Anika Limbach, November 2020

Supplementary information:

Belgium's imported electricity and CO_2 emissions in case of a nuclear phase-out

I. How much import electricity will be available to Belgium in the coming years?

The question is currently being discussed in the Belgian media and politics as to whether, in the years of the nuclear phase-out and beyond, the country will have enough imported electricity available to guarantee security of supply at all times. However, the concern expressed years ago that the nuclear and coal phase-out in neighbouring European countries would lead to a massive reduction in the supply of electricity in the European internal electricity market is unjustified. Electricity supply in Western Europe is fully sufficient - even in times of particularly high consumption - and will not fall dramatically in the coming years.

I.1 Development of the electricity mix in Europe

The fall in the price of electricity on the spot market over the last four years already indicates that the supply of electricity in Europe has increased in relation to demand. At the same time, the share of renewable electricity has been steadily increasing, as shown in table 1:

Table 1: Electricity production of the EU 28 (excl. Luxembourg and Malta) by energy source (percent)

Percentage	**2016**	**2017**	**2018**	**2019[1*]**	**2020[2*]**
Conventional electricity	*70,13*	*69,95*	*67,68*	*65,52*	*59,65*
➢ of which fossil coal	20,47	19,57	18,21	15,19	12,4
➢ of which nuclear	25,93	25,51	25,63	28,48	26,09
➢ of which fossil gas	19,91	20,85	20,11	20,66	19,88
renewable electricity	*29,54*	*29,87*	*32,13*	*34,48*	*40,35*
➢ of which wind	9,71	11,32	11,62	13,74	16,09
➢ of which solar PV	3,24	3,4	3,69	4,01	5,08
➢ of which biomass	3,79	3,86	3,86	3,92	4,03
➢ of which hydropower	11,18	9,64	11,39	12,59	14,93

Source: Entso-e: statistical factsheets 2016 - 2018 / Energy industry portal

The share of so-called base-loadable renewable energies such as biomass and hydropower has also increased. As a part of the wind power can also be considered available (see below), more base-loadable electricity from renewable sources than in 2016 will be available to the

1 Estimated value based on the table of the energy industry portal. Cf: https://www.energiefirmen.de/energie/erzeugung/strom-europa

2 ibid.

European internal market this year. In addition, this more than compensates for the decrease in capacity of coal-fired power plants. This trend will continue in the coming years.

I.2 Development of electric power capacity

The electricity market in north-western Europe is also prepared for extreme cases. Belgium's neighbouring countries have more reliable electric power capacity than they would need in the event of high consumption. This situation will not change fundamentally in the coming years.

Let us take a closer look at the individual countries:

I.2.1 Great Britain

When looking at the electric power capacities of the UK (see table 2), it is remarkable:

- The decommissioning of many coal-fired power plants totalling 8 GW was more than compensated for in the same period by the construction of new gas-fired power plants (of 12.5 GW).
- Wind power capacity has grown by almost 10 GW.
- "base-load" capacities such as biomass, hydroelectric and pumped-storage power plants have also increased strongly (by a total of approx. 4 GW)
- As can be seen from the Entso-e[3] statistical factsheets, the annual peak load in the UK has fallen in recent years - to 61.4 GW in 2018 (data for 2019 and 2020 are not yet available, but the trend is likely to continue).
- Since the UK now has around 70 gigawatts of "base-load" capacity, it could export electricity even at its peak load. This would also be the case if additional coal and nuclear power plants totalling 6 or 7 GW were to be shut down.
- In line with the increase in electricity generating capacity, it can be assumed that the UK has now transformed itself from a net importer of electricity to a net exporter.
- Belgium is able to import up to 1,000 MW of electricity from the UK.

3 https://www.entsoe.eu/publications/statistics-and-data/#statistical-factsheet

Table 2: Installed capacity per energy source (MW)

	2016	2017	2018	2019	2020
Nuclear Power	8981	8985	8074	8229	8209
Hard coal	14889	11097	10813	8280	6780
Wind onshore	8582	10150	12144	12638	12835
Wind offshore	5011	5471	6071	9379	10305
Biomass	1890	2119	2099	4061	4237
Running water	1540	1525	1758	1885	1882
Pumped Storage	2744	2744	2744	2744	4052
Solar	3954	8566	12471	13346	13276
Gas	25702	27688	27206	36149	38274
Oil / Other	792 / 4501	759 / 6082	8308	4344	4237

Source: Entso-e-Transparency Platform / under "Installed Capacity per Production Type

I.2.2 Netherlands

In the Netherlands, coal- and especially gas-fired power plants totalling 5.4 GW have been decommissioned since 2016. On the other hand, only 270 Megawatts of new "base load" capacity were built. Nevertheless, the Netherlands is still able to supply itself with electricity even in times of high consumption: the annual peak load has remained stable for years at around 18.5 GW. In contrast, the total number of base-load-capable power plants amounts to 22 GW. Even if a reserve capacity is included, Belgium's neighbouring country could still export electricity even at high peak loads. In addition, wind power capacity has increased by 2 GW since 2016. Solar installations in the Netherlands have recorded even greater growth - by around 4.3 GW.

I.2.3 France

No country in the world has as many nuclear reactors in proportion to its national territory as France. Many of the reactors have reached an advanced age. A nuclear phase-out in the future is inevitable, even though two years ago French President Emmanuel Macron postponed the shutdown of 14 reactors planned until 2025 by 10 years. The growing safety risk, escalating costs of upgrading and maintenance as well as the increasing unreliability of many reactors may change attitudes towards the operation of reactors in the coming years, thus contributing to an earlier closure. A significant reduction in the size of the French nuclear fleet should therefore be expected by 2025. A secured nuclear capacity of 30 to 35 GW seems realistic.

France's base-load-capable generation plants - excluding nuclear and coal-fired power - add up to about 40 GW. With a coal phase-out and a "half nuclear phase-out", a maximum of 70 GW would thus be available. This is significantly less than France's annual peak load, which is generally between 80 and 90 GW. For this reason too, the French government will have to promote renewables and, above all, efficiency and energy-savings measures much more

strongly than before. Within five years, wind power capacity has grown by just under 5 GW and solar installations by 2.7 GW, but that is far from enough.

If the energy turnaround does not accelerate rapidly, France will go from being an electricity export champion in Europe to a country that imports significantly more electricity than it exports. But that would not lead to a blackout. On the one hand, load peaks could be reduced through intelligent load management, and on the other hand they could be absorbed by imported electricity, e.g. from the UK, Switzerland or Spain. Spain in particular has considerably more capacity than necessary - even without coal-fired power plants.

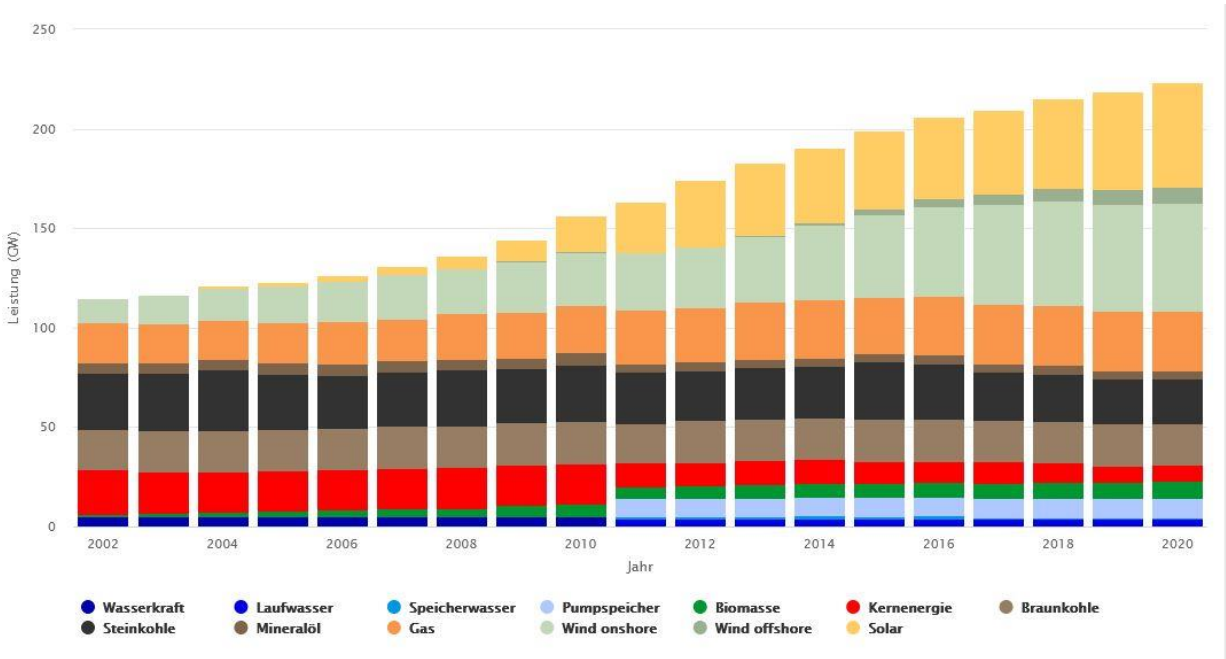
Belgium cannot count on French imported electricity in the medium term. However, since the majority of imported electricity comes from Germany, this is not necessary to secure the electricity supply in Belgium.

I.2.4 Germany

Like hardly any other country in Europe, Germany has built up an enormous amount of overcapacity in recent years. The expansion of wind and solar power plants was accompanied by a less ambitious timetable for the decommissioning of nuclear and fossil power plants.

As there is no corresponding data on the Entso-e-Transparency Platform, we refer here to the list of power plants of the Bundesnetzagentur[4] and to the following graph of the Energy Charts[5]:

Figure 2: Net installed capacity for electricity generation in Germany



Source: Energy-Charts.info (1.11.2020)

4 https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Versorgungssicherheit/Erzeugungskapazitaeten/Kraftwerksliste/kraftwerksliste-node.html

5 https://energy-charts.info/charts/installed_power/chart.htm?l=de&c=DE

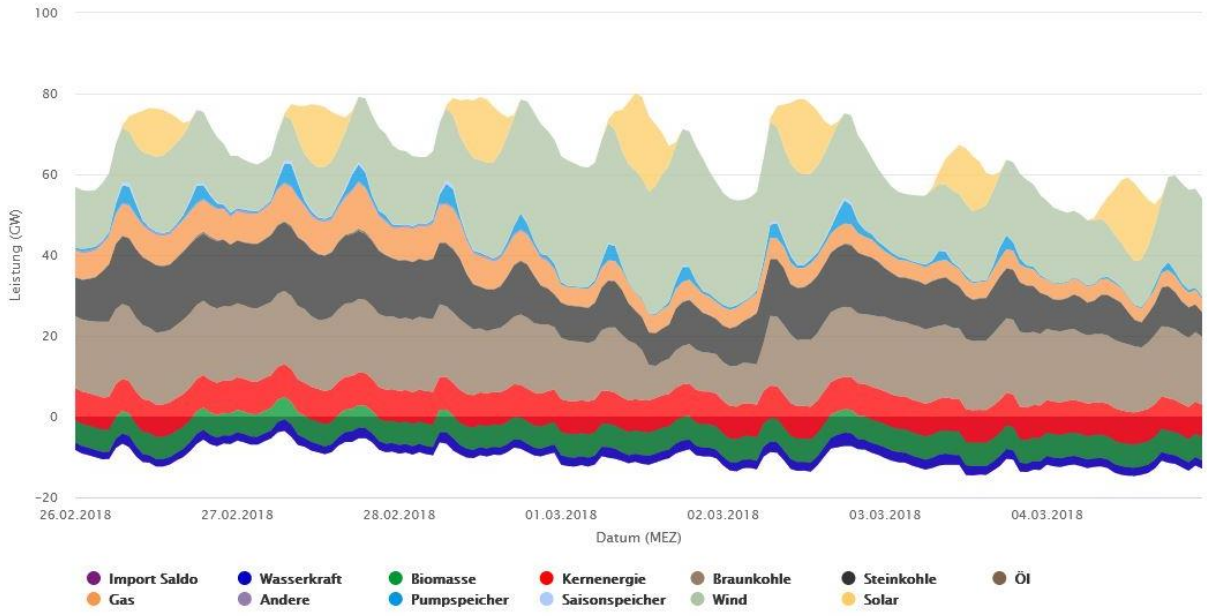
Germany currently has an installed capacity of 229.4 GW. This is not shown in full in Figure 2 because 5.9 GW from other power plants (waste, others, biogas, etc.) are missing.

Apart from this, Figure 2 impressively shows that the share of nuclear, coal and gas-fired power stations has hardly changed between 2012 and 2016. There is even a slight increase, despite the strong expansion of solar and wind power plants in the same period.

The resulting oversupply of electricity means that wind power plants may even have to be shut down at times in order to avoid overloading the grids. This situation has improved only slightly in recent years.

When the last nuclear power plant in Germany goes off the grid at the end of 2022, there will still be 104.5 GW of base-load capacity available - excluding the net decommissioning of some fossil power plants. If the reliably available share of wind power (3 %) is added, the figure rises to 106.4 GW. By contrast, the annual peak load is well below 80 GW. In the Entso-e statistical factsheet it is stated as 79 GW for 2018 (on 28 February).

Figure 3: Electricity production in Germany in week 9 2018



Source: Energy-Charts.info (04.06.2018)

However, this figure of the annual peak load for 2018 is deceptive. As Figure 3 shows, at the time of the highest consumption on 28 February 2018, over 9 GW of additional electricity was exported. The actual value was therefore around 70 GW. It is difficult to determine how high Germany's annual peak load actually is. However, if the possibility of available load management is taken into account, it should not be higher than 75 GW.

Even if the capacity reserve is very generously calculated at 10 GW, this means that after the complete nuclear phase-out there will still be a whole series of overcapacities (21.5 GW), which would only be reduced by about 7 GW by 2025 according to the plan of the coal phase-out decided in the Bundestag. Even if the coal phase-out were to be accelerated (and more appropriate), there would still be capacity in 2025 to export sufficient electricity to Belgium.

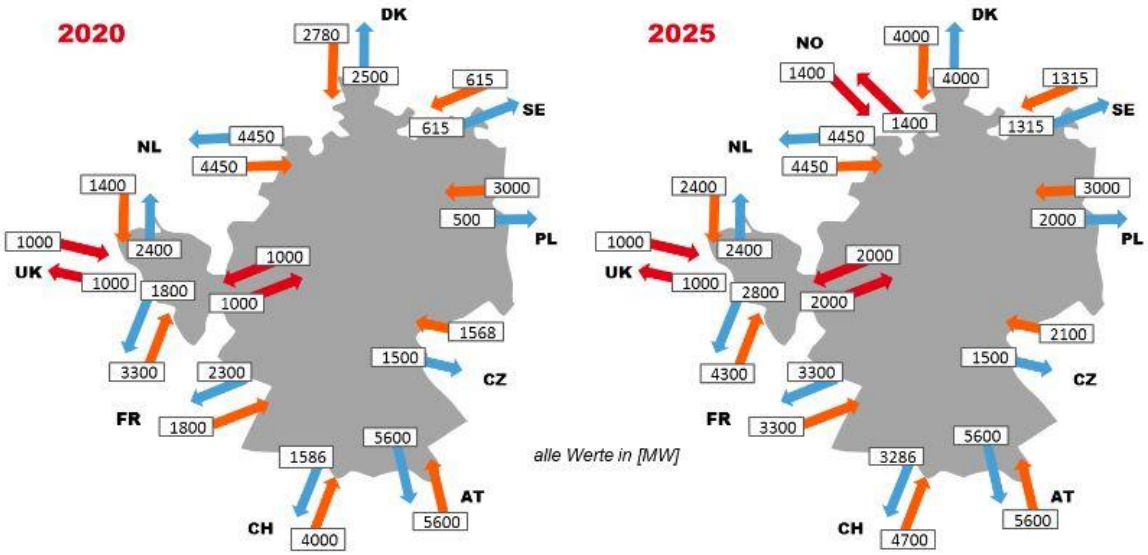
The Belgian Commission for Electricity and Gas (CREG) drew attention to another possibility to provide electricity to Belgium in Germany. It analysed a 2019 study by the Belgian transmission system operator Elia entitled "Adequacy and flexibility study for Belgium 2020 -2030" and concluded that Elia used outdated data, made overly conservative, sometimes distorting estimates and ignored many possibilities. On page 35 it says:

> *"This also implies that reserves and additional capacity in Germany, Austria, France, the Netherlands or other countries can also help the adequacy situation in Belgium. In this regard, it is important to point to the so-called winter reserves in Germany. These reserves, currently about 6.6 GW, are primarily located in the South of Germany to stabilize the German grid. When there is a lot of wind and coal/lignite power generation in the North of Germany, the internal grid within Germany needs to be compensated by these grid reserves in the South. These reserves are kept out of the market. If Belgium wants to use these reserves, there could be a need for an agreement with those countries, depending on the regulation under which these reserves would be used."*

I.3 How much electricity fits into the transmission grids?

The network capacities between Belgium and Germany are sufficient to transport a total of 4.7 GW at the same time, firstly via a new direct line and secondly via France and the Netherlands (see Figure 4). In total, the high-voltage lines between the neighbouring countries and Belgium have a network capacity of 6.7 GW.

Figure 4: Net Transfer Capacities



Source: BET Study 2017 "Diskussionsbeitrag zur Stromversorgung Belgiens im Falle eines Atomausstiegs"[6]

6 https://tihange-abschalten.eu/wp-content/uploads/2017/01/20161209_Studie-Versorgungssicherheit-Belgien_stc14564.pdf

I.4 Wind power available in Europe

Another possibility far too little considered: Wind power in Europe (especially in the windy north-west) could supply Belgium with imported electricity. Each wind turbine on its own cannot supply electricity at all times, as there are always phases of no wind. However, if you look at the wind power potential of all EU countries plus the UK as a whole, a not inconsiderable proportion of wind power is always available, as there is never a period of no wind throughout Europe. The German Federal Ministry of Economics (BMWi) stated in its "Green Paper" 2015:

> *„Beispielsweise beträgt der Beitrag von Windenergieanlagen zur gesicherten Leistung bei einer EU-weiten Berechnung rund 14 Prozent der gesamten installierten Windleistung (TradeWind 2009).“* (S. 35)
> *[*Translation: For example, according to an EU-wide calculation, the contribution of wind turbines to the guaranteed capacity is around 14 percent of the total installed wind power capacity (TradeWind 2009).]

If this quotient is applied to the current wind power capacities of the EU states (plus the UK), a value of approximately 30 GW is obtained. Of course, the transmission of such a quantity of electricity is limited by the capacity of the lines. But considering the generally high flow of electricity between Germany and its many neighbouring countries (which requires a high grid capacities), the wind power that could reach Belgium at any time should be at least 5 GW.

I.5 Conclusion

There are many possibilities for Belgium to use foreign electricity, now and in the future. In the neighbouring countries of the United Kingdom and Germany, more "base-load" renewable electricity is available, while consumption levels are falling. In many places, the capacity of gas-fired power stations has also increased (the Netherlands being an exception). If necessary, Belgium could use the reserve power plants in Germany, as well as large quantities of wind power that the European market has to offer on a permanent basis.

Each of these options would be sufficient in itself to close the potential electricity gap in the event of a nuclear phase-out in Belgium. In combination, they are of course all the more helpful and have a price curbing effect.

II. Will Belgium's nuclear phase-out increase CO2 emissions?

II.1 Development of the share of gas electricity in Belgium

As can be seen in table 3, the decline in coal-fired electricity and temporary reductions in nuclear power supply did not result in excessive gas electricity production. Belgium has done much to promote and develop renewable energy in recent years. The corresponding increase in renewable electricity was sufficient to keep the supply of gas electricity at about the same level, while at the same time the coal phase-out was completed and the share of nuclear electricity tended to decrease.

Table 3: Development of electricity generation and electricity mix in Belgium from 2016 to 2020 (TWh)

	2016	2017	2018	2019	2020
Gas electricity	20,2	21,3	22,1	23	22,2
Coal-fired electricity	2,5	2,2	2,1	0	0
Nuclear electricity	41,3	40	27	41	32,3
Green electricity	13	14,4	15,6	14,7	16,5

Source: Entso-e-Transparency Platform / www.energiefirmen.de

II.2 Development in Great Britain

In the course of the energy transition, gas-fired power plants are mainly used as "gap fillers", at times when no solar and only little wind power is available. As a result, the amount of electricity they produce is often even declining, even though their installed capacity is growing. This is particularly evident in the example of Great Britain:

Here, all conventional power stations have produced less and less electricity over a period of 5 years (cf. table 4). This decline was not only absorbed by the increasing share of green electricity, but also by falling consumption.

Table 4: Development of electricity generation and the electricity mix in the UK, 2016 to 2020 (TWh9

	2016	2017	2018	2019	2020
Gas electricity	150,1	143,6	129,9	113,3	91,2
Coal-fired electricity	30,2	23,7	16,8	5,9	3,8
Nuclear electricity	66,8	65,6	60,7	52,3	46,8
Green electricity	73,1	79,4	78,4	76,9	85,9

Source: Entso-e-Transparency Platform / www.energiefirmen.de

II.3 Conclusion

It is therefore clear that a nuclear or coal phase-out in countries like Belgium does not necessarily mean an increase in gas electricity generation. The key variables in deciding whether to use more or less gas electricity are a significant increase in renewable electricity capacity and effective measures to use energy more efficiently and economically.