generation in social progress. The members of the section usually meet before the board meetings of the Brussels-based Union of the Electricity Industry – Eurelectric.

The section has been active since 2004.

EZS
SEKCIJA EURELECTRIC

**The Energy Market Data Exchange Section** (IPET) strives for effective data exchange in the energy market and promotes the use of open data exchange standards that would allow unification of the approaches in the computerisation of data exchange processes among all market participants, based on an effective and standardised model.

The section has been active since 2010.

EZS | IPET
SEKCIJA ZA IZMENJAVO PODATKOV NA ENERGETSKEM TRGU

**The Slovenian Association for Energy Economics Section** (SAEE) brings together the members of the International Association for Energy Economics (IAEE), which is based in Cleveland, Ohio. The Section functions as an association of individuals interested in energy economics and creates a forum for professional discussion.

The section has been active since 2015.

EZS | SAEE
SEKCIJA SLOVENSKO ZDRUŽENJE ZA ENERGETSKO EKONOMIKO

**The District Heating Section** (DO) brings together companies from the field of district heating with the aim of exchanging their experiences and good practices, and planning development models in accordance with the EU and Slovenian district energy policy.

The section has been active since 2016.

EZS | DO
SEKCIJA ZA DALJINSKO OGREVANJE

**The Electricity Suppliers Section** (SVDEE) unites electricity suppliers and focuses on the exchange of opinions and mutual information, and on cooperation between members in the field of regulated energy activities.

The section has been active since 2016.

EZS | SVDEE
SEKCIJA ZA VPRAŠANJA DOBAVITELJEV ELEKTRIČNE ENERGIJE

**The Slovenian National Committee of the World Energy Council** (SNC WEC) Section has collaborated with the World Energy Council (WEC) on several projects, including the World Energy Trilemma.

The section has been active since 2020.

EZS | SNK WEC
SEKCIJA SLOVENSKI NACIONALNI KOMITE SVETOVNEGA ENERGETSKEGA SVETA

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