Time has become the biggest enemy of nuclear power plant construction

(This document is based on data available in June 2021.)

Currently 52 new nuclear power plant units are under construction around the world. And it is no coincidence that the fewest of them are in America and the most of them in Asia. Is Europe a lame duck? What does it mean that a nuclear power plant is 'under construction'? And why does this category exclude Paks II, which in fact has been in the pipeline since 2013?

'Nuclear power was supposed to save the planet. The plants that used this technology could produce enormous amounts of electricity without the pollution caused by burning coal, oil or natural gas, which would help slow the catastrophic changes humans have forced on the Earth's climate. (...) My journey, from admiring nuclear power to fearing it, was complete: This tech is no longer a viable strategy for dealing with climate change, nor is it a competitive source of power. It is hazardous, expensive and unreliable, and abandoning it wouldn't bring on climate doom. The real choice now is between saving the planet and saving the dying nuclear industry. I vote for the planet.'

These thoughts were published in The Washington Post two years ago, in the wake of the publication of a book on the nuclear industry, *Confessions of a Rogue Nuclear Regulator*. The author, Gregory Jaczko, is no stranger to the sector. For a long time, he has been an influential figure in the US nuclear industry. He worked for the Nuclear Regulatory Commission (NRC) for almost a decade, being its chairman from 2009 to 2012. He resigned before the end of his terms, partly because the NRC's split vote of four to one to authorise the construction of a new nuclear power plant in the USA country after decades. Jaczko, who now is a professor at Georgetown University and Princeton University and focusses on offshore wind energy, says that the vote on the Vogtle 3&4 reactor units in Georgia (which were expected to mark the beginning of a new Renaissance of nuclear power plant construction in the US) was a decision that completely ignored Fukushima.

The two AP1000 reactor units of the Vogtle Plant (of a capacity of 1200 MW each), have been under construction since March and November 2013, respectively, and although they are nearing completion, the power plant is not complete The construction process, however, caused construction company Westinghouse go bankrupt. Given that the construction costs, estimated at $25 billion (now a modest amount) in 2018, increased by $700 million in the late 2020s, and that the company announced further delays in January 2021 (although still envisaging commissioning in November 2021 and November 2022, respectively), the Vogtle Plant will become the most expensive nuclear power plant in the United States. Vogtle 3&4 are two of the 52 facilities currently under construction around the world.

The construction of 779 nuclear reactors started before May 2021 worldwide, of which 415 are currently operating in 37 countries. 193 reactors have already been shut down and a further 28 have been out of operation for a long time. Altogether, there are 52 reactor units under construction, not including 93 cases where decision has been made to halt the project before the construction is completed or the reactors are commissioned.

When does the construction of a power plant start?

As evidenced by the current list of IAEA, a total of 15 reactors are under construction in Europe and the Middle East, 4 in North and Latin America, and 33 in Asia. In theory, it is simple to define the starting date: the plant enters into the phase of 'under construction' when concrete is first poured into the base. Recently, however, there have been some projects where the investors tried, in order to cut investment time statistically, to carry out works that normally take place after the start of the construction process earlier, before the official start. The French builders of the British Hinkley Point C (already well into construction) or the project owners of Paks II (a project which is still not in the phase of 'under construction') are familiar with this approach.

The schedule of the active project period of a nuclear power plant project is usually quite tight, although there are hardly any nuclear power plants worldwide which have been completed on time. As per the IAEA chronology, it takes an average of 10 years to build a nuclear power

generation unit. This period is divided into three phases. **In the first phase** (1-3 years), a commitment is made to a nuclear power programme, which then results in setting up a programme implementation organisation that deals with the nuclear programme of the country concerned (but not with specific investments). **The second phase** is the project decision phase (3-7 years), which defines preparatory works and the procedure leading to bidding. In the meantime, in addition to the government's decision and role, the regulatory body and the owner/operator take on an increasingly significant role. The **third phase is the actual** construction phase (7-10 years). This is the phase of project completion, and its end is marked by the commissioning of the power plant unit.
There is only one problem with this schedule: there is hardly any player in the world which manages to complete Phase 2 and 3 in 10 years. Paks II (which is in its 8th year, but as of yet has not entered the construction phase) is an atypical, albeit not a particularly bad example. If the current officially announced dates are met and there are no further delays, the new Paks nuclear power plant unit could possibly be completed by 2030, in which case gross construction time will amount to 17 years.

But how do you define a nuclear power plant or project that is 'under construction'? This is a difficult question, which is indicated by the fact that even the World Nuclear Association gives a somewhat vague answer, saying that 'currently there about 50 reactors' under construction in the world. It is not by chance that the wording is so cautious: at some point it is difficult to tell if the term 'under construction' indeed means that the construction process is underway. A typical example of this ambiguity is the Belene Nuclear Power Plant in Bulgaria. The construction process started in 2005, but is still not finished. It has been inactive since 2012 and, therefore, is not included in the list of plants 'under construction', albeit rumour has it occasionally that the project will resume. Belene is currently not 'under construction', unlike Units 3 and 4 of the Khmelnitsky Nuclear Power Plant in Ukraine, which have been 'under construction' since 1986 and 1987, respectively. Time factor is not a decisive aspect: the Ukrainian project was launched 35 years ago, and Units 3 and 4 of the Mochovce Nuclear Power Plant in Slovakia have also been racing against time since 1987. Nowadays it looks more likely that Unit 3 will be commissioned in the foreseeable future.

As shown by the other end of the chronological list of projects 'under construction', the two newest projects were added on 19 May. In their case, it seems more likely that the construction process will be smoother. Still, the project launch ceremony, held by Russian President Vladimir Putin and Chinese President Xi Jinping via video conference, is telling: the world's two biggest constructors launch work in cooperation. The main equipment for Tianwan-8 and Xudapu-4 will be supplied by Rosatom, but the construction works will be performed by China's National Nuclear Corporation (CNNC), a key actor in China's nuclear industry. As agreed by the parties in June 2018, the new Tianwan Power Plant Unit, to be built in Lianyungang (Jiangsu Province on the east coast of China) and the new Xudapu Power Plant Unit, to be built in Huludao (Liaoning Province near the North Korean border, in northeast China) will also be equipped with a third-generation VVER 1200 reactor unit.

Too little anyway

It is most telling with regard to the future prospects of the nuclear industry that the 52 construction projects under construction promise a total increase of 54,515 GW in global power generation. The amount in itself seems to be huge, but while it is still not known exactly when each facility is going to be connected (or if it ever will be connected) to the grid, in 2020 alone solar power generation capacity and wind power generation capacity grew by a record level of 132 GW and 73 GW, respectively.

The IAEA's Top 10 list of nuclear power plants recently connected to the grid includes three projects in Russia, three in China, and one each in the United Arab Emirates, Belarus, Pakistan and India. The ranking of the construction projects which have been launched most recently is even more homogeneous: nine Chinese projects plus one Turkish, the most notable feature of the latter being that the construction processes of Akkuyu 1, 2 and 3 are virtually merging into a single gigantic construction. The situation is not much better with regard to the future. The IAEA prepared its last report on the international situation and prospects for nuclear energy four years ago. The report gives a highly optimistic outlook of some 30 countries considering the launch of nuclear power programmes, and a further 20 countries having shown interest in the sector.

Table 1.: **Nuclear power plants 'under construction'**

Country	**Number of reactor units**	**Total net electrical capacity [MW]**

China	14	13,175
India	6	4194
South Korea	4	5360
Russia	3	3459
Turkey	3	3342
United Arab Emirates	3	4035
Bangladesh	2	2160
Japan	2	2653
Slovakia	2	880
Ukraine	2	2070
United Kingdom	2	3260
USA	2	2234
Argentina	1	25
Belarus	1	1110
Brazil	1	1340
Finland	1	1600
France	1	1630
Iran	1	974
Pakistan	1	1014
Total	52	54,515

(Source: IAE Paris)

A small league – one front-runner?

However, it is worth bearing in mind that the global supply market for nuclear power plant construction is made up of a relatively small number of groups of companies. The Chinese and Russians are at the top, followed by the French, the South Koreans and the Americans - and that is where the list ends. The list may be even shorter, given that although China has been building the most nuclear reactors globally for some time now, it engages in such construction projects almost exclusively domestically due to the fact that Hualong One, the reactor unit it developed (and then improved) is not attracting much interest because of its lack of technical transparency. Extensive corruption, coupled with the safety concerns over the completed power plants, has been paralysing South Korea's nuclear sector (KEPCO) for years, and, in essence, stalled prospective domestic projects and international expansion alike. France's nuclear industry (where in 2017 Areva was sold to EdF to avoid bankruptcy) appears to be at the verge of breaking down because of a domestic construction project (Flamanville 3) and a construction project in the United Kingdom (Hinkley Point C). And even if it manages to stay afloat somehow, it needs to find financial, economic and political support to maintain France's nuclear facilities which increasingly call for replacement. The US Westinghouse, which, at least as far as rhetorics are concerned, would be willing to build the six reactor units, envisaged by Central European governments (among others, the Polish government), in fact needs heavy support to stay afloat, having not yet recovered fully from bankruptcy. Moreover, it dragged down Toshiba that intended to rescue it. Indeed, it would be a miracle if the Georgia construction project mentioned above was completed without delay or further cost increases.

This leaves a single country on the list: Russia (Rosatom). An earlier post on the Hungarian-language blog *Energiabox* gave a precise account on where and how Russian export of influence operates globally, how Rosatom is gaining ground in Africa (from Egypt to Uganda, Rwanda, Ghana, South Africa, Ethiopia, Nigeria, Sudan and Zambia), and how it offers (backed by the Russian government) flexible business models and attractive financial packages with a combination of diplomatic tools. In addition, Rosatom itself is such a large and complex group of companies that it is able to take on a complete project from design to commissioning or even beyond (e.g in Turkey), although STUK, Finland's licensing authority identified some problems. And there are places where even Russians do not have a stable position. When it was seriously considered that the Czech Republic would build two new units at the Dukovany Nuclear Power Plant and that the government would publish a call for tenders (which, however, is unlikely to happen this year given the general elections in autumn 2021), all major players of the nuclear industry came forward. However, the news that the Chinese General Nuclear Power Group (CGN), the US Westinghouse, the French EdF, the South Korean Korea Hydro & Nuclear Power (KHNP) and the Russian Rosatom are 'interested' in the project does not mean too much. All the more so as currently Rosatom seems to have been removed from the tender because of the Czech-Russian spy scandal and the Russian implications of the Vrbětice ammunition warehouses explosions.

Shoot forward...

In 2015, Foratom, the 'voice' of the European nuclear industry, envisaged that 100 new reactor units would need to be constructed in Europe by 2050 to meet greenhouse gas emission reduction targets and implement climate protection measures. In their opinion, this was not an ambitious wish, only 'maintaining nuclear power generation at least at current levels'.

As is clear from global processes that have been going on for years, Europe is not one of the continents which shows a strong interest in nuclear energy; indeed, in that regard it underperforms the world average. By 2030, 207 nuclear reactors (and by 2059, another 125) will reach the end of their life cycle, which means that they will have to be decommissioned and dismantled. About 60% of them are located in Europe. To put it another way, by 2030 the grid would need an extra nuclear generation capacity exceeding 152 GW only to maintain the global nuclear status quo. This would involve building around 110-120 power plant units, given that constructors (that is, those who actually construct) mostly build facilities of a 1000—1200-MW reactor capacity. Yet as indicated in the 2020 volume of the World Nuclear Industry Status Report (WNISR), a database of the nuclear industry published every year, a total of 58 new nuclear reactor units were commissioned in the world between 2010 and 2019. The situation is not improved by the fact that in the previous decade 67 reactor construction projects have been registered, but of the 62 that are still ongoing exactly 50% is located in China, while more than 40 of the projects that started between 2010 and 2019 are still in the 'under construction' phase.

By the end of 2020, the message conveyed by the nuclear industry had changed. When Rafael Grossi, Director-General of IAEA outlined the industry's perspectives at the end of last year, he envisaged a dozen new countries joining the nuclear club by 2030. But the focus was no longer on Europe. Grossi stated that the main challenge was to keep nuclear power in the world's electricity mix.

This is no small undertaking given that – according to the WNISR Report, which corroborates its claims with data - there are already better options, from an economic, social, technological and political perspective, in renewable energy.

...and shoot backwards

The intention of the nuclear lobby as an opinion leader to prove that nuclear energy is more necessary than ever is evidenced not only in the declarations of the IAEA, or in the publications of “ghost organisations” like Foratom and the New Nuclear Watch Institute (NNWI), but also in the operation and activity of websites funded by the nuclear industry that, so to say, pump industry propaganda into the public domain. In Hungary, a vivid example of the latter is *Atomenergiainfo*, which had been funded by Rosatom for years. The contents of the website have now been completely removed, but the traces of its activities are still visible on its now passive Facebook page. But representing the need to have, build and maintain nuclear power plants in communicating along the notions of *clean energy / decarbonisation / rapid response to the climate crisis* means not only shooting forward, but also shooting backwards. The best-known examples for this approach are to be found in the widespread, but still untrue, rumours that the Energiewende (Germany’s 2022 nuclear phase-out) will be backed up by the excess capacity of French nuclear power plants. A similar motif can be identified behind the new thought experiment that Spain, also intending to implement a nuclear phase-out, should change its mind.

At the beginning of 2019, Spanish Energy Minister Teresa Ribera announced the schedule of the transformation of Spain’s energy system until 2031 and, in the long run, until 2040. The schedule is based on the fact that in 2018 40% of Spain’s onshore electricity generation was provided from green energy sources, and this rate will be drastically increased: as per calculations, the process will require a 3-GW renewable energy growth per year and an investment of around €235 billion. This is what is needed to close coal-fired power plants by the end of the decade, and to put Spain on a path where a ban on petrol and diesel vehicles can be introduced by 2040 and a complete phase-out of nuclear capacity (which currently makes up 20% of its energy mix) can be implemented by 2035. Less the than four months before the declaration, the target date for nuclear phase-out was 2040, which makes it very clear that Spain does want to get rid of coal and nuclear power generation.

The IEA report published a few weeks ago seems to ignore this fact completely. In the report, the International Energy Agency opines that ‘though Spain’s progress on ramping up renewables in its electricity mix is commendable’ and Spain ‘appears well on track’, ‘the future trajectory of its power mix warrants careful consideration to ensure a smooth transition.’ The IEA says that the plan to decommission four of Spain's seven nuclear reactor units (of a total capacity of 7.4 GW) by 2030 and the remaining three by 2035 poses problems. The report finds that 'the rapid closure of (...) nuclear facilities' could increase the Spain's demand for natural gas, and, therefore, it must be re-considered whether 'there is such a need to rush to shut down coal and nuclear generation - especially given the cost implications for consumers'. The IEA *believes* that 'nuclear technology is considered to have great potential to contribute to decarbonisation of not only the electricity system but (through hydrogen production) also hard-to-abate sectors, such as manufacturing and transport.' From the report, World Nuclear News readily concludes that 'Nuclear could help Spain reach net-zero goal'.

The report fails to mention the fact that an extension of operating lifetime is not a realistic option, given that the seven Spanish plants still in operation are quite old (the average age of all Spanish nuclear facilities is 35.9 years only because in 2017 the then 47-year-old Santa Maria de Garona Nuclear Power Plant was taken off the grid and permanently shut down although in 2014 it was given the licence to continue operating until 2031). The report also ignores that (1) should there be intention, the construction and commissioning of new reactor units would only be likely to take place before 2032-2035; (2) the costs of building the new nuclear plant(s) would be passed, in some form, on to the consumers; and (3) Spain, in an attempt to address the most pressing problems of renewable energy production, is already in a race with Portugal to build infrastructure suitable for green hydrogen production and storage. These facts are dominant aspects of the overall picture.

Nuclear power plant projects in the phase of 'under construction' can be categorised on the basis of various criteria (such as those in delay vs. those that appear to be on schedule, or having been under construction for at least 10 years vs. for less than 10 years). However, the author of this paper decided to present the construction projects in each country based on two broad categories as follows:

I.) **Countries I**: Belarus, Finland, France, Slovakia, Ukraine, Russia, Turkey and the United Kingdom, that is, Europe in the broad sense.

II.) **Countries II:** All other construction sites in the world outside Europe as defined in the previous point (Argentina, Bangladesh, Brazil, China, India, Japan, South Korea, United Arab Emirates, USA).

Nuclear power plants 'under construction' -- Countries I.

1) Belarus

BELARUS 2 - 27 April 2014, 1110 MW

In Belarus, which, along with Ukraine, was the country most severely affected by the Chernobyl nuclear disaster, nuclear power plant construction had been a taboo subject for long. Then in the early 2010s, the planning of the Astravets Nuclear Power Plant was launched. The concept was to construct two Russian reactor units, each of a capacity of 1200 MW, in a location less than 50 km from the Lithuanian capital, near Poland, Latvia and Estonia. Although the European Union had opposed the investment for years, mainly due to safety concerns and risks associated with the construction, the first unit was switched on in November 2020 after some delays. The construction costs possibly exceeded €10 billion. Although some serious problems arose with the reactor units and some of the system components around it, the faults have been corrected so far. In March 2021, Unit 1 was connected to the grid.

The significance of the above information lies in the fact that the second Belarusian nuclear unit is also being constructed near Astravets. Officially, Astravets 2 has been under construction since 27 April 2014, and, similarly to the other unit, it relies on Russian technology and funding. The unit, to be based on a VVER-1200 reactor, will have a net power peak identical to that of Unit 1 (1194 MW).

The most recent announcement of the constructors of Astravets 2 was made in April. They informed the public that the nuclear fuel had arrived at the site and that Belarusian Energy Minister Viktor Karankevich claimed that Unit 2 was 80% complete. As per schedule, the test run and fine-tuning may take place later in 2021, and Unit 2 can be operational and connected to the grid by 2022. A change in schedule may be expected if the resolution adopted by the European Parliament in February 2021, stating that it is necessary 'to delay launching the plant until all EU stress test recommendations are fully implemented and all the necessary safety improvements are in place' reaches its goal.

2) United Kingdom

HINKLEY POINT C 1 - 11 December 2018, 1630 MW
HINKLEY POINT C 2 – 12 December 2019, 1630 MW

The Hinkley Point C Nuclear Power Plant Project (Somerset, south-west England) entails the construction of two 1600-MW EPR reactor units. Years ago, The Guardian labelled it the most expensive power plant in the world, despite the fact that nuclear technology has been in use to generate electricity in the windy and barren location since 1965. The third Hinkley plant (which obtained planning permission in 1990 yet its construction did not start until 11 December 2018, or December 2019 for Unit 2) has a long history dating back to Margaret Thatcher's premiership. The Iron Lady saw the construction of ten new British nuclear power plants as a way out of the problems posed by coal-fired power plants and coal mining. However, of the ten plants only Hinkley Point C finally got to the construction phase even though in 2006 Tony Blair regarded it as a means to end dependence on natural gas.

There are many strange stories surrounding the third Hinkley Nuclear Power Plant, such as the story how the French EdF got a central role to play or how Chinese investors were ultimately denied access to the stalled project due to national security risks. The Anglo-Saxon press investigated the case in minute detail throughout the years. The story of Hinkley Point C, with all the events and their interconnections up to September 2020 was also published by the Hungarian media.

As for the construction of the first reactor unit (originally planned to be completed by 2025), it must be noted that the planned costs of the investment, £16 billion in 2016, were estimated in December 2017 to reach £20.3 billion, which is the upper limit of the previously estimated construction cost calculated for the planned operational lifetime of 60 years. Currently, EdF is envisaging the start-up of the first reactor unit for 2027 and the estimated construction costs is £22.5 billion. The price will be paid by consumers as the government and the constructor/operator concluded a fixed-price power purchase agreement binding for the first 35 years of operation. Official government communication still maintains that £92.5/MWh, the price specified in the agreement with EdF, is a result of a competitive bidding process, but this does not invalidate the fact that, due to the emergence of green power generation, electricity price currently is much lower, between £55 and £70/MWh. As evidenced by a parliamentary committee report, this means that the government ignored the interests of consumers.

At the end of May, the BBC gave another account of the problems surrounding the construction: (1) the Covid19 outbreak, although did not halt the work, slowed it down; (2) the costs are approaching the £23 billion mark; (3) labour shortage puts further pressure on the start-up deadline, currently delayed until June 2026; and, on top of all this, (4) the latest price of energy generated from offshore wind is £40/MWh in the power market.

3) Finland

OLKILUOTO 3 – 12 August 2005, 1600 MW

Beside France's Flamanville 3 project, Finland's Olkiluoto 3 is one of the nuclear power plant construction projects that present the most problems, delays and cost overruns. The 1600-MW reactor, under construction since August 2005, was originally due to start commercial operation in May 2009. In 2021, 12 years later, there is only a promise that in October 2021 it will be connected to the grid and will start regular power generation in February 2022.
Faulty parts have been found, safety test have been delayed, and there have been disputes ending in lawsuits and, obviously, major cost overruns. Currently, the costs are over $8.5 billion, triple of the original cost estimates. When plant owner Teollisuuden Voima (TVO) announced one of the last delays in 2020 (when power generation was still expected to start in March 2021 instead of September 2020), it attributed the problems to the slowness of system testing and the shortcomings of spare parts supply. If completed, the power plant would be capable of producing up to 13 TWh of power a year, which would meet about 14% of Finland's electricity demand.
Finland's other 'construction project', the Hanhikivi 1 Nuclear Power Plant, planned to be constructed in Pyhäjoki, a remote area in the north-west, has not yet entered the 'under construction' phase. The power plant, to be constructed in a framework of Russian-Finnish cooperation, would be built around a 1200-MW reactor unit, similar to the one designed to be installed in Hungary's Paks II. For the time being, however, Hanhikivi 1 is stuck in phase zero, due to problems which emerged - again - in the construction license procedure. In late April, constructor company Fennovoima announced that the construction project would be delayed by another year because it was taking longer than expected to bring the design and licensing documents 'to the required level'.

4) France

FLAMANVILLE 3 – 3 December 2007, 1630 MW

In France, there are 56 active nuclear reactors and 14 decommissioned ones, and only one unit under construction. Most probably, not only the French, but the entire nuclear industry would be happy to forget Normandy's Flamanville 3, which has been under construction since December 2007. The planned development of a single reactor unit (designed to produce 1650 MW), which has exhibited almost all conceivable technological, financial, safety and quality problems from the history of nuclear power plant construction, had an original budget of €3,3 billion and was intended to showcase the model of the generation change in France's nuclear power plants in 2013.
However, the project, often referred to in the Hungarian press as a 'basket case' had not been completed by 2019 either, when the expenses reached €10.9 billion. A year later, after further delays, the costs reached the €12.4 billion mark, while promises were made to switch the nuclear power plant on in 2022. With regard to the construction project, which from 2017 onwards (after 75.5% of Areva, the bankrupt original constructor was acquired by state energy giant EdF) has been kept afloat as a public investment, Edf announced in February that commercial operation would start by mid-2023. But in March yet another design fault was identified, when three nozzles of the EPR reactor unit were found to have a design anomaly. The problem had been known since 2013, and redesign and correction had been performed at the time, which, however, failed to bring the expected result. This was one of the reasons why the government made an official announcement at the end of March about postponing the launch of Flamanville 3 until 2024. Obviously, this will postpone the concept development of the construction of the six new reactor units requested by the government in 2020, given that concept development process was requested to start after the commissioning of Flamanville 3.

5) Russia

BALTIC 1 – 22 February 2012, 1109 MW
KURSK 2-1 - 29 April 2018, 1175 MW
KURSK 2-2 – 15 April 2019, 1175 MW

Baltic 1, also known as the Kaliningrad Nuclear Power Plant, has been 'under construction' since 22 February 2012. The original designs included two VVER-1200 reactor units to be connected to the grid in 2016 and in 2018. Baltic 1 was launched as a counter-project in response to Lithuania's plans to construct a nuclear power plant in Visaginas (which, despite a lengthy

preparation phase, was dropped in 2016 due to a 2012 referendum that objected the project and due to the fact that Hitachi, the chosen contractor proved to be unsuccessful and the construction process was suspended.) The Baltic Nuclear Power Plant, planned to be built near the town of Neman (in the north-east part of the Russian exclave of Kaliningrad, between Lithuania and Poland) would serve geopolitical purposes. While it would ensure power supply to the Kaliningrad region with one unit that would effectively replace local gas-based electricity generation, it would also export significant volumes to the greater region (above all, to Lithuania, Latvia and Sweden). This plan was thwarted when in 2013 the three Baltic member states of the EU decided to leave the electricity system dominated by Russia and to connect to the EU's electricity grid. The construction of the Baltic Nuclear Power Plant was suspended, and, although equipment production continued as per the existing contracts (since then the equipment has been stored in warehouses), the construction itself was effectively halted.
The Baltic 1 Power Plant would be an excessively large and unregulated power generating unit for Kaliningrad, a town of a population of half a million people. Therefore, should the Russians build the nuclear power plant, from the technical and economical perspective the logical step for Kaliningrad would be to synchronise with the EU grid so that it could sell surplus electricity. However, from the political perspective, it is far from being that simple. And albeit Russian state-owned company RosEnergoAtom has not given up the Baltic Power Plant, in spring 2019 Russia opted for the installation of new gas-fired power plants. It was at that time that Russian state-owned energy company InterRAO announced the launch of the Pregolsky gas-powered station (455 MW), which, combined with two smaller units installed earlier (Mayakovskaya and Talakhovskaya, each of a capacity of 156 MW), will be able to cover Kaliningrad's power supply needs.

The nuclear power plant, built 40 kilometres south-west of the city of Kursk, in the vicinity of Russia's western border, currently has four operating units. The units have been in operation since the late 1970s to mid-1980s. All four operate the same type of RBMK-1000 reactor unit, similar to the one at Chernobyl, albeit of a different model. Originally, two more similar 1000-MW units were planned to be installed, but the Kursk 5 investment was halted in 1989 and eventually cancelled in 2012. Russia gave up on the concept of the construction of Kursk 6 in 1993. Currently, the first two reactor units are approaching the end of their life cycle. They were planned to be replaced by Kursk II-1 and II-2 reactor units, which are of a different type and a larger capacity (1255 MW).

On the site of Kursk II 1, concrete was first poured in April 2018. The construction process on Kursk II 2 was launched a year later. Kursk II will be the first Russian nuclear power plant where, throughout the construction process, cost management and construction scheduling are supported with digital automated systems, reported World Nuclear News in early 2020, adding that, besides the technical improvement of the VVER-1200 reactor units (VVER-TOI), the plant will be equipped with improved safety systems, modern control systems and diagnostics. According to the official figures provided by Rosatom, the estimated investment costs are $3.5 billion and the units are expected to be completed by September 2023 and August 2024, respectively. Based on the information currently available, the end date seems to be feasible, although the deadline for the construction of Kursk II was in fact set as the date of decommissioning of the currently operational Kursk 1 and 2, which the new plant will replace on the grid. After 15-year extensions of operational lifetime, the old units (which have been in operation since 1977 and 1979) are planned to be decommissioned in 2021 and 2024. As for the 2021 decommissioning, further delays are likely. Albeit with regard to the construction of Kursk II 1 Rosatom published a very optimistic account of a completed pressure test at the end of December 2020, the power plant unit is still not completed.

The fact that AEM Technologies, manufacturer and supplier of the 340-tonne tank, tested the tanks at pressure levels of 24.5 MPa (1.4 times higher than actual operating pressure) was not revealed until April, in an article which, like other news reports on the construction of the Kursk Power Plant, failed to specify any planned completion date. What is certain is that Kursk II-1 will not be switched on in 2021.

6) Slovakia

MOCHOVCE 3 – 27 January 1987, 440 MW
MOCHOVCE 4 – 27 January 1987, 440 MW

In May 2021, Slovakia's Nuclear Regulatory Authority (UJD) authorised the commissioning of Unit 3 of the Mochovce Nuclear Power Plant, and assured everyone that the authorisation was based on comprehensive tests, analysis and verification that were performed at levels higher than those specified by relevant established standards. The Mochovce pressurised water reactor units (Number 3 and 4, each of a capacity of 471 MW) operate with the VVER-440/V213 Soviet technology and are, so to say, historical relics: officially, they have been under construction since 27 January 1987. Had they been completed on time, their decommissioning would be approaching now. The construction work, halted after the change of regime in Central Europe, was re-launched in 2008 by the Italian company Enel, the majority shareholder in Slovenské Elektrárne (SE). Enel expected to finish Unit 3 in 2012 and Unit 4 in 2013 at a total expense of €1.8 billion before the set date of connection to the grid, but it was not be able to meet the deadlines, which, by then, had been modified several times. In fact, Enel left Slovakia in 2016 mainly due to the fact that the expenses of the Mochovce project were getting out of hand. In 2008, Enel had a projected budget of €2.8 billion, which increased to €3.8 billion in 2013 and to €4.63 billion in 2014. After the withdrawal of Enel, SE (now in Slovak ownership) was very optimistic: it expected that Unit 3 and Unit 4 (at a completion rate of 95% and 83%, respectively) would be switched on by 2020. Yet the expectations did not materialise due to the numerous faults identified during inspections, typically by the competent authorities. For example, in 2019, on a hearing before the Slovak parliament's economic committee, SE CEO Branislav Strycek stated that the commissioning of Unit 3, originally scheduled for July 2019, would be postponed. Obviously, this was not a result of the fact that Austrian newspaper Kronen Zeitung had just published an interview, recorded in Bratislava, with an anonymous former engineer from Mochovce about the very serious safety shortcomings he or she had experienced during the construction of the plant. SE dismissed the interview as a hoax, and UJD called it whipping up hysteria. Yet Strycek announced an eight-month delay (coupled with a €270-million project cost increase) attributed only to the fact that the investigation and troubleshooting a false alarm detected during the fire alarm tests took one and a half month. Afterwards, still in September 2019, Slovakia's Nuclear Regulatory Authority identified faults, which lead to the decision to postpone the start of the reactor unit again. At the time, the cost was €5.7 billion. In mid-May, Reuters had the information that in March SE had reported Unit 3 and Unit 4 as of a completion rate of 99.95% and 88%, respectively. Once Unit 4 is operational (which currently is expected to happen in 2023) the two units will make Slovakia self-sufficient for power. According to the latest information published in May, the Slovak state spends €6.8 billion to complete the Mochovce Nuclear Power Plant.

7) Turkey

AKKUYU 1 – 3 April 2018, 1114 MW
AKKUYU 2 – 8 April 2020, 1114 MW

AKKUYU 3 – 10 March 2021, 1114 MW

Turkey does not have an operating nuclear power plant. Yet if the agreement between Russia and Turkey on the construction of three reactor units is implemented between 2023 and 2026, Ankara will become a major player in the field of nuclear power plants in the region. The construction of Akkuyu 1, 2 and 3 (of a total capacity of 3600 MW) was officially launched in April 2018, early April 2020 and 10 March 2021, respectively.

Less than three months elapsed between the first pouring of concrete at Akkuyu 3 and the installation of the pressure vessel of Unit 1, which evidences that Rosatom prioritizes the export of VVER-1200 reactor units to Turkey. It was even noted that, to facilitate faster success, the installation was carried out ‘Open Top’, that is, through the uncovered top of the reactor building, which allows construction and assembly operations to be performed simultaneously.

Currently, Akkuyu is the site for the largest-scale nuclear construction, and there is also an ideological reason for meeting the deadline: Unit 1 must be completed by the centenary of the Republic of Turkey, 29 October 2023. This is a remarkable turnaround after the Turkish companies (Cengiz, Kalyon and Kolin) had simply withdrawn from the project when the construction was about to start, claiming that although, after years of preparation, in 2017 they had signed a contract with Rosatom, under which they would have owned 49% of the project, they had failed to agree on the details.

In mid-March, when concrete was first poured at Akkuyu 3, at a video conference between Russian President Vladimir Putin and his Turkish colleague Recep Erdoğan, Vladimir Putin gave an enthusiastic address, stressing that the plant is ‘truly a flagship project’. The entire amount of $20 billion invested in the plant, designed to operate for 60 years, is paid by Rosatom, which will realise returns from the operation of the plant, via a power purchase agreement valid for 15-30 years. Rosatom promoted the launch of the construction of Unit 3 with a Twitter post, which also stated that the Turkish regulator is expected to issue the licence for Unit 4 in 2021. If Unit 4 is also built, by the end of the 2020s Turkey will have nuclear capacity of 4800 MW concentrated in a single site, which, however, may have unexpected consequences, or at least this is what Henry D Sokolski, Executive Director of the Nonproliferation Policy Education Center thinks. Sokolski opines that the funding model of the Akkuyu Nuclear Power Plant may not only further increase Turkey’s dependence on Russia (which is already one of Turkey’s main energy suppliers, c.f. Turkish Stream), but also poses new threats.

Any news which reports that Akkuyu, once completed, could provide an annual 35 billion kWh of electricity, meeting one tenth of Turkey's total electricity demand, exposes Turkey to potential attacks. In March, an Al Jazeera article highlighted the fact that the construction and concentration of a nuclear power plant is also a security issue in the Middle East (where Saudi Arabia and Jordan have been considering for years the possibility of building their own nuclear potential, while Egypt and the United Arab Emirates have actually started it, Israel has a nuclear bomb and Iran is on the same trajectory). Moreover, a nuclear power plant can not only become a target for attack, but also opens up for its user/owner/operator the possibility of producing nuclear weapons. And it must be added that the Turkish government - which usually does not avoid conflicts, even armed conflicts - has serious enemies. In addition, Turkey has long-standing military cooperation agreements with Pakistan (which does not shy away from nuclear proliferation), and earlier this year Turkey signed military cooperation agreements with Kazakhstan (which holds more than 35% of the world's uranium reserves).

8) Ukraine

KHMELNYTSKY 3 – 1 March 1986, 1035 MW
KHMELNYTSKY 4 – 1 February 1987, 1035 MW

The construction of the Khmelnitsky Nuclear Power Plant came to an abrupt end with the Chernobyl disaster. In the area designated for the construction in the late 1970s near the town of Netishyn, only two of the planned four reactor units (each of a capacity of 1000 MW) were fully completed. Khmelnitsky 1 was commissioned as early as in 1987, 'on the fly'. But due to lack of funds Unit 2 was not connected to the grid until 2004, after the collapse of the Soviet Union as Ukraine was reorganising itself. The situation of Units 3 and 4 is even less favourable. Their construction officially started in 1985 and 1986, respectively, but the project is still stuck in its status of 1990.

More than 11 years ago, when Ukraine and Russia signed an agreement on the technical design of Units 3 and 4, Rosatom calculated that the plant would be completed in 5-6 years at a cost of €4-5 billion: Russia would install two 1000-MW VVER-1000 reactor units at its own expense, the amount then being paid back by Ukraine in goods. However, work has not been resumed ever since either on Khmelnitsky 3 or Khmelnitsky 4, which have been under construction since September 1985 and June 1986 respectively, and, therefore, are dubbed as 'zombie' power plants. When, not unrelated to the 2014 war in Ukraine, Rosatom rejected criticism concerning its alleged failure to respect its contractual obligations, in 2015 Ukraine finally terminated the agreement. A year later, attempts were made to involve South Korean nuclear power company KHNP in the project. To facilitate the completion of the Khmelnitsky plant, Ukraine's state-owned nuclear power plant operator Energoatom also considered the possibility of developing relationships with China in the field of the construction of nuclear power plants developed on the basis of Russian technology. All these failed to bring tangible results. Another unsuccessful move was when Ukraine, 'looking for an international partner', would have been willing to conclude an agreement with US company Westinghouse. Not only did Ukraine face the problem of lack of funds, the condition of the reactor block units (whose construction was suspended in 1990, at a completion rate of 75% and 28%) had also been deteriorating. Had the two new Khmelnitsky reactor unit had been completed as originally planned, then today's news would report either decommissioning or a lifetime extension instead of a 'ghost construction project' (similar to Slovakia's project to expand the Mochovce Plant). Instead, in 2019 Hungarian site Átlászó published a long article on the willingness to continue the construction, revealing the fact that according to impact assessments the building's degree of completion was maximum 30-40% (or, more likely, 5-10%). In addition, a study by the Environment Agency Austria concluded that the ageing of the unfinished structures renders a restart practically impossible, while it remains unclear how a reactor type that is different from the one in the original design could even be installed in a structure that, at some point, had been almost completed.

Still, in November 2020, it was officially announced that construction will continue on Units 3 and 4 of the Khmelnitsky plant. Yet no further details have been published on this new momentum, although Piotr Kotin, head of Energoatom, stated that since the condition of the reinforced concrete structures of the unfinished power plant units 'fully complies' with the relevant design requirements, the environmental impact assessment report on the construction of Units 3 and 4 is expected to be quickly approved by the competent ministry. Nevertheless, the would-be constructor and contractor, or, for that matter, the specific reactor technology, the budget or the construction schedule, have been specified as of yet.