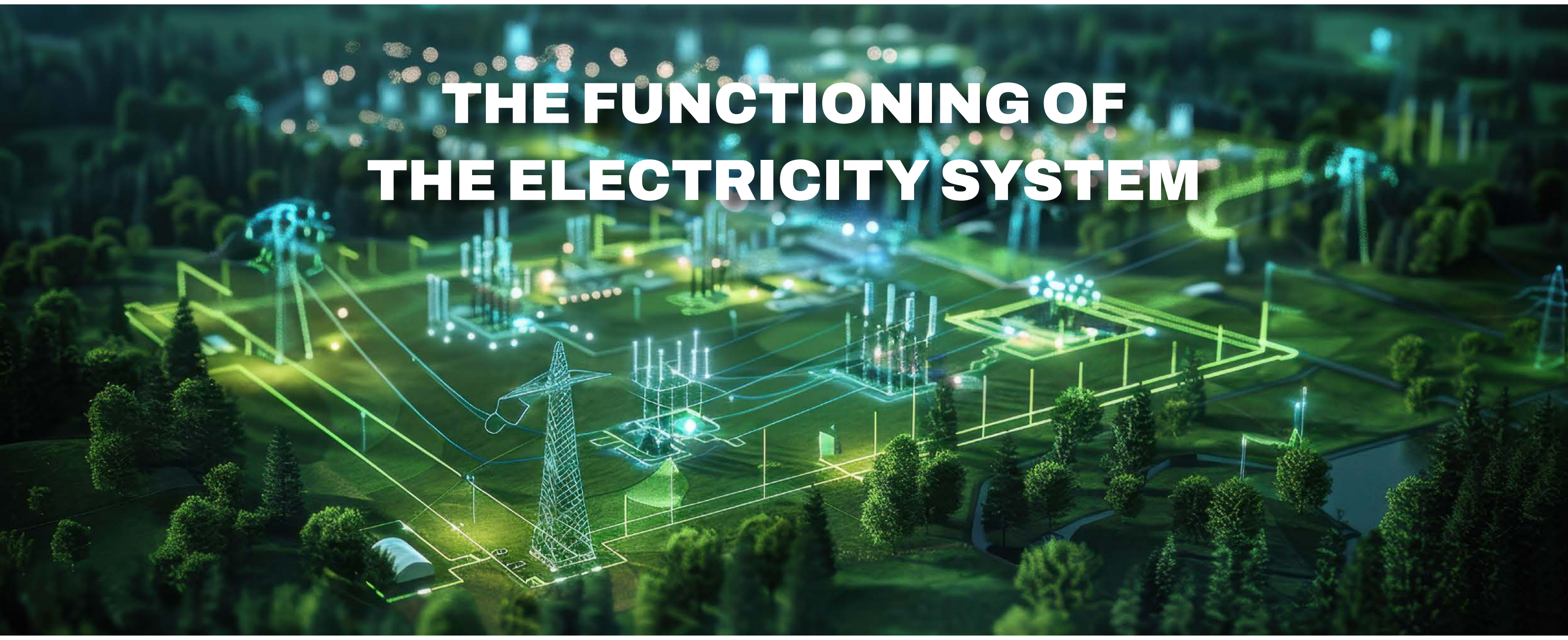
THE FUNCTIONING OF THE ELECTRICITY SYSTEM



1 WHAT ARE THE LARGE INFRASTRUCTURES THAT MAKE UP THE ELECTRICITY SYSTEM?

The electricity system is composed of different power generation units, each with its own characteristics, the main ones of which are listed below:

- **Carbon-intensive or low-carbon power generation units:** power stations generating power through the combustion of fossil energies (coal, fuel oil and gas) emit greenhouse gases when they generate electricity, whereas renewable power generation units (mainly hydro, wind and photovoltaic) and nuclear do not emit any when in use[1].

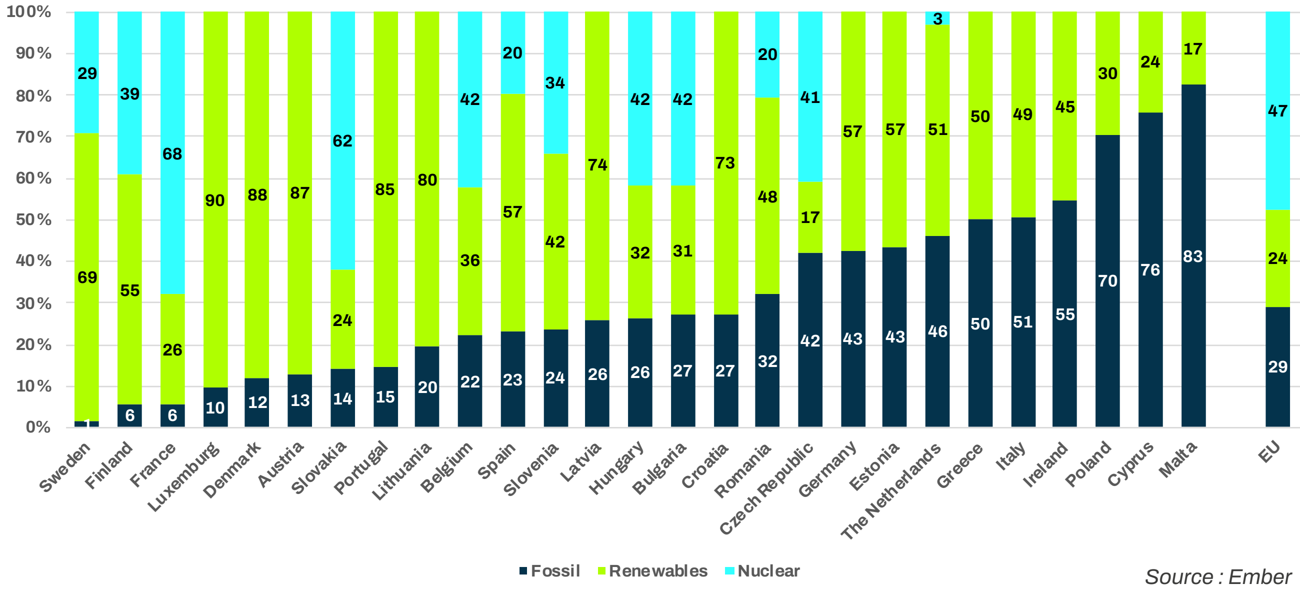
- **Dispatchable or variable power generation units:** nuclear, fossil fuels and hydro power stations with storage capacity are dispatchable power generation units, as their activation and variations in power output can be controlled. On the opposite side of the spectrum, wind, photovoltaic and run-of-river hydro power stations are considered as variable power generation units, as their maximum instantaneous production relies on weather conditions (amount of wind, sunshine or water flow)[2]. However, if equipped with control systems, these power generation units can adjust in order to lower the level of electricity that is injected into the network.

[1] Power stations also emit greenhouse gases during other phases of their lifecycle (construction and dismantling). This is why it is preferable to use the term “low carbon” rather than “decarbonised” when referring to renewable and nuclear energies.

[2] It is advisable to use the word “variable” rather than “intermittent” as the latter implies a binary state of production (all or nothing, like the workings of a switch), which does not express the physical reality of wind and photovoltaic power generation (which rises or falls due to weather conditions, without necessarily reaching zero or full capacity) and which does not take into account the increasing accuracy of production forecasts using meteorological data analysis and the capacity of some sites to adjust their production.

France stands out as having a very large share of nuclear-powered energy in its electricity mix, accounting for 67% of its total electricity production in 2024. Due to predominant reliance on low-carbon sources of energy generation (nuclear, hydro and, more recently, the fast-developing wind and solar energies) and the progressive closure of the largest carbon-emitting power plants (coal and fuel oil), **France's electricity mix**, with a carbon intensity of 21gCO_2eq/KWh in 2024, **is one of the lowest emitters in Europe.**

Electricity generation per country in the EU in 2024

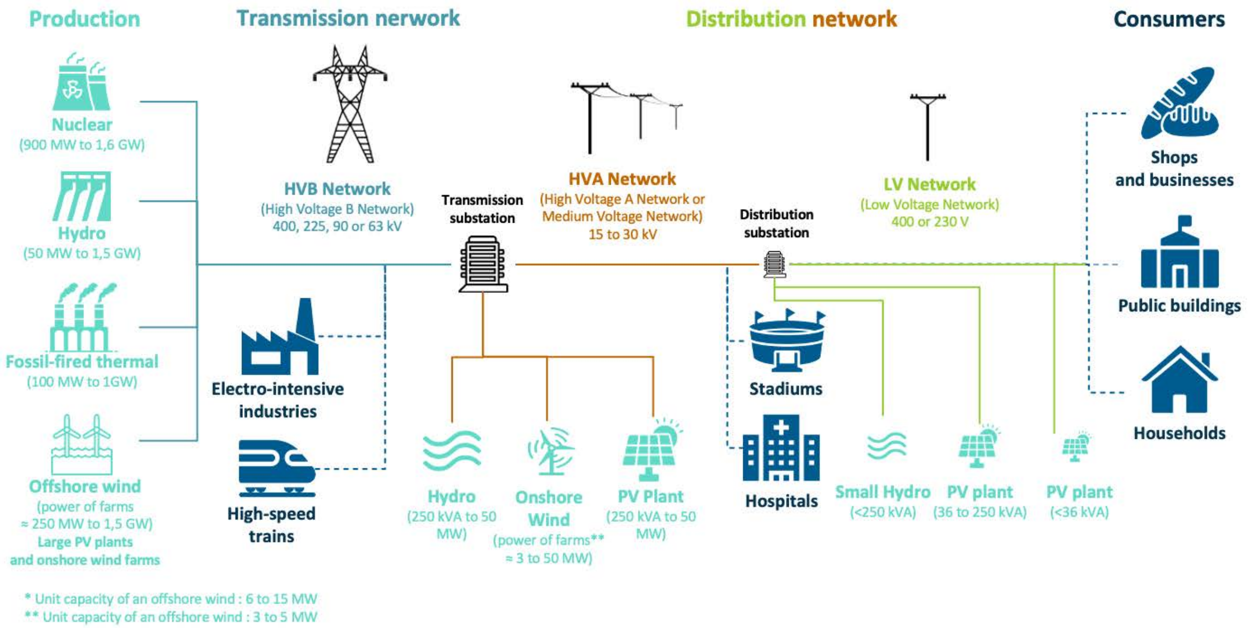


Source : Ember

Once generated, the electricity is then injected into the electricity network which is structured very much like a road network:

- **The transmission network, made up of high and extra-high voltage lines, can be likened to motorways and national roads.** They are used to transmit the electricity generated by high-power stations over long distances, to the large consumers and the distribution network. In France, the electricity transmission system operator (TSO) is RTE.
- **The distribution network is composed of medium and low-voltage lines, which can be likened respectively to departmental and communal roads.** The former distribute electricity on a scale of regions and counties, whereas the latter supply electricity to households, public buildings and businesses. In France, Enedis (covering 95% of the country), and around a hundred local distribution operators are the electricity distribution system operators (DSOs).
- Transmission and distribution substations act as "junctions" by adapting the level of voltage when it travels from one type of line to another.
- A high demand in electricity can cause congestions/power outages if the network is not sufficiently dimensioned, just as heavy traffic can cause traffic jams on roads.

Simplified representation of the electricity network



The volume of electricity consumed varies constantly due to multiple factors such as temperature, hours of sunshine and the level of economic activity. In the European Union, the consumption of electricity within the same day differs from one country to another due to different time zones, different weather conditions and even diverse cultural activities[3]. Not only is the need for electricity variable depending on the time of day, it is also difficult to store it in large amounts and over a long period of time. **Generation and consumption must therefore be continuously adjusted in order to maintain a balance in the electricity system.** This balance is ensured in real time by RTE.

In the past, the high share of dispatchable power generation units has enabled the electricity supply to adjust to fluctuations in demand and thus to maintain the balance of the electricity system. Although they play an important role in decarbonising the European economy, the development of variable renewable energies has made the task of reaching this balance increasingly challenging to achieve. The electricity system must now also integrate these ever-growing fluctuations in production which are uncorrelated to variations in consumption.

From now on, **flexibility solutions**, such as energy demand-side management (dynamic/horo-seasonal electricity price contracts, demand response...), dispatchable low-carbon power generation units, storage (pumped, battery, hydrogen...)[4] and interconnections, **are playing an increasingly significant role by allowing to adapt to the variability of the different modes of power generation and consumption.**

The interconnections ensure that electricity can be exchanged between different countries. They therefore both have a physical dimension (optimising the balance of the electricity system and improving the security of supply by fostering mutual support between States) and an economic one (mobilise in priority the most competitive power generation units available in Europe).

[3] For example, during mealtimes and public holidays.

[4] Electricity storage can now be achieved mechanically (pumped storage power plants, flywheels and compressed-air energy storage), electrochemically (storage using batteries), chemically (storage using hydrogen), thermally (through heat stored in molten salts or bricks) or electro-magnetically (storage using superconductors).