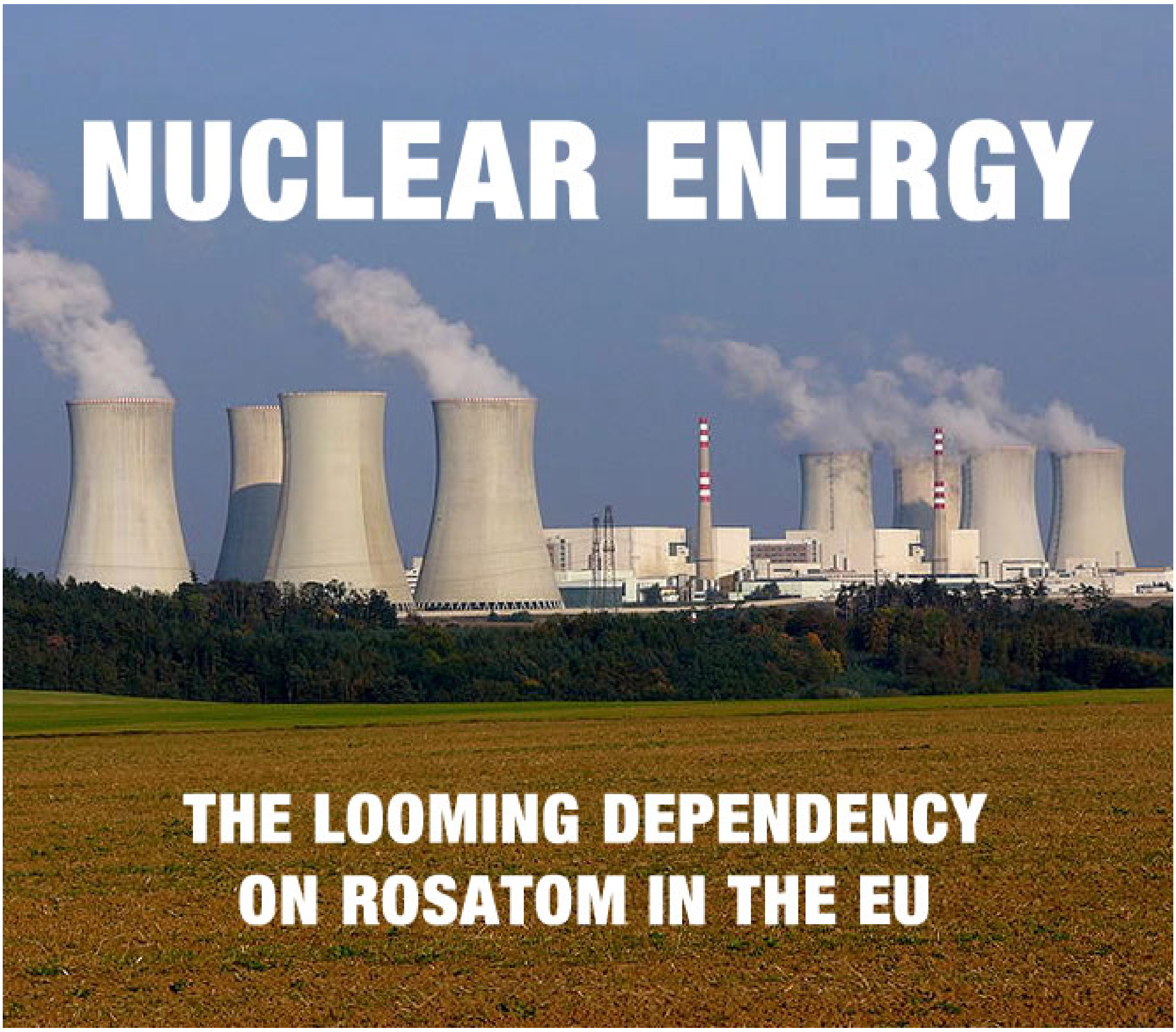

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in commission for The Greens/EFA in The European Parliament

The Greens | EFA
in the European Parliament

NUCLEAR ENERGY – the looming dependency on Rosatom in the EU

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Contents

Abbreviations

Bln	Billion (10^9)
CZK	Czech Crown
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPR	European Pressurised Water Reactor (EdF / Framatom, former Areva)
GDR	German Democratic Republic – the former Eastern Germany
GWe	GigaWatt electrical output capacity (10^9 Watt)
LTO	Long Term Operation or nuclear plant life-time extension
NPP	nuclear power plant
MWe	MegaWatt electrical output capacity (10^6 Watt)
MWh	MegaWatt hour – one million Watt hour electricity output
ONR	Office for Nuclear Regulation – the UK nuclear regulator
PINC	Nuclear Illustrative Programme – irregular report under the Euratom Treaty art. 40 on the state of nuclear power in the EU from the European Commission
PRA	Probabilistic Risk Assessment; also sometimes called PSA – Probabilistic Safety Assessment
SÚJB	*Státní úřad pro jadernou bezpečnost* – the Czech state office for nuclear safety
ÚJD	*Úrad jadrového dozoru Slovenskej republiky* – the Slovak office for nuclear supervision

1. Introduction

Nuclear power has been an important factor in energy policy in Central Europe ever since the Soviet Union decided to give it a central role, based on military need and genuine pride in the prowess of socialist engineering skills. The Soviet Union motivated nuclear developments in all socialist states, and the Soviet enthusiasm inspired home grown nuclear capacity development in countries like the Bulgaria, Czechoslovakia, the German Democratic Republic (GDR) and Hungary, and former Soviet states like Ukraine, Belarus, Lithuania and Latvia. And even in countries that were tagging a somewhat dissident line like Romania and Yugoslavia. Since that time, nuclear engineering has an almost religious status in many countries from the former Warsaw Pact, and strong relations between the nuclear sectors of these countries remain to today.

This legacy was introduced into the EU with the accession of nine former Warsaw Pact countries on the 1st of May 2004 and Romania and Bulgaria following in 2007.

Where nuclear power is on the decline in most of the world, Central Europe's enthusiasm for the technology appears untouched.[1] Bulgaria, the Czech Republic, Hungary, Slovakia and Ukraine are preparing to prolong the lifetime of their old Soviet reactors, and to enable that, they are closely cooperating with Rosatom – the Russian nuclear giant that includes all important former Soviet nuclear institutions and companies, both military and civilian – and its enormous network. Belarus and Hungary are currently constructing, respectively preparing construction of new nuclear capacity, in set-ups completely controlled by Rosatom. Bulgaria, the Czech Republic and Slovakia are positioning their remaining hopes for new nuclear also for a large part on close cooperation with Russia. Even Ukraine, with all its tensions with Russia, appears to be bound hand and feet to cooperation with Rosatom and its network in order not only to upkeep and potentially expand its own nuclear fleet, but also continue to provide Rosatom with fuel and services. And Finland, the country that in its long history always needed to balance closeness and distance with Russia, appears to be well stuck in a nuclear bear-hug with its Loviisa nuclear plant, its plans

1 See for instance: Foratom, *What People Really Think about Nuclear Energy*, atw Vol. 62 (2017) | Issue 3 ı March; https://www.kernenergie.de/kernenergie-wAssets/docs/fachzeitschrift-atw/2017/atw2017_03_157_What_People_Really_Think.pdf

for the Hanhikivi new build reactor and in having to tolerate the expansion of the Leningradskaya nuclear plant near Sosnovy Bor on its borders.

Rosatom tries to expand its presence on the European electricity market. It has been argued extensively in the last years that this is driven not by a sense to service a traditional market, but rather by a political agenda in which nuclear power partially replaces the receding political influence of gas. This hypothesis only makes sense when we can also see an increase in dependency on Rosatom as a result of its nuclear cooperation with EU and surrounding countries.

This report tries to give a sketch of the contours of that debate. It concludes that the dependency on Rosatom indeed is growing and that in some cases Rosatom is instrumental to political goals beyond the company's realm. We argue that this increased dependency should be a factor in the discussion whether the EU and EU Member States should continue their reliance on nuclear power and hence on Rosatom, or rather move away from it towards greater self-reliance through energy efficiency and the introduction of renewable energy sources.

2. Nuclear power in the EU – state of play

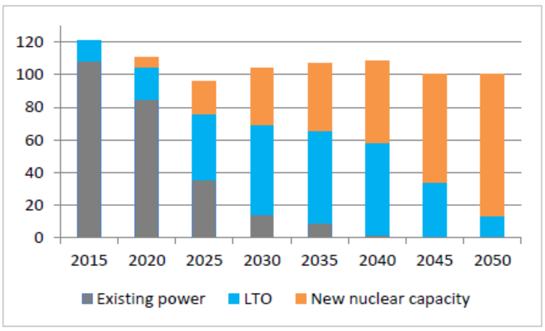
The 169 operating nuclear power reactors in Europe are only one of the faces of nuclear energy. Although the nuclear industry is clearly in retreat, there is still ongoing construction of a few new nuclear power stations, and against all trends, some countries are planning more – not only in the EU, but also around its borders; projects that also pose sincere risks for the EU.

Russia is implementing plans to nuclearise the Arctic region: a fleet of floating nuclear power stations and nuclear icebreakers in order to enable further exploitation of gas, oil, coal in that pristine area, where exactly the burning of fossil fuels has caused dangerous global warming and the retreat of the sea ice and permafrost.

Next to that, there are legacies from the past – closed power stations in different states of decommissioning, and the overall legacy of nuclear power in the form of radioactive waste.

In all this, the role of the Russian nuclear giant Rosatom is growing.

Figure 2.1 – European Commission estimate of nuclear power capacity – PINC 2017



In the European Union, nuclear power is in retreat. The European Commission estimated in its 2017 PINC report that in order to upkeep 100 GWe of power in the electricity mix in 2050 (current capacity is around 120 GWe), as can be seen in Figure 2.1, around 90 GWe of new capacity would need to be build, and 10 GWe of capacity would have to be operating because of life-time extensions.[2] In reality, life-time extension, or Long Term Operation (LTO), as the Commission refers it to, appears to be fraught with complications, and it is more likely that most nuclear reactors will cease to operate around their 40st anniversary, some of them 10 years later. The new construction numbers in PINC are heavily overestimated, and in the current trends only the prediction for 2020 might be achieved, but after that no new reactors are to be expected (see also paragraph 2.2).

2 European Commission, Nuclear Illustrative Programme presented under Article 40 of the Euratom Treaty - Final (after opinion of EESC) {SWD(2017) 158 final} - COM(2017) 237 final; https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0237&from=EN

The data used in this chapter come from the World Nuclear Industry Status Report 2018[3] and the IAEA PRIS (Power Reactor Information Service).[4]

2.1 Operating nuclear power plants

Currently there are 169 operating nuclear power reactors in the Europe. An overview is given in Table 2.1. Annex 2 has a full list.

Table 2.1. Nuclear reactors in Europe

	reactors	total capacity (GWe)	average age (yrs)
Europe	169	163.33	32
EU	126	118.42	33
EU without the UK	111	109.50	33

In the EU, Bulgaria, the Czech Republic, Finland, Hungary and Slovakia have operating reactors from Soviet design that are for part of their maintenance depending on support from the Russian nuclear giant Rosatom and/or for their fuel from Rosatom's fuel company TVEL (Table 2.2). On the borders of the EU, Russia, Ukraine and Armenia are operating Soviet design reactors.

3 Schneider, Mycle and Antony Froggatt (eds), *World Nuclear Industry Status Report 2018*, Paris (2018) Mycle Schneider Consulting; https://www.worldnuclearreport.org/-2018-.html

4 https://pris.iaea.org/pris/

Table 2.2. Operating Soviet design nuclear reactors in the EU and neighbouring countries					
	reactors	reactor type	total capacity (MW)	design lifetime (yrs)	average age (yrs)
Bulgaria	Kozloduy 5,6	VVER1000/320	1926	40	29
Czech Republic	Dukovany 1,2,3,4	VVER440/213	1878	30	32
	Temelín 1,2	VVER1000/320	2052	40	16
Finland	Loviisa 1,2	VVER440/213	1009	40	40
Hungary	Paks 1,2,3,4	VVER440/213	1902	30	33
Slovakia	Bohunice 3,4	VVER440/213	942	30	34
	Mochovce 1,2	VVER440/213	872	30	19
Armenia	Metsamor	VVER440/270	376	30	39
Russia	34 reactors in Europe	RBMK (11) VVER440 (5) VVER1000 (12) VVER1200 (2) FBR (2)	28194		30
Ukraine	15 reactors	VVER440/213 (2) VVER1000/320 (13)	13107		29

The largest risk is posed by the Chernobyl type RBMK reactors, which still operate in Kursk, Smolensk and Leningradskaya near St. Petersburg. Together with the older design VVER440 reactors, as still can be found at the Russia Kola NPP (2 reactors), Novovorenezh (1) and the Armenian Metsamor NPP (1), these reactors were deemed by the G7 summit in 1992 in Munich not upgradable to an acceptable risk level.

Metsamor is on top of that situated in a high risk seismic area, where a heavy earthquake in 1988 killed 25,000 people and closed the Metsamor 1 reactor for good. The Metsamor 2 reactor continues operating because Armenia failed to develop alternative generation capacity and relied in 2017 for 37% of its electricity on the ageing reactor. After upgrades in 1997 and 2017, it received a life-time extension with 10 more years and is supposed to be closed in 2027. As a further safety measure, the plant management brought Katholikos Garegin I to bless a new chapel in the plant's main administrative building in 1997.[5]

With an average age of 37 years, well beyond their design life-time of 30 years, these old design reactors continue to form a severe risk factor.

The slightly less old generation VVER440/312 reactors that still operate in Russia (2), Ukraine (2), Hungary (4), Slovakia (4) and the Czech Republic (4) are seen as higher risk because they lack a secondary containment that would protect them from impacts from outside, for instance by a malevolent attack with an aircraft or during acts of war. Finland, for that reason, demanded such a secondary containment for its VVER440/312 reactors at Loviisa.

Accepted risk levels in the licenses of these reactors are on a 1980s, early 1990s level, and also the post-Fukushima stress tests have led to only limited upgrades. These older reactors had a design lifetime of 30 years and most of them are reaching that age or already past it after upgrades were carried out to somewhat manage the increased risk.

Such upgrading programmes have been carried out in Armenia, Ukraine, the Czech Republic, Hungary and are currently, with co-financing from the European Investment Bank (EIB) under way in Slovakia. There are wide concerns whether this lowered the risk of these ageing reactors sufficiently for the 10 or 20 extra operation years that these reactors have received. Upgrading costs amounted to several hundred million Euro per reactor.

The average age of the VVER440 fleet is currently 35 years with 20 out of 22 reactors beyond their 30 years design life-time.

5 http://www.armeniapedia.org/wiki/Metsamor_Armenian_Nuclear_Power_Plant

The VVER1000/320 reactors were the workhorse of the Soviet reactor programme. They have a secondary containment and were build throughout the Warsaw pact countries. There are, however, reports of concerns about construction quality, varying from replacement of stolen concrete with lower quality, quality problems in welding[6], seismic robustness and others. These reactors have a design life-time of 40 years, and the first ones (in Ukraine and Bulgaria) are facing in the coming year decisions concerning necessary upgrades in case of life-time extension.

This is the most standardised reactor of the Soviet fleet, but still, for instance, the two Temelín reactors in the Czech Republic, among the last ones to the be build, needed severe adaptations and construction costs raised from an initial budget of 29 Bln CZK in 1990 to 110 Bln CZK when they were delivered in 2000 and 2002. Germany decided that the safety level of VVER1000 reactors was insufficient to be upgradeable and it scrapped the four unit Stendal nuclear power station during reunification.

The European VVER1000 fleet of 30 reactors has an average age of 24 years, with 14 reactors older than 30 years.

Rosatom developed on the basis of the VVER1000 in the 1980s and 1990s in several steps a third generation nuclear reactor, the VVER1200, which is currently marketed in two forms, one designed by its Moscow / Nizhny Novgorod based department (the VVER1200/392M) and one by its St.Petersburg based department (the VVER1200/491). The first unit started up in 2016 in Novorenezh, a unit of the latter in 2018 at the Leningradskaya NPP at Sosnovy Bor near St.Petersburg. The VVER1200 is also known as AES-2006, MIR or TOI.

Russia further operates at the moment two fast breeder reactors at Beloyarsk. These reactors function as test reactors for a next generation that should be able to breed plutonium from spent nuclear fuel for further use as reactor fuel. However, the fuel

6 See for instance:
Haverkamp, Jan and Jiri Tutter, *Unsettling facts on Temelín – Factsheet, version 3.2*, Prague (2011) Greenpeace Czech Republic – available from jan.haverkamp@greenpeace.org

Majer, Dieter, *Potential weak spots in the primary circuit in Block 1 of the Temelin nuclear plant in the Czech Republic – Short advisory statement on behalf of the Alliance 90/The Greens parliamentary group in the Bundestag*, Wiesbaden (2013); https://kotting-uhl.de/site/wp-content/uploads/2013/09/Majer_-_statement_NPP_Temelin_1_-_2013_Aug_english.pdf currently used is specially prepared. The oldest 560 MW reactor is already 38 years old, whereas the 820 MW output version only started up 3 years ago.

2.2 New build projects in Europe

There are currently four reactors under construction in the EU (Mochovce 3,4 in Slovakia, Olkiluoto 3 in Finland, Flamanville 3 in France) and five under preparation (Hinkley Point C (2) in the UK, Hanhikivi in Finland and Paks II (2) in Hungary).

The European Commission PINC estimates 90 GWe of new capacity to be on-line in 2050. That would make it necessary to start up 3 new reactors in the European Union every single year. The last reactor to have been brought on line in the EU was Cernavoda 2 in Romania in 2007. 2019 is supposed to see the extremely delayed Mochovce 3 in Slovakia and Oikiluoto 3 in Finland to be brought to grid. 2020 Mochovce 4 and France's Flamanville 3. Then there is no new reactor foreseen until at least 2027 (Paks II and Hanhikivi), and noting else before 2030. The European Commission's view therefore means that after 2030 more than 4 reactors per year need to be started up. This is given the current cost developments completely unrealistic, and it is more likely that if Mochovce 3,4, Olkiluoto 3 and Flamanville 3 will manage to be brought on line, these will be the last new build nuclear projects in the EU.

Olkiluoto 3 in **Finland** is the first French Areva EPR design reactor to go into construction. First-of-a-kind problems, but also management problems, complexity of sub-contracting, material problems and labour market problems as well as structural underestimation of the technical complexity of generation III+ nuclear reactor designs has led to at least 7 years construction delay and the budget of the project went from an initially estimated 2.5 Bln€ to a current estimate of 9.6 Bln€.

France's Flamanville 3 was to be EdF's managed attempt to show that the EPR was ready for further export, but it suffered similar problems as Olkiluoto 3, as well as additional problems with technology and material quality, and if it will receive an operation license (which is currently not a given), this will not come before 2020, meaning also 7 years delay and the construction cost of over 10 Bln€ will be more than three times the original estimate.

Mochovce 3,4 in **Slovakia** is constructed under the lead of Slovak utility Slovenské elektrarne (SE), which is currently owned for 34% by the Slovak state, 36% by Czech/Slovak EPH and 30% by Italian ENEL. It consists of two 1970s designed VVER440/213 reactors which are widely criticised for among others their lack of secondary containment. The construction of these two reactors started already 1985 but was halted in 1991 due to lack of funds and need, and on the basis of environmental concerns.

Construction was restarted in 2008 as part of the privatisation deal of SE to ENEL (66%, 34% remained with the Slovak state). Construction of these outdated designs is severely delayed. The original start-up year was set on 2013, it is now expected that one reactor will be connected to the grid in the end of 2019 and one in 2020. Construction costs for the total 942 MWe capacity rose from 2.8 Bln€ to a current estimate of 5.4 Bln€[7], but these costs could still increase.[8] ENEL remains the main responsible for the finalisation of construction, although the company already indicated in 2016 that it wanted to step out.
In the agreement to divest from SE, ENEL will receive 750 Mln€ for its total share of SE, which next to Mochovce 3,4 also owns four other nuclear reactors (Bohunice V2, Mochovce 1,2) the Novaky and Kosice coal power stations, a heat station in Kosice and around 30 hydro power stations.[9] In 2018 ENEL needed to lend another 700 Mln€ for the Mochovce 3,4 project.[10] The owner SE is currently loss-giving, among others because of "the unfortunate" Mochovce project.[11]

Construction is carried out by different sub-contractors, large parts were delivered by Škoda JS in Plzen, Czech Republic, and by Rosatom's sub-company Atomstroyexport. Rosatom is at this moment not directly involved in the Mochovce project, but the main

7 https://spectator.sme.sk/c/20843255/mochovce-nuclear-power-plant-might-be-delayed-again.html

8 https://spectator.sme.sk/c/20899018/new-unit-at-mochovce-nuclear-power-plant-is-closer-to-completion.html

9 https://www.marketscreener.com/ENEL-70935/news/Enel-agreement-on-the-sale-of-Slovenske-Elektrarne-to-EPH-updated-27242040/

10 https://spectator.sme.sk/c/20868614/is-the-completion-of-mochovce-nuclear-plant-close.html

11 https://spectator.sme.sk/c/20934192/slovenske-elektrarne-power-producer-in-the-red.html

construction continues to be carried out by the Czech based company Škoda JS, which is owned by the Russian OMZ, in turn majority owned by Gazprombank (98.6%).

Currently, SE is under fraud investigation, partially related to the Mochovce project.[12]

Hanhikivi, Finland. Next to the heavily delayed French build project Olkiluoto 3, the Finnish company Fennovoima Oy develops currently Finland's sixth nuclear reactor on the coast of the Gulf of Bothnia at Pyhäjoki, using a Rosatom VVER1200/491 reactor. After German E.On sold its 34% share in Fennovoima in 2012, this share was taken over in 2014 by Russian Rosatom, which as part of the deal also signed a plant supply contract with Fennovoima in December 2013. In 2015, Fennovoima chose the Russian company Titan-2, which is also responsible for the construction of the Leningradskaya II NPP, as main building contractor.

Hanhikivi was the first contract for a VVER1200 reactor in the European Union. The project has since been accompanied by scandals and beset with delays. It was initially planned to come on-line in 2020 and receive its construction license in 2014. At the moment, Fennovoima hopes to secure the construction license in mid 2020.[13]

Recently, Rosatom and Fennovoima were accusing one another to be responsible for quality problems with the documentation delivered to Finland's nuclear regulator STUK. STUK furthermore criticised the lack of safety culture at Rosatom, Titan-2 and Fennovoima.[14]

In 2014, Rosatom indicated it wanted to increase its ownership of Fennovoima to 49%, but the Finnish government demanded a 60% ownership of Fennovoima from countries from the EU or the EEA. After Fennovoima could not find any new investors, it proposed in June that the Croatian renewable power company Migrit Solarna Energija would take a 9% share for 158 Mln€. However, Finnish research journalists found out that Migrit was sharing its office with a Russian company linked to a former mayor of Moscow, had Russian owners and only had a capital base of 2700 €.[15] Migrit

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12 https://venergetike.sk/policajti-intenzivne-vysetruju-dostavbu-mochoviec/

13 Peach, Gary, *Hanhikivi Project Delayed*, Nuclear Intelligence Weekly, Vol. 12, No. 44, November 2, 2018, p 4.

14 https://yle.fi/uutiset/osasto/news/uncertainty_over_fennovoima_nuclear_project_worries_local_developers/10338705

15 https://euobserver.com/beyond-brussels/129431

was not accepted by the Finnish Minister for Economy, former EU Commissioner Olli Rehn.

In reaction on this, Rehn was called to Moscow, together with Finnish state utility Fortum, which owns among others hydro-power assets in Russia and which wanted to expand its interests. However, instead of talking about expansion, Fortum had to accept to take a share in Fennovoima or it otherwise risk loosing its Russian assets. On 5 August 2015, Fortum made a U-turn and bought a 6.6% share in Fennovoima.[16]

Because of the delays and cost increases, two municipal shareholders, Kesko and Vantaan/Helsinki, sought to leave the Fennovoima consortium, but could not do so under contractual obligations. In January 2017, Kesko municipality received court permission for its divestment on the basis of financial, contractual and scheduling uncertainties.[17]

Fennovoima is with this probably the most clear example of direct political influence via Rosatom.

The Hungarian Paks II project is to consist of two third generation VVER1200/527 reactors, which are versions of the VVER1200/491 reactor.

Like Hanhikivi in Finland, Paks II was awarded to Rosatom in 2014 without a public tender. The initial budget for the project is 12 Bln€, and Russia would provide a sovereign loan of 10 Bln€ for construction, which hence is guaranteed by the Hungarian state. One of the more critical points in the contract is the repayment start in 2026, which was initially thought to be when the reactors would have started to bring return on investment, but with current delays it becomes clear that Hungary will have to start its pay-back before any reactor is connected to the grid. Given the hefty penalty on delay of payment, this will be more a problem for Hungary than for Russia.

Hungary announced that the agreement with Rosatom would guarantee that 40% of the work would go to Hungarian companies.[18] The agreement also included a 20 year

16 https://www.fortum.com/media/2015/08/fortum-participate-fennovoima-project-66-cent-share-tgc-1-restructuring-negotiations

17 http://www.helsinkitimes.fi/finland/finland-news/domestic/14765-helsinki-votes-for-divesting-stake-in-fennovoima.html

18 See for instance the declaration on Corporate Social Responsibility of the Paks II project: http://www.paks2.hu/en/PaksII/CorporateSocialResponsibility/Lapok/default.aspx

exclusive contract for fuel delivery by Rosatom's TVEL, but this was challenged by the Euratom Supply Agency and the European Commission, and then cut to 10 years.

The European Commission started investigations into the compatibility of the deal with EU law concerning the lack of tendering of the project and into potential illegal state aid. In both cases, during an intensive conflict between the European Commission and Hungary about migration, it cleared the project. Hungary had, however, to separate the Paks II project from the state utility and owner of the existing Paks I power plant MVM. Neighbouring Austria, supported by Luxembourg, appealed against the non-tendering and state aid decisions at the European Court of Justice. Proceedings are pending.

In order to give a positive economic picture to the European Commission, Hungary asked its financial advisor Rothschild to make a feasibility study that supported the image of viability of the project.[19] This study came under wide and severe critique as one-sided and insufficient, among others in a study by financial analysts Candole and partners.[20]

After Paks II secured an environmental permit, the Hungarian nuclear regulator HAEA invited Paks II to submit the documentation necessary for the construction permit of the project. Like in the case of Finland, also HAEA struggles with quality problems with documentation, as well as with its capacity to deal with the several hundred-thousand pages of material, with the education/experience level of its staff, and (Russian) language skills.

Already from the very start, Rosatom took steps to secure control over potential Hungarian participation in the project. Ganz EEM, a 2008 Russian-Hungarian joint venture between Ganz (49%) and Rosatom (51%), counted in 2014 as one of the few companies that made a chance to participate in the Paks II project and help fulfil the 40% Hungarian participation in work. When the Paks II project became serious, using its majority, Rosatom bought out the Hungarian side and brought the company fully

19 Rothschild& Cie, *Economic analysis for the Paks II nuclear power project – A rational investment case for Hungarian State resources*, Budapest (2015); http://www.kormany.hu/download/7/84/90000/2015%20Economic%20analysis%20of%20Paks%20II.pdf

20 Ondrich, Jan and Martin Bebiak, *NPP Paks II: Economic Feasibility, Impact On Competition And Subsidy Costs*, Prague (2015) Candole Partners; https://secured-static.greenpeace.org/austria/Global/austria/dokumente/NPP Paks II Candole.pdf

under its control.[21] Its representative in the company intervened to have Vladimir Putin receive the title of Civis Honoris Causa at the University of Debrecen, whereby the university had the hope it would benefit from the close links to the Paks II project.[22]

Geopolitically, the Paks II deal gave Russian politics some relief in what they consider a hostile environment. Prime Minister Orbán was the only EU leader who invited Vladimir Putin for an official visit after the downing of the MH17 over Ukraine by a Russian Buk rocket. Since then, the links between Budapest and Moscow improved further.[23]

Hinkley Point C, UK. Because it did not take warnings about costs seriously, Great Britain is now bound to the Hinkley Point C project in Somerset. The set-up was done in a Build, Own, Operate (BOO) model that was earlier introduced by Rosatom in Turkey. French utility EdF, owner of Britain's current gas-cooled nuclear fleet, was granted the construction of two third generation EPR reactors on the existing nuclear site of Hinkley Point. Because this was considered a first of a kind project in the UK, the government granted extensive financial support. It copied the idea of feed-in tariffs from the successful German renewables development policies and granted EdF a price guarantee, called strike-price, of 9.2 £/MWh for 35 years, inflation corrected, to be lowered to 8.5 £/MWh if EdF also starts its Sizewell C project. When market prices would ever go over these prices and EdF would thus cash a profit, that difference would be repaid to the state. The scheme therefore was called Contract for Difference. Currently, electricity market prices in the UK are in the order of magnitude of 3 to 4 £/MWh. This strike price for Hinkley Point C was deemed competitive with similar strike prices at the time foreseen for solar PV, off-shore wind and tidal power, and only slightly more than on-shore wind. Because EdF was to be the first to restart this nuclear building programme in the UK, it was also granted a government guarantee for 10 Bln£, and a political guarantee that the UK would be liable for any loss of profit in case a reactor would be closed before its 60 years design lifetime for other reasons than culpable insufficient safety. The European Commission accepted

21 https://www.direkt36.hu/en/igy-szoritottak-ki-az-oroszok-a-magyarokat-paks-2-egyik-fontos-cegebol/

22 https://edu.unideb.hu/news.php?id=385 and https://unideb.hu/en/node/1848

23 https://www.reuters.com/article/us-russia-europe-hungary-specialreport/special-report-inside-hungarys-10-8-billion-nuclear-deal-with-russia-idUSKBN0MQ0MP20150330

this state aid under the argumentation that EU Member States under the Euratom Treaty art. 2(c) have the possibility to support the development of nuclear energy. An appeal from Austria and Luxembourg, opposed not only by the UK and France (the owner of EdF), but also by other countries with nuclear plans like Poland, Slovakia, the Czech Republic, and Romania, was lost and is currently in Cassation. In the mean time, strike prices for other generating sources were not contractually granted (like with Hinkley Point C), but tendered and have dived all far under the Hinkley Point C strike price.

It is important to see the role of Slovakia, the Czech Republic, Hungary, Poland and Romania in the discussion. These countries had no direct interest in the case, but all are planning new capacity and hoping to be able to subsidise this. Hungary's state aid over a sovereign loan from Russia for Paks II is relying on similar argumentation as the accepted state aid for Hinkley Point C. Slovakia has openly mentioned a Russian project as preferred option for new capacity at the Bohunice NPP, which will also need a subsidy scheme, and although the Czech Republic declares that a potential new nuclear project will not be able to get fixed prices or state guarantees, with its intervention at the European Court, it clearly keeps this avenue open as a possibility.

2.3 Potential future projects

It has become clear over the last decades, roughly since the cost rise of the Temelín project in the Czech Republic in the 1990s, that nuclear power has basically priced itself out of the market. The costs for projects like Olkiluoto 3 in Finland, Flamanville 3 in France, Hinkley Point C in the UK and Paks II in Hungary are widely quoted in many countries (e.g. Belgium, Spain, Netherlands, Sweden) as reasons not embark on nuclear projects in the foreseeable future.

Nevertheless, several countries are still playing with the idea for new nuclear capacity. In the first place there is the UK, which launched in the mid 2000s an ambitious plan to replace its fast ageing fleet of gas-cooled reactors with new capacity, because of fears that renewable energy sources would be too expensive and not able to fill demand. Then there are countries with legacy projects, old plans that were started, but never have been (fully) implemented: Bulgaria's Belene and Kozloduy 7 projects, Romania's Cernavoda 3,4, and the Czech Republic's Dukovany 6 and Temelín 3,4 projects.

Slovakia and newcomer Poland launched completely new plans in the late 2000s.

The UK governments of the last decade have staunchly set on a plan for 14 new reactors to replace the old fleet, that is 12 reactors next to Hinkley Point C (see above). EdF is to build a second EPR in **Sizewell** and when the project will take off, will reward the UK with a lower strike price of 8.5 £/MWh for its Hinkley Point C electricity. This is argued with lower costs for serial production, although every new EPR project so far has cost more than the previous one. EdF is to build this EPR, just like Hinkley Point C, partially with funds from the Chinese nuclear giant CGN, and CGN will have a share in ownership. In return, CGN received the option to build three Hualong 1 reactors in **Bradwell**. The design is currently undergoing the general design assessment process with the British nuclear regulator ONR. Only when this design is accepted for the UK, CGN will be able to come with an offer.

At **Moorside**, near the Sellafield nuclear complex, Toshiba was to build three Westinghouse AP1000 reactors. However, both Westinghouse and Toshiba retracted from the nuclear new build market and an attempt to sell the option to Korean KEPCO for the construction of three Korean reactors also failed.[24] There is some ongoing interest from KEPCO[25], but it has so far not come with any concrete offer.

After German E.On and RWE decided to move away from nuclear in 2012, they sold their Horizon project for 3000 MWe new capacity at **Wylfa, Angelsey** in Wales to Hitachi from Japan. On 10 December 2018, however, Asahi TV indicated that Hitachi was looking at cancelling its Wylfa project. Hitachi, however, denies.[26]

For projects in **Dungeness**, **Hartlepool** and **Oldbory** no concrete plans exist for the time being.

From the start, Russian Rosatom has shown interest in entering the UK market. This interest is repeated regularly when there are indications that one of the proposed

24 https://www.reuters.com/article/us-britain-nuclear/south-koreas-kepco-loses-preferred-bidder-status-for-uk-nuclear-project-idUSKBN1KL1YB

https://www.theguardian.com/environment/2018/nov/08/toshiba-uk-nuclear-power-plant-project-nu-gen-cumbria

25 https://www.cnbc.com/2018/11/08/reuters-america-update-2-south-korea-shows-uk-nuclear-interest-after-toshiba-scraps-project.html

26 https://www.theguardian.com/environment/2018/dec/10/uk-nuclear-plant-hitachi-wylfa-anglesey
https://www.bbc.com/news/uk-wales-46508305

projects is failing.[27] Some analysts indicate that the UK would be seen by Rosatom as the top-prize for its export attempts, and that its activities in other EU countries are perceived as preparations for the UK market. In 2013, Rosatom agreed with Rolls Royce and Fortum from Finland to prepare the generic design assessment procedure for its VVER1200 reactor, but to date this process has not started with the UK regulator ONR.

Bulgaria is another good example of Russian interference with national and EU nuclear policies. Its in 1992 stopped, in 2004 restarted, in 2012 cancelled and recently again restarted **Belene** project for two 1000 MWe reactors was widely seen as one of the reasons that made the Russian EU Ambassador Vladimir Chizhov say in 2006 on the eve of Bulgarian EU accession and shortly after Rosatom daughter Atomstroyexport had been chosen as constructor of Belene, that "*Because of our traditional good relations, Bulgaria is interesting for us and as a member of the EU and this interest is not only economic. Bulgaria is in a good position to contribute to EU-Russia relations and we rely on you to be our special partner, a kind of Trojan horse in the EU, of course, beyond the negative original meaning of this metaphor. EU foreign policy decisions are made by consensus and here your country can play a very positive role: to soothe "crazy heads", to enthuse the indecisive.*"[28] Rosatom received the contract for construction in 2006 after a tendering process that was widely criticised as biased or corrupted, among others by the participating Canadian nuclear constructor AECL, itself accused of attempted bribing.[29] In 2009, German utility RWE, which joined the construction as a 49% partner only a year-and-a-half before, decides to pull out of the project, because it noticed that vital decisions were taken behind its back and important technical, financial and economic information was withheld by the Bulgarian partner NEK and Atomstroyexport.[30]

27 For example: https://www.theguardian.com/uk-news/2016/may/13/russias-state-owned-nuclear-group-keen-to-break-into-uk-market

28 https://www.capital.bg/politika_i_ikonomika/bulgaria/2006/11/10/293214_vladimir_chijov_vie_ste_nashiiat_troianski_kon_v_es_v/

29 https://www.theglobeandmail.com/news/national/police-probe-nuclear-firm-after-bribery-allegations/article1136623/

https://www.novinite.com/articles/38928/Canadian+Bidder+Quits+Second+N-Plant+Tender

30 https://www.novinite.com/articles/147148/Bulgarian+Govt+Accuses+Ex-Rulers+of+%27Lying%2C+Lying%2C+and+Lying%27+over+Belene+NPP
The letter of RWE withdrawal can be found here: http://old1.mee.government.bg/files/useruploads/

In 2012, the Bulgarian government cancelled the project after an analysis by HSBC had shown that Atomstroyexport had systematically understated the costs and financial risks to the project. Atomstroyexport started an international arbitration procedure claiming 1.2 Bln€ in damages, which resulted in 2016 in a verdict in which Bulgaria had to pay 620 Mln€ compensation and would in return receive large components that were already produced for the project.[31] The negotiations in the Paris International Court of Arbitration were carried out not during one of the governments of GERB leader Boyko Borrisov, who cancelled the project, but by a government from the Kremlin-friendly Bulgarian Socialist Party (BSP), which could explain why the evidence brought forward by HSBC only had limited result.

Following the delivery of two reactor vessels, heat exchangers and emergency water vessels to the Belene site, new discussions started from the side of BSP and former consultants to the Belene project to restart it again in order to use these materials. After a severely criticised "feasibility study" from the Bulgarian Academy of Science, the current Bulgarian government, again under Borrisov's GERB, decided to allow the preparation of a tender, under the condition that the project would find investors on fully commercial terms without state support.[32] Because of the high costs of any new project, this attempt is widely expected to fail, but it will keep Russian – Bulgarian relations, and thus BSP opposition quiet for a while.

Part of this saga are discussions around a potential new reactor at the site of the existing **Kozloduy** NPP, 150 km Danube-upwards from Belene. Discussions about this project started directly after cancellation of the Belene project with support from Westinghouse, but have fallen somewhat to the background after Westinghouse faced bankruptcy and would clearly not be able to find finance for this project. There are voices that argue that the use of the unused Belene parts for an NPP at Kozloduy would be cheaper, because of the already available infrastructure and the lower seismic risk.

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files/vop/RWE/pismoRWE5.pdf
This was part of a larger batch of letters published by the Bulgarian government in order to clarify that collision between the Bulgarian utility NEK and Atomstroyexport behind the back of RWE had actively undermined trust.

31 https://sofiaglobe.com/2016/06/16/bulgaria-loses-belene-nuclear-power-plant-arbitration-court-action/

32 https://www.novinite.com/articles/193750/Bulgarian+Energy+Minister:+Procedure+to+Select+Strategic+Investor+for+Belene+NPP+Should+be+Completed+within+a+Year

The **Czech Republic** is pursuing nuclear power with an almost religious zeal. After its Temelín reactors went on-line in 2000 and 2001, after a double construction time and three times higher budget, directly plans came under discussion for further expansion. This in spite of the fact that electricity demand in the Czech Republic stabilised and the Temelín electricity virtually completely went into export. Nevertheless, every energy strategy developed since that time includes new nuclear capacity. A special government commission set up in 2008 to work out an energy policy refused to take nuclear phase-out options into account. A following proposal for eight new reactors in a draft energy concept from Ing. František Pazdera in 2012 was met with wide ridicule. The first focus was on two new units at **Temelín** (3 and 4), for which even a complete environmental impact assessment (EIA) was carried out in 2012. In 2014, however, Czech majority state owned utility CEZ cancelled the tender for this project, because it could not secure the necessary finances.[33] In the tender procedure, French Areva had been disqualified because it could not deliver a full financial package. Remaining contenders were Westinghouse and Rosatom's Atomstroyexport. Although it had become clear that it would not be possible to build new reactors that were commercially viable, and the Czech government refused to give guarantees for financial support, discussions continued. This was partially because of pressure from the municipality of Třebíč, which depends economically largely on the **Dukovany** nuclear power station and feared large consequences once the ageing reactors will be closed in the coming one or two decades. On the other side, president Miloš Zéman, who has close links with Moscow, kept pushing for nuclear expansion.

Anno 2018, Prime Minister Andrej Babiš initially opposed proposals for new nuclear capacity on financial grounds, but recently turned his opinion.[34] He excluded the financial option of sovereign loans like Hungary chose for its Paks II programme.[35] Although announced deadlines for the start of a tender in 2018 have been missed, Czech industry minister Marta Novakova announced that CEZ will come with a call for

33 https://www.reuters.com/article/cez-temelin/update-3-cez-scraps-tender-to-expand-temelin-nuclear-plant-idUSL6N0N23OO20140410

34 https://www.denik.cz/ekonomika/babis-na-dostavbe-dukovan-trvam-investice-do-jadra-je-navratna-20181211.html - "I insist on the construction of Dukovany, an investment in nuclear will pay off," insists Andrej Babiš, 11 December 2018

35 https://www.reuters.com/article/us-czech-nuclear/czechs-not-looking-at-hungary-type-deal-to-build-nuclear-power-plants-pm-idUSKCN1NZ1DX

bids in 2019.[36] Rosatom, CGN, and South Korean KHNP already expressed their potential interest.

Romania's Cernavoda 3,4 are a remnant of former communist dictator Nicolae Ceaucescu's obsession to build the largest nuclear power station of the Canadian CANDU heavy water reactors. Initially five reactors were planned at the shores of the Danube, but during the early 2000s, it became clear that available cooling water would not be sufficient for five reactors and plans for the fifth reactor were shelved. The plan to finish the remaining units of which construction started in the late 1980s is regularly revived, in spite of the fact that in 2011 all strategic partners, RWE, GDF Suez (nowadays Engie), Iberdrola and Arcelor Mittal, drew out because the project was not deemed viable. Their place has been taken by a regularly repeated interest, but not active share-taking, of China's CGN. Given the state of the construction site and costs necessary to finalise these outdated reactor designs, it is doubtful that construction will ever be restarted.

Slovakia started in 2013 the environmental impact assessment procedure for two new units at the Jaslovske **Bohunice** site. This process was finalised in 2016 and by this author called a "frivolous procedure" in his EIA submission because of the fact that too many crucial factors, including constructor, design, time-table, budget, etc. were unknown at the time of the procedure. Since 2016, the project has not much proceeded. There were rumours that Rosatom was interested in taking over the 49% share of Czech national utility CEZ, but these talks stalled in March 2014.[37] The state-owned utility responsible for nuclear legacy projects JAVYS holds the majority 51% of shares of JESS.

Although Slovakia officially keeps this project open to any potential constructor (mentioned were Korea, China, Japan, US, France), the currently available information appears to give a clear preference for Rosatom, because of the nuclear history of Slovakia.

The discussion in **Poland** to become a nuclear power country already dates back to just after the second world war, when some openly sought to rebuild Poland also as a military nuclear power. A famous popular song from that time said: "Give us a small

36 https://voiceofpeopletoday.com/czech-republic-in-2019-will-announce-a-tender-for-the-construction-of-nuclear-power-plants/

37 https://venergetike.sk/czech-company-cez-remains-new-bohunice-npp-project/

nuclear bomb and we'll return to Lwow [Lviv, JH], give us a big one and we'll be in Wilno [Vilnius, JH]", relating to the areas of pre-war Eastern Poland, now Ukraine and Lithuania.

In the 1980s, Poland followed the examples of Czechoslovakia, the German Democratic Republic (GDR), Hungary and Bulgaria in the preparation for the introduction of Soviet nuclear power. Construction was started of four VVER440/213 reactors near Gniewino in the municipality of Zarnowiec. However, extensive protests after the Chernobyl disaster in 1986 forced the new non-communist government to skip the programme in 1990.

In the late 2000s, under the government led by then Prime Minister Donald Tusk, the plans for Poland to introduce nuclear power were re-introduced and an implementation company PGE EJ was set up under Poland's largest state utility PGE, with a 10% participation each of the utilities Tauron and Energia and copper mining firm KGHM. For political reasons, the implementation of the project was brought in 2012 into a new sub-daughter PGE EJ1, in order to secure a high salary for ex-finance-state-secretary Alexander Grad.[38] PGE EJ was cut out of this constellation after Grad had left the company. The project was based on a Polish Nuclear Energy Plan (PNEP), which was subjected to a transboundary strategic environmental assessment and received a lot of opposition from neighbouring Germany, but also Austria and Denmark. Initially, it was to consist of six reactors on two different locations in the North of the country, not far from Gdynia and Gdansk. Both, the PO government of Donald Tusk and the current PiS government, led by Lech Kaczynski, have repeatedly denied that Rosatom could be one of the main contractors for this project. In the initial years, Poland looked at Areva (now Framatom / EdF) from France, Toshiba / Westinghouse from the USA and Hitachi GE from Japan. After the downfall of Areva and Westinghouse, the PiS government mentioned China and Korea as potential partners.

Currently, the plans are on hold because of lack of ideas how to finance them. Tauron, Energia and KGHM indicated they wanted to shed their shares in PGE EJ1.[39] Earlier

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38 https://www.rp.pl/artykul/946959-Aleksander-Grad--Nie-jest-prawda--ze-zarabiam-110-tys--zl.html

39 https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapid=209513678, consulted 13 December 2018: PGE EJ 1 sp. z o.o. Key Developments - ENEA Plans To Sell Stake In PGE, Dec 5 18; Tauron Seeks To Sell Stake In PGE EJ 1, Nov 30 18; KGHM Plans To Sell Stake In PGE, Nov 29 18

attempts by the Polish government to have the also state oil company PKN Orlen take over control of PGE EJ1 and all nuclear developments failed, after Orlen's ratings fell when the government floated the idea.[40] In the run-up to the climate COP24 in Katowice, Polish energy minister Krzysztof Tchórzewski pushed the idea back into the public debate, while teaming up with nuclear lobby organisations like Foratom and the World Nuclear Association. It is unclear, however, to what extent he has government backing for this.

2.4 Near border projects outside the EU

The spread of nuclear materials after a severe accident does not halt at borders. For that reason, the EU and EU Member States have always had keen attention for the potential risks near-EU nuclear projects, certainly after the accident in Chernobyl, 450 km from the current EU border, spread large amounts of radioactive substances all over Europe, with the need to take mitigation measures as far away as in the United Kingdom and North Sweden.

Rosatom is currently finalising the construction of two reactors at the **Astravets** NPP in **Belarus**, around 12 km from the Lithuanian border and 45 km from the Lithuanian capital Vilnius. The project has two VVER1200/419 reactors.

Lithuania has expressed strong concerns about the quality of the project[41] and the Lithuanian Parliament even declared the construction of Astravets a national security issue.[42] It took earlier steps to prevent becoming dependent on electricity from this power station and reduce its dependency on electricity from Russia, and hopes to be integrated into the EU power grid (ENTSO-E) in 2025.

The Astravets project suffers several problems that raise concern in the EU.

First of all, there are concerns about the capacity and independence of regulatory oversight. The Belarusian Gosatomnadzor is heavily depending on its cooperation with the Russian nuclear regulator Rostechnadzor. But it is also understaffed and, in spite of intensive training efforts, building up experience from a zero level in the

40 https://www.parkiet.com/Energetyka/311209887-Atom-doluje-notowania-PGE.html

41 https://urm.lt/default/en/news/fundamental-problems-of-the-astravets-nuclear-power-plant-under-construction-in-belarus-

42 https://www.lrs.lt/sip/portal.show?p_r=25342&p_k=2&p_t=174377

oversight of a nuclear power project proves to be a challenge. Where Finland and Hungary have found problems with the quality of documentation delivered by Rosatom for similar reactors, and Finland criticises the lack of safety culture in Rosatom and its sub-contractors, Gosatomnadzor has not been seen critical in any way. When Belarus proposed to submit the Astravets reactors to the European post-Fukushima nuclear stress tests, this was experienced by both sides, the European Nuclear Regulators Group ENSREG and Gosatomnadzor, as a steep learning experience.[43] Belarus still has to publish a national plan based on the stress-test reports and the peer-review process, which also needs to be open for public consultation. Belarus started the stress tests in a very late stage of construction of the project – an estimated year to a year-and-a-half before bringing the reactors to the grid. This means that conclusions concerning among others seismic robustness and other issues may be difficult to remedy, and certainly will lead to increase in costs.

The project is financed fully with loans from Russia, which further increases the dependence of Belarus on Russia.

The Astravets project was initially build as a way for Belarus to become an exporter of electricity, but with the Baltic States actively wanting to block access of this electricity to EU markets, and Belarus having sufficient generation capacity (mainly gas) for lower prices than Astravets will deliver, its main customer is likely to become Russia as well. Environmentalists have criticised that Belarus with that receives the nuclear risk and the financial risk, whereas Russia can, as only main customer, dictate the prices.

During construction, several major incidents came to light. In one, the reactor pressure vessel fell 4 meters on a concrete floor out of a crane hinge. The vessel was after international pressure replaced by Rosatom. During the transport of the replacement vessel, the transport container hit a railway infrastructure frame. Both incidents only came to light after whistleblower information reached social media.

During the preparation and construction of the Astravets project, the Belarusian authorities have actively tried to suppress critique on the project from civil society. In 2012 two activists were jailed for short times after they attempted to submit a petition to the Russian Embassy before a visit of Russian president Putin to Minsk, and Belarus was found in 2017 in non-compliance with the Aarhus Convention for harassing

43 Presentations from ENSREG and Gosatomnadzor during the presentation of the final report of the ENSREG peer-review commission in the European post-Fukushuma nuclear stress test for Belarus, 3 July 2018, Brussels.

members of the public who wanted to use their right on public participation.[44] But the authorities also continue to withhold permissions for demonstrations against the Astravets project.[45] The voice of civil society is especially important in a centralised organised country like Belarus, as a counter balance to the state controlled media that often give a strongly biased reflection of conclusions of, for instance, international institutions. They depict, for instance, the stress tests as a green light from the EU, and a limited site assessment mission (SEED) from the IAEA as a green light from the UN.

Russia is currently planning to finalise in the coming year one more reactor at the Leningradskaya NPP near Sosnovy Bor, **Leningrad 2-2**. Also this is a VVER1200/419 reactor.

Although **Ukraine** mainly sets on life-time extension of its current nuclear fleet, there are still plans to finalise reactors 3 and 4 at **Khmelnytksyi**. Construction of two VVER1000/320 reactors started there in 1985, but was halted in 1990 with respectively 75% and 28% of the concrete in place. In 2011, the owner, state utility Energoatom, signed a deal with Rosatom's daughter Atomstroyexport to finish the construction of the two reactors. However, due to the growing tensions between Russia and Ukraine, the contract was cancelled in 2016. It was then proposed to have the Czech company Škoda JS finalise the project, but this idea was cancelled after it became too clear among the public that Škoda JS is owned by Russian OMZ. Currently, Energoatom is preparing a feasibility study and parallel to that started the environmental impact assessment procedure. However, because it is completely unclear whether the original standing material is still in a state that it can be used (which would bind the project to a second generation VVER1000 design) or whether it has to be removed because of poor quality (much of the concrete has been standing in water and was unprotected over the last 25 years), who will be the main constructor (Rosatom and Russian allied companies like Škoda JS are excluded, no other company has experience with construction of the VVER1000 design), which design will be build (depending on constructor and whether old material can be used), what the costs will be (Energatom budgets 2.8 Bln€, but rough estimates show that the two reactors will cost at least 10 Billion Euro, probably more), and how this is to be financed (Energoatom was loss-bringing in the first nine months of 2018[46]), it is unlikely that this project will ever go ahead.

44 https://www.unece.org/fileadmin/DAM/env/pp/compliance/CC-58/ece.mp.pp.c.1.2017.19.e.pdf

45 https://jamestown.org/program/belarusian-nuclear-power-plant-proceeding-full-speed-ahead/

In the mean time, Ukraine builds an energy bridge from Khmelnitsky to Poland in order to enable export of surplus electricity to the EU from the Khmelnitsky 2 nuclear reactor, and to create a market for Khmelnitsky 3 and 4. Whereas Ukraine could definitely benefit from larger interconnection between its grid and the European ENTSO-E grid in order to develop its enormous renewable potential, this project is solely oriented on development of nuclear capacity[47] and is to create facts on the ground to argue for expansion of the Khmelnitsky NPP, no matter what the cost.

Turkey officially has three planned nuclear projects. There are vague plans for two Chinese build Westinghouse AP1000 designed reactors and two Chinese designed CAP1400 reactors in İğneada near the border with Bulgaria. The plans to build four ATMEA reactors near Sinop in North East Turkey on the Black Sea coast by Mitsubushi from Japan and Framatom from France have just faltered with Mitsubishi closing the door on its nuclear department.[48]

Rosatom has started with the construction of four VVER1200 reactors at **Akkuyu** near Mersin in the South of Turkey on the Mediterranean coast opposite Cyprus. Where this project originally had a hard start, the closer relations between Turkey and Russia are currently pushing it forward. This is the first Build, Own, Operate, Transfer (BOOT) project, a set-up that Rosatom introduced as new financing model: Rosatom will build, own and operate the nuclear power station and will transfer spent fuel back to Russia. This last feature came under legal pressure, because Russian law does not allow for import of foreign spent fuel or radioactive waste.

After Rosatom noticed that costs could become a problem, it tried to open the project for 49% Turkish participation. It targeted for that companies that already had expressed their interest in being involved in construction work: Cengiz Holding, Kolin Construction and JSC Kalyon Construction, each for a 16.33% share. However, when it became clear that shareholdership would not automatically result in construction

46 http://energoatom.com.ua/ua/press_centr-19/infografika-28/p/rezul_tati_dial_nosti_energoatoma_za_9_misaciv_2018_roku-6785

47 See for instance: http://www.world-nuclear-news.org/NP-Energoatom-awaits-approval-for-energy-bridge-tender-18041801.html and https://economics.unian.info/10304175-poland-s-role-in-ukraine-s-energy-bridge-concept-regional-energy-security-atlantic-council.html

48 https://asia.nikkei.com/Business/Business-Trends/Japan-risks-losing-nuclear-prowess-with-Turkey-project-abort

contracts, these companies retracted their interest. President Erdoğan organised that the national utility EUAS entered talks for potential participation.[49]

In April 2018, construction started under a limited construction permit that was granted on 14 December 2018, much still depending on approval of documentation by the Turkish nuclear regulator TAEK. TAEK is facing similar problems as Gosatomnadzor in Belarus: this is the first time it has to deal with a nuclear construction project and it is highly depending on the quality of information it receives from Rosatom without having sufficient capacity, skills and experience to objectively judge it. Different than Gosatomnadzor, it cannot rely on so much support from the Russian regulator Rostechnadzor, nor does it get any support from ENSREG. In September 2018, Rosatom announced that Titan-2 would be the construction contractor for Akkuyu[50], the same company also responsible for the construction of Hanhikivi in Finland, and severely criticised by the Finnish nuclear regulator STUK for lack of safety culture.

The **Metsamor** 2 reactor in **Armenia** is sometimes characterised as the most dangerous nuclear power plant in the world. The outdated early second generation VVER440/270 reactor is already 8 years beyond its design life-time, it is build in one of the most seismic active areas in the world, where a heavy earthquake in 1988 killed 25,000 people and closed the Metsamor 1 reactor for good. The Metsamor 2 reactor continues to operate because Armenia failed to develop alternative generation capacity and relied in 2017 for 37% of its electricity on the ageing reactor. After upgrades in 1997 and 2017, it received a life-time extension with 10 more years in 2017 and is supposed to be closed in 2027. As a further safety measure, the plant management brought Katholikos Garegin I to bless a new chapel in the plant's main administrative building in 1997.[51]

Rosatom is further actively trying to sell nuclear power stations to the **Middle East** and **Africa**. It finalised the Busher NPP in Iran and seeks its extension, and currently prepares with Egypt the Daaba nuclear power station. These are also to be build in a

49 http://tass.com/economy/988668

50 https://www.dailysabah.com/energy/2019/01/01/nuclear-gas-renewables-petrochemicals-turkish-energy-sector-enjoys-a-prolific-year-of-projects

51 http://www.armeniapedia.org/wiki/Metsamor_Armenian_Nuclear_Power_Plant

BOO or BOOT financing scheme. It furthermore tries to sell reactors to Sudan and Saudi Arabia.

2.5 Floating reactors in the Arctic

A relative new development is the construction of the Akademik Lomonosov, a two reactor floating nuclear power station that is currently being tested in Murmansk, before it continues on a 5000 km voyage through the Northern Ice Sea to Pevek in Chukotka in the far East. There, the two 35 MWe KLT-40 submarine reactors are to power this small port town and some mining activities in the surroundings.

However, the Akademik Lomonosov is to be the first of a fleet of floating reactors that are to deliver energy to the increased exploitation of the Arctic, now the sea-ice is retracting under global warming. Russia expects large profits from these activities, but infrastructure is difficult to build in the high North.

The Akademik Lomonosov was initially build in Severodvinsk, but construction was moved to the Baltiiskaya wharf in the centre of St. Petersburg, around 2.5 km of the St. Isaac Cathedral and 3.5 km from the Hermitage.[52] Initial plans to load and test the reactors on this location were met with fierce resistance in St. Petersburg as well as from the countries around the Baltic Sea, who were concerned about the barge, which does not have own propulsion, being towed in loaded and irradiated state along their shores. St. Petersburg citizens and Greenpeace Russia criticised also the fact that no environmental impact assessment was made for the construction, and that construction was not properly overseen by the Russian nuclear regulator Rostechnadzor.[53] There is a history of nuclear accidents on Russian nuclear shipyards, where in the 1970s and 1980s dozens of people died.

After increasing pressure, a petition signed by 12,000 St. Petersburg citizens[54] and an informal peer review mission from the Finnish nuclear regulator STUK, Rosatom decided to move loading and testing from St. Petersburg to Murmansk, so that less people would be exposed to the risks of accidents during testing, and only Russian

52 http://www.world-nuclear-news.org/NN-Russia_relocates_construction_of_floating_power_plant-1108084.html

53 https://www.greenpeace.org/international/press-release/16305/greenpeace-escort-protests-worlds-first-purpose-built-floating-nuclear-power-plant/

54 https://www.greenpeace.org/international/story/16149/32-years-on-chernobyl-on-ice/

coastline would be exposed to the risk of towing an unpropelled barge with irradiated nuclear fuel on board over a distance of thousands of miles. The barge measures 144 by 25 meters, has a water displacement of 21,500 tonnes and 69 crew. Greenpeace peacefully escorted the transport of the unloaded barge through Danish waters and was met with aggressive acts from accompanying Russian tug-boats (dangerous manoeuvring, spraying with water), while Rosatom published press releases falsely accusing Greenpeace of attacking the flotilla.

This first Russian floating nuclear power station is to be the first of a fleet. Russia plans to increase fossil fuel exploration and exploitation in the Arctic now the ice is retracting because of global warming. For that, it handed over the entire management of the Northern Sea Route to Rosatom, which currently prepares several new nuclear ice-breakers for that purpose.

Because the Akademik Lomonosov has several problems like high radiation levels for the on-board living crew, Rosatom also develops a new generation floating nuclear power stations with two 90 MWe reactors. Next to that it prepares the construction of a special icebreaker to enable spent nuclear fuel transport through the Arctic seas. Currently it is foreseen that the Akademik Lomonosov will be towed back after 12 years of operation with three cycles of spent fuel on board to Murmansk for maintenance and refuelling.

Russia also intends to export floating nuclear reactors and claims interest from 15, mostly island countries. Several of these are situated in seismic active areas with the risk of tsunamis. Floating nuclear power plants are especially vulnerable when lack of control, storm or large waves throw them on a coast.

2.6 Legacy projects

In 1992, the G-7 meeting in Munich, Germany, came to the conclusion that VVER440/230 type reactors and the Chernobyl-type RBMK design were not upgradable to a sufficient safety level and needed to be closed down. Early closure dates were embedded in the EU accession treaties of Lithuania (Ignalina, 2 RBMK, closure 2004, 2009), Slovakia (Bohunice V1, 2 VVER440/230, closure 2004, 2008) and Bulgaria (Kozloduy, 4 VVER440/230, closure 2004 (2), 2006(2)). A separate TACIS/PHARE action programme addressed acceleration of the closure of the remaining three RBMK reactors at Chernobyl. Decommissioning work of all these reactors is overseen by the European Bank for Reconstruction and Development (EBRD).

Slovakia furthermore also is currently decommissioning its twice melted down (1976, 1977) A1 reactor at Bohunice, a very early gas-cooled KS150 reactor.[55]

Sixteen further reactors of the old Soviet designs RBMK and VVER440 are still operating: one in Armenia (Metsamor) and the rest in Russia.

Five reactors in Greifswald, Eastern Germany, were already closed in 1990, directly in the run-up to the German reunification.

So far, the Greifswald reactors are to only ones to have been almost fully decommissioned.

At Lubmin near **Greifswald**, former Eastern **Germany** (GDR), in November 1989, during the heat of the Wende, the newest VVER440/213 reactor unit 5 (brought on-line in April 1989) was closed down after an incident in which tens of reactor elements had become overheated while the emergency shut-down did not function and had to be carried out by hand. After that, the four units VVER440/230 from the 1970s were closed down during the reign of the first non-communist government of the German Democratic Republic after an initiative from the Round Table[56] where after the Wende in the GDR, civil society and government decided the further development of the country. In the run-up to the closure, an article in Spiegel created large attention for the incident-ridden past of the five reactors, including a fire in 1975 that brought unit 1 close to a melt-down (INES 3 level).[57] 5.037 spent fuel elements are stored in dry storage on site, waiting for a final depository. In the start of the 1980s, 233 tons of spent fuel were transported to Mayak, Russia for reprocessing. 235 partially used fuel elements were sold to the Hungarian Paks NPP in 1995.[58] Large material is currently prepared for intermediate storage on site. The sixth unit, which was never started, is

55 Urban, Ondrej, *The A1 Nuclear Power Plant in Jaslovske Bohunice, Slovakia*, Stanford (2015) Stanford Universit; http://large.stanford.edu/courses/2015/ph240/urban1/

Kuruc, Josef, Ľubomír Mátel, *Thirtieth Anniversary of Reactor Accident in A-1 Nuclear Power Plant Jaslovske Bohunice*, Bratislava (2007) Omega Info, ISBN: 978-80-969290-9-2; http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/38/059/38059373.pdf

56 Personal communication with Klaus Schlüter, Minister without Portfolio and Felix Christian Matthes

57 http://www.spiegel.de/spiegel/spiegelspecial/d-52397652.html

https://de.wikipedia.org/wiki/Kernkraftwerk_Greifswald

58 https://www.atommuellreport.de/daten/akw-greifswald-1-5.html

currently functioning as a museum. The costs for decommissioning of the five reactors that operated is currently estimated on 6.5 Bln€, Greenpeace Germany counts even with 10.6 Bln€.[59]

The decommissioning of the two RBMK reactors at **Ignalina**, **Lithuania** is underway, and in 2017 a 200 Mln€ dry storage facility for spent fuel and high level waste was launched.[60] In early 2018, the removal of fuel from the reactors was finalised.[61] The next step will consist of dismantling the reactor vessels. The total expected costs are estimated to be around 2.5 Bln€, around 80% to be funded by the EU and 14% by Lithuania, the rest by other sponsors. Ignalina's spent fuel is to remain on-site in dry storage until a final depository is developed. The dry storage is build with an operation life-time of 50 years and contains 201 CONSTOR RBMK containers with around 22.000 fuel assemblies[62], and was build by the 100% Rosatom daughter GNS Nukem from Germany. This dry storage is situated on surface and supposed to be resistant to an aircraft crash and seismic activity.

Preparation for decommissioning of the **Bohunice V1** reactors in **Slovakia** started in 2012 and is supposed to be finalised in 2025. The total budget is estimated on 1.14 Bln€, of which around 850 Mln€ is to be covered by the EU. Decommissioning of Bohunice V1 is planned to be finalised in 2025[63], though delays are possible. Bohunice V1 is owned by the Slovak state utility JAVYS, that specialises in decommissioning projects (it also owns the Bohunice A1 reactor). Spent fuel is to be stored in the interim wet storage on-site awaiting final disposal. Part of the spent fuel from Bohunice V1 and V2 has been transported to Mayak for reprocessing before the velvet revolution in 1989, with Russia retaining the resulting waste.

59 https://www.tagesschau.de/inland/atomausstieg-kosten-monitor-101.html
https://www.greenpeace.de/themen/energiewende-atomkraft/atomkraftwerke/akw-rueckbau-die-altlast-des-nuklearen-wahns

60 https://www.ebrd.com/news/2015/decommissioning-of-ignalina-nuclear-power-plant-moves-a-big-step-closer.html

61 https://enmin.lrv.lt/en/news/ignalina-npp-decommissioning-progress-discussed

62 http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/lithuania.aspx

https://pubs.geoscienceworld.org/minmag/article/79/6/1581/301116/overview-of-the-lithuanian-programme-for-disposal

63 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0467

The four VVER440/230 reactors at **Kozloduy**, **Bulgaria**, were closed down in 2002 (units 1 and 2) and 2006 (units 3 and 4) respectively. Because none of the reactors was directly decommissioned, even as late as 2009 there were discussions to restart them, officially because of gas-delivery problems from Russia over Ukraine (though Bulgaria only has a limited use of gas in its electricity system), but in reality under pressure from the pro-Moscow nuclear lobby in Bulgaria. Decommissioning started in 2011[64] and it is foreseen that the main equipment will be removed in 2019. Decommissioning is to be finished in 2030 and total costs are estimated to be 1.3 Bln€.[65] Decommissioning is carried out by mainly West European contractors, including Westinghouse Spain, Enresa (Spain) and the German nuclear waste management company BGE Technology GmBH (former DBE Technology). Spent fuel of the VVER440 reactors was sent for reprocessing to Mayak, Russia, with an obligation to take back resulting waste.[66] The when and how of this repatriation is so far unknown.

2.7 Radioactive waste management

Radioactive waste is one of the more problematic legacies of the use of nuclear power. Roughly 90% of the radioactive content of radioactive waste in the European Union comes from the nuclear power industry, and over 80% of the volume. Especially the high-level radioactive waste poses unsolvable dilemma's, and only four countries in the Union are currently working on projects that could eventually lead to final disposal of (a part) of this waste category – Finland, Sweden, France and Belgium. However, each of these projects is facing severe technical, social and economic challenges in implementation that could still become a game-stopper before any of them would go into operation. It is fair to claim that neither in the EU, nor world-wide, there is an operating solution for this category of waste.

Before 1989, Central and Eastern European countries tended to rely on high-level radioactive waste management in the Soviet Union. Only Finland, not part of the Warsaw pact, tried and currently tries to build a final disposal for its high-level waste

64 https://www.me.government.bg/en/themes/kozloduy-international-decommissioning-support-fund-kidsf-905-348.html

65 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0467

66 http://news.bbc.co.uk/2/hi/programmes/from_our_own_correspondent/7911972.stm

http://bellona.org/news/nuclear-issues/radioactive-waste-and-spent-nuclear-fuel/1998-12-more-bulgarian-fuel-to-mayak in its own country, be it with technical challenges and ongoing uncertainty about potential operability, because it relies on Swedish container technology that recently was found insufficient proven by the Swedish Environmental Court. All former Warsaw Pact countries with nuclear power before 1989 expected to be able to transport their spent nuclear fuel from RBMK and VVER440 reactors for reprocessing to Russia's Mayak complex in the Southern Urals, or for the more modern VVER1000 reactors to Zheleznogorsk in the Krasnoyarsk region. Hungary and Bulgaria continued with that for their VVER440 after the changes in 1989, though now with an obligation to once take back resulting waste, and Bulgaria even after EU accession. Belarus plans to follow this old pattern for the spent fuel from its new Astravets NPP: the spent fuel is to be stored in a wet interim storage for around 10 years and then transported to a (as yet for the VVER1200 fuel not yet existing) reprocessing facility in Mayak or Zheleznogorsk.[67]

It has to be noted that the reprocessing complex in Mayak, Southern Urals, has a very poor track record. It was not only the scene for the third largest nuclear accident in history (INES 6) when on 29 September 1957 poor handling resulted in an explosion that released 800 PBq of radioactivity into the atmosphere. As a result of the explosion, but also exacerbated by later leaks, the Techa river passing by the Mayak complex is severely contaminated to today, and surrounding inhabitants are still exposed to unacceptable levels of radiation.[68]As to today, the shroud of secrecy and denial continues to be Rosatom's default reaction on severe incidents in Mayak, as can be seen in the recent ruthenium-106 incident (see par. 3.2).

In the 2000s, it became clear that Western European nuclear enrichment facilities, Areva (former Cogema and Eurodif) in Pierrelatte, France and Urenco in Capenhurst (UK), Almelo (Netherlands) and Gronau (Germany) disposed of their depleted uranium to the closed city of Zheleznogorsk in the Krasnoyarsk region or to Seversk in the Tomsk region in Western Siberia.[69] Depleted uranium is the uranium that remains

67 http://belarusfeed.com/nuclear-waste-repository-belarus/

68 Haverkamp, Jan (ed.), *Rosatom's Mayak: More Reprocessing, More Contamination*, Vienna (2017) Greenpeace Central and Eastern Europe; https://www.greenpeace.org/archive-hungary/PageFiles/762727/Rosatoms_Mayak_more_reprocessing_more_contamination.pdf

69 http://www.bandepleteduranium.org/en/greenpeace-target-european-uranium-dumpers

after an enriched part of the initially natural uranium has been removed. Officially, the stored depleted uranium in Zheleznogorsk is meant for re-enrichment, which means that Tenex (now: TVEL) was supposed to extract still more uranium-235 out of the already depleted uranium. However, most of the depleted uranium is simply stored in gaseous form (UF6) in corroding containers in the open air. It was furthermore contractually unclear what would happen to the resulting double-depleted uranium, once the Rosatom daughter Tenex (now: TVEL) had removed some of the remaining uranium-235. It would probably simply have to remain in Russia. Given the high level of toxicity of UF6 (after a leak, in contact with water in the air, it yields fluoric acid) and the remaining level of radioactivity, this material, called TENORM (Technically Enhanced Naturally Occurring Radioactive Materials) will have to be kept out of the environment for extremely long periods. After almost a decade of protests by among others Greenpeace and Bellona, this dumping practice from Western Europe to Russia was stopped in 2011.[70]

As a result of the lack of final solutions for high-level radioactive waste, countries using or having used nuclear power are by default relying on temporary storage of the most dangerous categories of radioactive waste.

For spent nuclear fuel, there are two types of storage: wet storage in pools, where water is taking care of the necessary cooling, and dry storage in casks or containers with cooling by natural air-flow. Fresh spent nuclear fuel, just coming out of the reactor, has to be stored for some time, several years, in pools, because air-convection would not deliver sufficient cooling. If the method of dry-storage is chosen after this initial wet storage, the fuel elements are moved to dry storage casks and placed in the dry-storage interim facility, waiting for a final disposal solution. Other mid- and high-level wastes (like radioactive sources, some decommissioning waste) can be stored in dry form directly.

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http://www.atominfo.ru/en/news/e0452.htm

http://www.greenpeace.org/russia/en/news/europe-s-secret-nuclear-waste/

http://www.spiegel.de/international/spiegel/radioactive-waste-german-company-sent-nuclear-material-for-open-air-storage-in-siberia-a-655934.html

70 http://www.wise-uranium.org/ediss.html#UPGRRU

Wet storage can pose a considerable risk. Cooling is secured with active pumping of water and if either the water or the pumping is lost, there is a chance the stored spent fuel may fall dry, melt and burn. A recent campaign and report from Greenpeace France has illustrated also the security risk posed by wet storage on site.[71] Dry storage also has to be secured properly, for instance against attacks by large aircraft or with certain weaponry. The German court decided in 2015, that dry interim-storage should be able to withstand the impact of an Airbus A380 or the attack with certain weapons.[72] None of the existing dry storage sites in the world fulfils that criterium.

The Soviet nuclear system has always relied on long-term wet storage and Russia is one of the countries lagging behind with the development of a final disposal solution. The country has so far build up a rather dismal track record of dealing with radioactive waste, including badly protected dump-sites, sea-dumping (including of complete discarded reactors), injection of liquid radioactive waste into the underground, etc. There is furthermore very little transparency about radioactive waste management.

The primary Soviet choice for wet storage can be seen reflected in Bohunice in Slovakia and in Finland, where all spent fuel is also stored in pools.

Bulgaria, the Czech Republic and Hungary are all moving to dry storage, but none of these countries foresees a storage facility that would fulfil the criteria currently set by the courts in Germany.

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71 https://www.reuters.com/article/us-france-nuclear-security/frances-nuclear-spent-fuel-pools-major-security-risk-greenpeace-idUSKBN1CF1HJ

Becker, Oda, Manon Besnard, David Boilley, Ed Lyman, Gordon MacKerron, Yves Marignac, Jean-Claude Zerbib, *Report Summary - “Security of nuclear reactors and spent fuel pools in France and Belgium and related reinforcement measures”*, Paris (2017) Greenpeace France; https://cdn.greenpeace.fr/site/uploads/2017/10/Summary-of-the-report.pdf

https://www.dailymail.co.uk/news/article-5912993/Greenpeace-crashes-Superman-shaped-drone-French-nuclear-plant.html

72 https://www.shz.de/regionales/schleswig-holstein/politik/brunsbuettel-ein-bvg-urteil-neun-castoren-viele-fragen-id8707671.html

3. Who else is impacted – cross-border emergency preparedness, electricity market, security

Nuclear power poses risks – safety risks, risks around the management of radioactive waste, security risks, financial risks – for the countries that choose it, but also for countries in its vicinity. And that irrespective of whether these countries choose to use the option of nuclear power or not.

3.1 Transboundary risks in case of severe accidents

In the case of a **severe accident**, depending on how much of the radioactive content of mainly iodine-131, caesium-134, caesium-137 and strontium-90 is released, and depending on the weather, impacts can be felt up to hundreds kilometres of distance. In a landmark case, the Convention on Transboundary Impact Assessment, also known as the Espoo Convention, forced the UK to notify all UNECE countries of its plans to build a new nuclear power station at Hinkley Point, because Austria had shown it could be impacted by a severe accident. The reactions from the Netherlands and Norway confirmed the possibility of adverse effects of a severe nuclear accident in the UK on their territory.[73] Especially countries with near-border nuclear power stations are impacted by the risk of a severe accident.

Annex 1 shows which countries from that perspective run a considerable risk from nuclear power stations outside their borders.

We see that countries that chose to be non-nuclear, like Austria, Denmark, Estonia, Greece, Latvia, Luxembourg, Portugal, but also countries that decided to phase-out their nuclear programme, like Germany, Italy and Lithuania, are facing serious problems when a nuclear accident happens at their borders.

73 Meeting of Parties to the Convention on Environmental Impact Assessment in a Transboundary Context, Implementation Committee, *Report of the Implementation Committee on its thirty-fifth session*, p.17 point 37, p.18 point 40 and 42, p.20 point 52, p.21 point 63, p.22 point 66 (Findings); https://www.unece.org/fileadmin/DAM/env/documents/2016/EIA/IC/REPORT_ENG_ece.mp.eia.ic.2016.2_e.pdf

Other countries, like Belgium, France and the Netherlands do not only have to fear their own fleet, but also be prepared for accidents that can happen virtually on their border.

Croatia is a special case, co-owning the Krško nuclear power station in Slovenia, but risking its capital Zagreb on only 25 km distance.

In 2012, the Institute for Risk and Safety Studies at the BOKU University in Vienna, together with the department for Meteorology at the University of Vienna carried out a series of studies on the geographical distribution of the risk due to severe accidents in nuclear facilities of nuclear power plants in Europe in randomly chosen real weather situations from 1995. This study resulted in a database of spreading maps of impacts after a severe accident based on an accident scenario from the probabilistic risk assessment (PRA) of the involved reactor with a source term of several percent to several tens of percent of its I-131 and Cs-137 inventory – an accident comparable with the severity of each of the three Fukushima explosions.

As illustration, Figure 3.1 shows the results of several calculation runs for an accident in the Belene nuclear power station, if it ever were to be built; figure 3.2 for an accident in the Dukovany nuclear power plant in the Czech Republic; figure 3.3. for Tihange in Belgium; and figure 3.4 for an accident in the Astravets nuclear power plant in Belarus.

Figure 3.1 – Illustrative Flexrisk results for an accident in the 1st unit of the Belene NPP, Bulgaria[74]

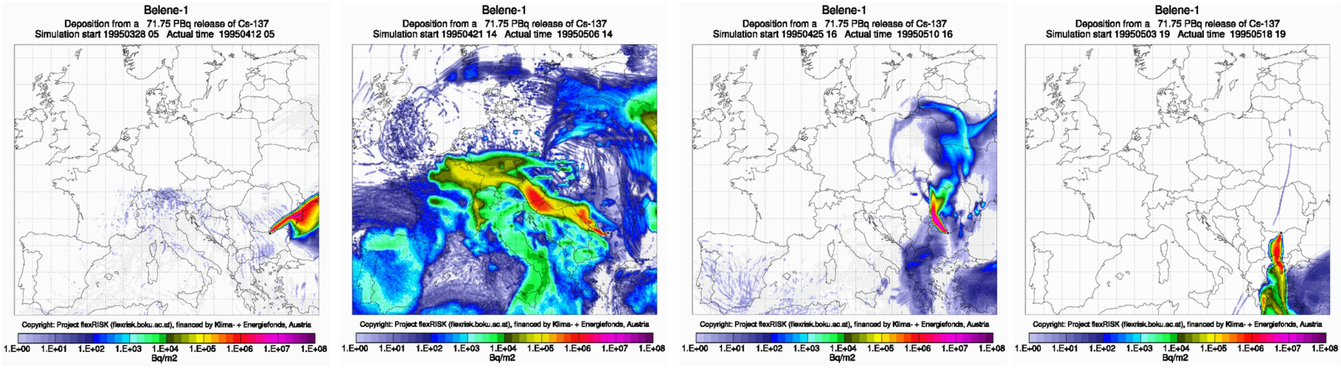


Figure 3.2 - Illustrative Flexrisk results for an accident in the 3rd unit of the Dukovany NPP, Czech Republic

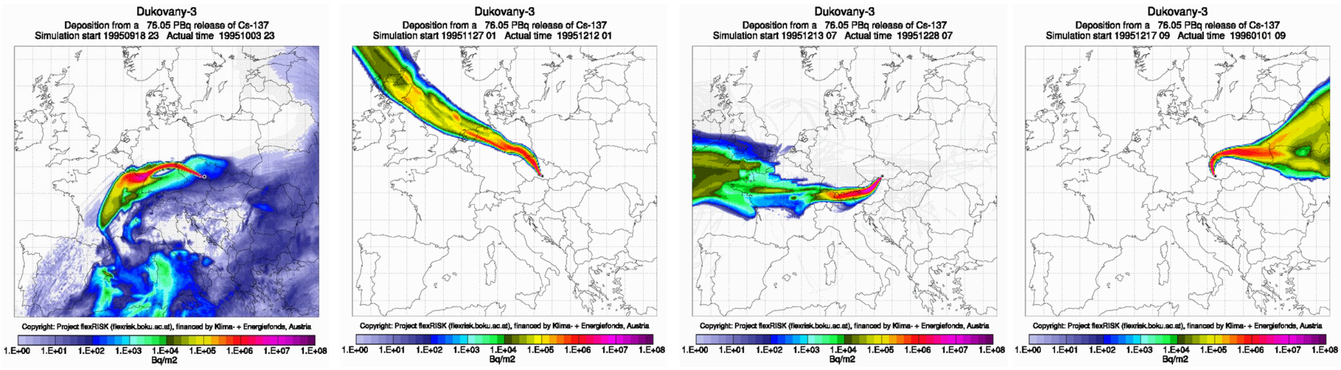
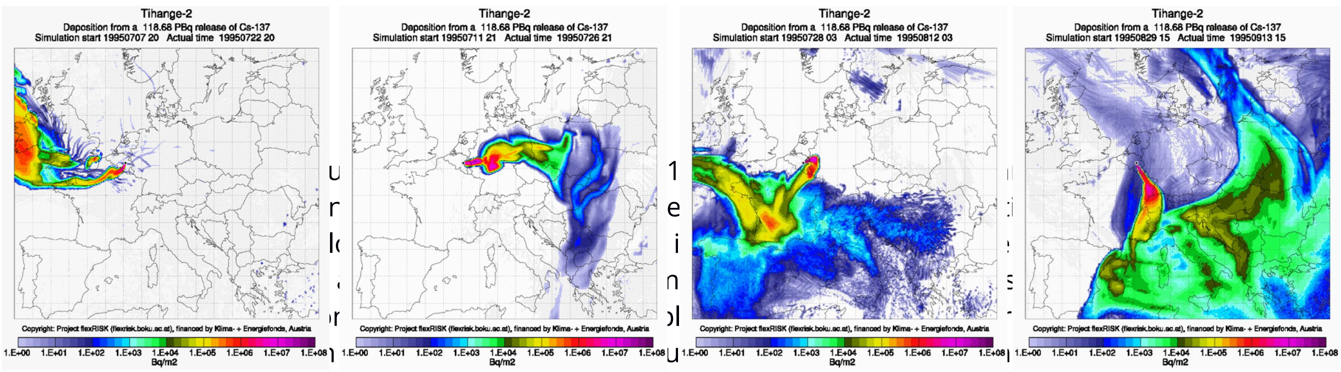
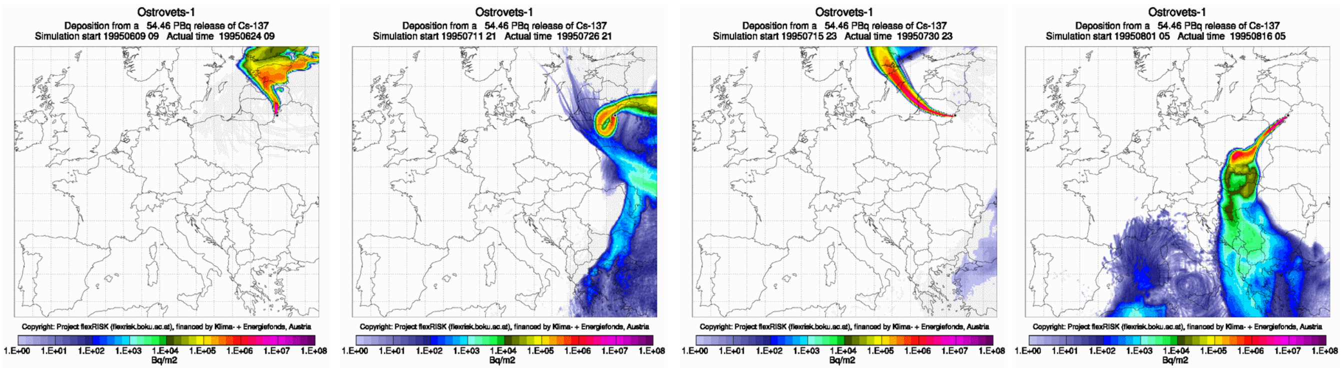


Figure 3.3 – Illustrative Flexrisk results for an accident in the 2nd unit of the Tihange NPP, Belgium



The time of accident has been chosen within a limited three month period to illustrate different effects and impacts of a severe nuclear accident.
Source: http://flexrisk.boku.ac.at/en/

Figure 3.4 – Illustrative Flexrisk results for an accident in the 1st unit of the Astravets NPP, Belarus



The figures show that even though the chance on these impacts may be small, if a severe accident occurs, the impacts may result in the need for very heavy measures, indeed. In the case of the fourth scenario for Belene, evacuation or shielding measures may be necessary in Pleven or even Sofia, and Greece will have to take measures to protect its agriculture. In the case of Dukovany, we see that such evacuation or shielding might be necessary as far as in Bavaria, Saxony, Austria or Poland. The pictures also give an indication of the disruption of agricultural and industrial activity, for instance in the Ruhr area in Germany after a severe accident in the Tihange NPP.

The independent French nuclear research institute IRSN has calculated in 2014 that were an accident of this severity to occur in France, the total economic damage could be in the order of magnitude of 450 Bln€.[75] It has to be clear from the Flexrisk analysis, that a large part of this damage could be caused in other countries, because radiation does not halt at a border. There is furthermore a saying in the nuclear field that "one accident in a nuclear power station in an accident in all nuclear power stations", referring to the loss of reputation of nuclear power world wide after every accident, and the need to submit all nuclear power stations to an in-depth assessment to assess whether a similar accident could not happen there – an exercise that severely increases operation costs.

75 IRSN, *Methodology used in IRSN nuclear accident cost estimates in France, report PRP-CRI/SESUC/2014-132*, Fontenay-aux-Roses (2014); http://www.irsn.fr/EN/publications/technical-publications/Documents/IRSN-PRP-CRI-SESUC-2014-00132_Methodology-of-IRSN-accident-cost-estimates.pdf

This all means that neighbouring countries have a clear interest to be involved in the regulatory safety regime of nuclear reactors near their borders. However, nuclear safety is considered, also in the EU and Euratom, a national sovereignty, which means that any cooperation is on voluntary basis and non-binding. That this can lead to tension may be seen in the case of the in paragraph 2.1 mentioned welding problems in the first unit of the Temelín nuclear power plant. Although the accessible documentation clearly shows reasons for high concern and Austrian and German authorities have communicated intensively about the issue with their Czech counterparts, the Czech nuclear regulator SÚJB has from the start refused to give open and transparent access to all documentation. This results in the highly unsatisfactory situation that although German and Austrian authorities and many of their citizens have sincere concerns about the safety of this border-near nuclear reactor, they have no means to force the Czech Republic to open up the file completely, let alone demand a shut-down of the reactor if they deem the risks too high.

Something similar is happening between Germany and Belgium concerning the Tihange NPP in Belgium. Also the tensions between Lithuania and Belarus around the Astravets NPP that is under construction in Belarus on 40 km of the Lithuanian capital Vilnius illustrate this: The site was chosen without consent from Lithuania, and the construction of the same type of reactor in Finland and Hungary is running into severe delays because the national regulators in those countries have genuine problems with the quality of the design documentation. Lithuania has no instruments to force the Belarusian nuclear regulator to be as rigorous as the Finnish and Hungarian one. Lithuania is fully depending on the skills of their neighbour's relative new and small regulatory authority that is under strong influence of the Russian constructor of the power station.

The post-Fukushima nuclear stress tests carried out by the European nuclear regulators group ENSREG have to some extent tried to improve cooperation by introducing an intensive, but voluntary, peer review process.[76] Also EU-surrounding countries like Switzerland, Norway and Ukraine participated in this, and even Belarus submitted after five years its construction project to a peer-review. But these tests only assessed a limited amount of issues and did not address important fields like

76 http://ensreg.eu/EU-Stress-Tests/Background-and-Specifications

nuclear security or emergency preparedness and response, independence of nuclear regulators and lessons learned after 2012.[77] However, they did force all participants, also Belarus and Ukraine, that are not a member of the EU, to accept the WENRA guidelines for nuclear safety as a common basis. Especially for countries like Ukraine and Belarus that is an improvement. But the national action plans that were developed on the basis of this process show that in countries where the national regulator is lacking distance from the nuclear industry, which unfortunately still is the case in most of Europe, these plans contain many studies ("*studies do not increase nuclear safety. Implementation of recommendations does.*"[78]) and (sometimes with a decade) delayed implementation of measures in response to serious safety related concerns.[79]

The European Commission has introduced in the 2014 review of the Nuclear Safety Directive the peer-review process on specific issues as an every three year returning operation.[80] The first one, carried out in 2017 and 2018, dealt with long term operation. However, instead of addressing the issue in a broad way, the European regulators were not able to agree on more than a limited technical point of view. Issues like risk perception (what factors should be taken into account when establishing which risk is deemed acceptable – not only technical factors, but also environmental, economic and social ones) and resulting necessary steps to bring power stations in line with what Europe considers an acceptable risk – were not addressed at all.[81] That means that in most cases, ageing nuclear power stations are posing a risk that may have been seen as acceptable for a limited time 30 or 40 years ago, but that is not acceptable today any longer because of our increased insight in

77 See for instance the presentation this author made during the third ENSREG conference about the implementation of the stress tests in 2015: http://www.ensreg.eu/sites/default/files/0.5-Haverkamp.pdf

78 Quote from the head of the UK nuclear regulator at the second ENSREG conference, 11-12 June 2013, in Brussels

79 https://www.greenpeace.org/archive-eu-unit/Global/eu-unit/reports-briefings/2013/Report_EU_Stress_Tests_NAcPs.pdf

80 Council Directive 2014/87/Euratom, article 8e; https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0071-20140814

81 http://ensreg.eu/sites/default/files/attachments/11-haverkamp-text.pdf

potential impacts and/or because changes in the environment has made impacts increase – think of increases in the amounts of economic activity, important natural habitats or amount of inhabitants surrounding a nuclear plant.

Especially transboundary risk situations are, however, increasing the pressure from neighbouring states and their citizens to change this situation. The potential risk of life-time extensions in Ukraine has led the Espoo Convention's Implementation Committee to demand a transboundary environmental impact assessment (EIA).[82] The Netherlands have been found in non-compliance with the Aarhus Convention for not providing public participation during its decision to prolong the lifetime of the Borssele nuclear power station.[83] In a Belgian court case by the Friends of the Earth member organisations BBL and IEW about the life-time extension of the Doel 1 and 2 reactors, which referred crucial questions to the European Court, the advocate general has submitted an opinion that also demands an EIA before any decision about long term operation.[84] Friends of the Earth member Global2000 in Austria has started procedures against the lack of a transboundary EIA for the prolongation of the Czech Dukovany reactors beyond their foreseen technical design life-time.[85]

3.2 Transboundary risks related to spent fuel and radioactive waste

The transboundary effects of nuclear power stations go beyond those in the case of severe accidents, however. The issue of **radioactive waste** is often perceived as one of limited impact. However, as long as countries like the Netherlands and Bulgaria continue to **transport** spent nuclear fuel for **reprocessing** to France, respectively to Russia, and resulting high-level waste back, this transport draws concern in countries

82 UNECE, *Report on the activities of the Implementation Committee to the Meeting of the Parties on its seventh session*, points 68 – 70; https://www.unece.org/fileadmin/DAM/env/eia/meetings/Decision_VI.2.pdf

83 UNECE, *Findings and recommendations with regard to communication ACCC/C/2014/104 concerning compliance by the Netherlands - Adopted by the Compliance Committee on 4 October 2018*; https://www.unece.org/fileadmin/DAM/env/pp/compliance/C2014-104/C104_Netherlands_Findings_advance_unedited.pdf

84 https://curia.europa.eu/jcms/jcms/p1_1480221/fr/

85 https://www.global2000.at/presse/abschalten-nicht-ausbauen-stellung-nehmen-gegen-neubau-akw-dukovany

en route. In Belgium, there is increasing unease about and resistance against the trains with spent fuel or vitrified waste running through towns like Antwerp and Ghent. The Bulgarian waste transports pass the Danube through Romania. If Hungary sticks to its plans to have the spent fuel from Paks II reprocessed in Russia, train transports of spent fuel will pass cities like Kecskemet, Debrecen and Zahony, but also in Ukraine Chop and other larger towns.

The issue of spent fuel reprocessing creates also transboundary responsibility: the problems surrounding the Mayak (Russia), la Hague (France) and Sellafield (UK) reprocessing installations are also caused by the insistence of European countries like Bulgaria, Belgium, Germany, Hungary, the Netherlands, Slovakia, and Switzerland to have their spent fuel reprocessed. Especially the case of Mayak is important in this respect, which because of its many problems sees strong opposition within the Russian population and resulting suppression by the Russian government. Mayak operates in a closed city, impenetrable for independent oversight. A local human rights lawyer standing up for the rights of employees and inhabitants in the closed town of Ozhersk, Nadezhda Kutepova, had to flee the country after she was declared "foreign agent" and faced threats.[86] The abysmal human rights track record of Mayak was also illustrated by photographer Robert Knoth with his pictures of the inhabitants of the village of Muslimovo, which is depending for its water on the Techa river and where only part of the population has been compensated and evacuated.[87] More recently, Rosatom showed its lack of reliability when all over Europe traces of the isotope ruthenium-106 were measured. Intensive international cooperation saw that there is virtually no other possibility than that this resulted from an attempt to harvest Ce-144 from fresh spent nuclear fuel for an experiment in Italy in a recently renovated installation in the Mayak complex. Although different independent assessment leaves

86 https://www.aljazeera.com/programmes/talktojazeera/2017/12/nadezhda-kutepova-life-russia-secret-nuclear-city-171214121737252.html

https://themoscowtimes.com/articles/suck-it-up-foreign-agent-57397

87 https://www.rferl.org/a/1063825.html

Haverkamp, Jan (ed.), *Rosatom's Mayak: More Reprocessing, More Contamination*, Vienna (2017) Greenpeace Central and Eastern Europe; https://www.greenpeace.org/archive-hungary/PageFiles/762727/Rosatoms_Mayak_more_reprocessing_more_contamination.pdf little space for doubt, Rosatom continues to deny anything went wrong in Mayak. This is especially concerning, because calculations from the French nuclear institute IRSN indicate a severe risk for people that were in a radius of 30 km from the installation when the release happened.[88]

3.3 Transboundary security risks

Another reason for transboundary concern is **security**. One of the major threats during the Fukushima catastrophe was the risk that the spent fuel pools could collapse, which would lead to far higher emissions of radioactive substances than happened now and could have threatened a much larger area. Near border installations with wet spent fuel storage like Fessenheim, Cattenom, Chooz and Gravelines in France, or Bohunice, Mochovce an Dukovany in Slovakia and the Czech Republic, or Astravets in Belarus and Leningradskaya in Russia pose a direct security threat not only for the host countries, but also for their neighbours. To reduce this risk, intensive cross-border security cooperation would be necessary which up to now is not in place.

Other security issues concern dependence on foreign knowledge for the operation of nuclear installations from countries with whom there are tensed relationships. This can be seen among others in Ukraine, where it appears to be impossible to untangle the close links between the Ukraine nuclear industry and Rosatom and other Russian companies like Gazprom owned OMZ (see for instance the story about the finalisation of Khmelnitsky 3,4 in par. 2.4).

3.4 Transboundary economic risks

Transboundary economic risks include the negative influence on the development of the electricity market in countries neighbouring or near to countries with an aggressive pro-nuclear policy. We see currently that the Netherlands and Germany have to deliver large amounts of electricity to Belgium, because several of the Belgian

88 https://www.irsn.fr/EN/newsroom/News/Pages/20180206_Detection-in-October-2017-of-Ruthenium-106-in-France-and-in-Europe-Results-of-IRSN-investigations.aspx

https://www.sciencemag.org/news/2018/02/mishandling-spent-nuclear-fuel-russia-may-have-caused-radioactivity-spread-across nuclear reactors are off-line for maintenance or because of incidents. This hampers the attempts of these countries to move away from their dirty coal installations.

Initially, Russia had plans to build the Baltiiskaya nuclear power station near Neman in the Kaliningrad oblast, an enclave surrounded by Poland and Lithuania. Together with the soon to be finalised Astravets power plant in Belarus, it was thought to be able to deliver large amounts of electricity to the Baltic States, Poland and Germany and undermine attempts of some in the political elite in Lithuania to build a new non-Russian nuclear plant at Visaginas. Kaliningrad was cancelled when it became clear that Germany would not accept a direct link for the output. Lithuania dropped its Visaginas project, when Lithuanian citizens refused to participate in such a power game in a 2012 referendum. As a result of the risk that Lithuania feels from the Astravets NPP, it strives to accelerate binding in the Baltic electricity system into the European ENTSO-E grid and as much as possible severe its links to the Baltic Ring in the Western Russian electricity grid. This is now foreseen to be finalised before 2025.

That brought Belarus in a difficult position. It had counted on income from export of surplus capacity to Lithuania and through Lithuania to Kaliningrad and the rest of Europe, where electricity prices are a lot higher than in Belarus. It intended to continue to provide its own population with electricity from cheap gas it receives from Russia. Now it faces the choice either to provide its own citizens with much more costly nuclear power or become fully depending on Russia. Russia, in turn, tries to resolve the falling away of the Baltic Ring with a new electricity connection between the Leningradskaya and Smolensk NPPs, where also Astravets could be linked to. For Russia, this is a double opportunity: it fully finances Astravets with a loan, which means that both the safety and financial risks are completely on the side of Belarus. But it could as main customer probably dictate the buying price for the electricity, which Belarus then only would be able to sell for prices competitive with the low electricity prices from its gas-powered stations.

Greenpeace Energy e.V., an of Greenpeace independent renewable energy utility in Germany, filed complaints against the construction of the Hinkley Point C nuclear power plant in the UK and the Paks II project in Hungary, because studies showed it could be impacted when the operation of heavily subsidised nuclear projects would put a downward pressure on the market prices for renewable electricity. Because of the interlinkage in Europe, this would be felt even several borders away.[89]

89 https://blog.greenpeace-energy.de/wissen/atomkraft/europaeischer-gerichtshof-weist-klage-von-greenpeace-energy-endgueltig-zurueck/

4. The increasing role of Rosatom

In the last two decades, it became increasingly clear that the need for a high level of nuclear safety is pushing nuclear energy out of the market. The success of the introduction of renewable energy in Germany and the accompanying decrease of price of these clean sources proved that the gamble of the Energiewende, which was started by the red-green German federal government in 2002, already removed the basis under the nuclear growth model of the large German utilities. This was closely followed by Belgium and Switzerland, which also decided for phase-out policies. The catastrophe in Fukushima only accelerated this development: even countries that did not want to turn away from nuclear power insisted on technical measures to exclude an accident as happened in Japan, which further increased the costs of nuclear construction and operation of the existing fleet.

This development pushed the nuclear construction companies Areva (now Framatom EdF), EdF, Toshiba – Westinghouse, Mitsubishi and Hitachi out of the market. Underestimation of the complexity of nuclear construction export to the United Arabic Emirates also has undermined the position of South Korean to spur its nuclear export plans. China's nuclear expansion programme slowed down after Fukushima, and attempts to expand with its Hualong 1 design to the export market are currently proving to be less straightforward – the first country where the design was submitted for a general design assessment, the UK, has reacted with a long list of adaptations if it is to meet UK nuclear safety standards. This will inevitably push up the price.

The Economist recently concluded that Rosatom has become the de facto monopoly provider for new nuclear construction.[90]

In order to expand against the global trend in which nuclear power construction costs continue to increase and renewable alternatives become cheaper, Rosatom uses a mix of intensive lobby, unrealistic advertisement promises, and offering full financial packages. Because its own financial capacity is limited, it sets focused priorities on where it moves forward. In order to be able to compete on the international market, Rosatom was in the forefront of developing generation III+ reactors and was the first

90 https://www.economist.com/europe/2018/08/02/the-world-relies-on-russia-to-build-its-nuclear-power-plants

to introduce evolutionary safety improvements like a core-catcher. After try-outs of an improved concept in China (the AES-91 in Tianwan) and India (the AES-92 in Kundankulam), where oversight is less rigorous and delays and cost overruns less transparent, it first tried to move into the EU over Bulgaria with the Belene project, also with an AES-92 design. When this project failed because costs appeared to be in line with similar designs from Areva / EdF, Westinghouse and Hitachi, which means too high to be affordable, and Bulgaria was not willing to take the related financial risk and dependency on Russia, it focused on speeding up its turtle-pace development of its VVER1200 projects in Novovorenesh 2 and Leningradskaya 2 in order to be able to come with a more or less standard design for the export market.

In order to show what it was capable of export, the Astravets project in Belarus got full priority. This was easy, because Belarus did not have a fully developed independent nuclear regulator and also no financial capacity for such an endeavour, so Rosatom could keep the project well under control.

After initial attempts to expand to the Czech Republic and Slovakia also failed on cost, it grabbed the opportunity when E.On decided to leave Fennovoima in Finland, and directly took over E.On's share against a promise that not Areva's winning EPR design would be built, but a VVER1200 / AES-2006. Without this offer, Fennovoima would have stranded, and thus Rosatom came into a comfortable position. As soon as the head of Finland's nuclear regulatory agency Jukka Laaksonen indicated his retirement, he was hired by Rosatom to lead it's export wing. It was from the start clear, however, that a project in Finland would be more complex than another opportunity which arose: the wish from Hungary to expand its nuclear fleet. Although Victor Orbán was originally seen as anti-Russian because of his role in the early 1990s, the nuclear card could bring him nearer to Russia, and Hungary unilaterally decided to cancel an ongoing tender with participation of Toshiba – Westinghouse, Areva / EdF, Hitachi and Rosatom, to only continue with Rosatom, risking problems with the European Union's competition rules. Russia wooed Hungary with offering a full financial package that would never be matchable by any other player, in spite of this opening the risk of problems with EU state aid rules. The Kremlin offered Hungary furthermore that 40% of the work would go to Hungarian companies. That was the sausage to make Orbán's entourage bite, even if also that meant more tension with the EU. For Moscow, this opened a second door into the EU, better controllable than a Finnish project (see under), yet with a stronger standing than a project in Bulgaria. It decided to punnish Bulgaria and sue it for lost costs (fully using the opportunity of having a Kremlin-loyal social-democratic government during the final procedures) and focus completely on Hungary instead. In the mean time it has become clear that the chance that 40% of the work on Paks II will go to Hungarian companies has withered away and that European rules for independent nuclear oversight mean that Russian standards, working practices and safety culture need severe adaptations, and the work both in Finland and Hungary has slowed down – both projects face currently 4 to 9 years delay in comparison with initial plans, and construction hasn't even started. This has given Rosatom space, however, to restart its attempts to pursue possibilities in the Czech Republic and Bulgaria, and make openings to enter the UK market.

Because Rosatom acknowledges the chance it might not succeed in what it originally thought to be its top prize, the EU and the UK, it also expands its interest in the developing world: Vietnam (cancelled because of costs), Bangladesh (Roopur, construction ongoing, fully Russian financed), South Africa (cancelled after corruption allegations), but also Kenya, Tanzania, Sudan, Nigeria and others.

4.1 Financial dependency

The case of Fennovoima's Hanhikivi in **Finland** (see paragraph 2.2) shows how dependence is built up Russian style: Rosatom bought up the share of E.On, but that is not sufficient to have full control over the project company Fennovoima. For security reasons, Finnish law requires that at least 60% of nuclear companies is owned by Finnish, EU or EEA countries. In order to gain more control, Rosatom tried to increase its participation over Migrit Solarna Energija, a Russian owned and led company registered in Croatia. This failed and that failure threatened to cancel the entire project. It then forced Finland's state utility Fortum with a mix of diplomatic and economic threats to save Fennovoima, while other partners in Fennovoima are not allowed to leave the company. Rosatom's 34% participation is sufficient to make it difficult to give up, but too little to run an overly large financial risk. Sub-contracting was granted to Russian firms like Titan-2, which also work in Russia as fixed partners of Rosatom.

In **Hungary**, Rosatom arranged more control. A sovereign loan covering 80% of the financing of the project against low interest but severe penalties for non-performance secured a strong line of financial dependence on the longer term.

Because financing of nuclear power projects has become impossible on the market, the possibility that the European Commission opened for the UK and Hungary – high levels of state aid with the argumentation that it cannot refuse this because of a debatable Euratom obligation to support nuclear energy development – offered Rosatom a unique opportunity in Europe. Because those countries that still look favourable to nuclear power are not in a position to find finances and neither are Rosatom's competitors. Rosatom offers full financial packages now also to the Czech Republic, Bulgaria and Slovakia. Where it struggles is in its attempts to have the financial risk rest on the host country. So far, the Czech and Bulgarian governments have made clear that also Russian financing has to happen on market conditions and that they accept no risk for their own budgets. Within those countries, politicians and groups that try to open this up can count on strong support from the Kremlin. Examples include president Miloš Zeman of the Czech Republic and the Bulgarian Socialist Party, currently ruling party GERB's main rival for power.

4.2 Corporate dependency

The Rosatom universe tries to maintain control over its market partners over as many lines as possible. It attempts to remain the monopoly provider of nuclear fuel over its sub-company **TVEL**. Fuel elements have to fulfil very specific technical criteria, and initial attempts from the Czech Republic, under pressure of the European Union, to diversify its fuel provision by using fuel for VVER1000 reactors made by Westinghouse failed for technical reasons.

Also Ukraine initially had to rescind on attempts to use Westinghouse fuel on technical grounds. The political pressure to reduce dependency on Russia after the Maidan protests, however, was so large that Westinghouse was given a second chance and will provide in the near future most of Ukraine's fuel. Once Ukraine decided to go ahead with Westinghouse, it was bombarded by media- and social media-campaigns trying to convince Ukrainian citizens that the use of Westinghouse fuel would be extremely risky. Although there is a thin layer of truth in the expectation that it will be easier for TVEL to deliver fuel that fulfils the exact conditions than for Westinghouse, and that this may have safety consequences, this concern was strongly exaggerated and not part of an expert discourse about those risks and what alternatives could be, but one of an attempt to scare the population.

In order to prevent loosing this grip, the bilateral contract between Hungary and Russia on Paks II included initially exclusive provision of fuel by TVEL for 30 years. Under pressure of the European Commission, this was reduced to 10 years with the possibility of prolongation.

TVEL is also responsible for reprocessing spent nuclear fuel, when a country opens that possibility. Initially, proposals for the 2011 radioactive waste directive from the European Commission blocked the possibility to move spent fuel out of the Union, unless return of all resulting waste from reprocessing was fully guaranteed. Under pressure of among others Hungary, the text was adapted in such a way that transfer of radioactive waste would be possible if the third country (i.c. Russia) would have installations to deal with the resulting waste. Because it is not clear how that has to be proven, it keeps the way open for reprocessing deals with TVEL.

One of the weakest parts of the Russian nuclear industry is that of decommissioning and final waste disposal. Rosatom for that reason bought the German firm Nukem in Hanau as soon as its initial owners, the German utilities, sought to divest following the nuclear phase-out decision. Nukem is now the main partner in decommissioning work in Lithuania, where Russian and German experiences can be combined. It also gives Rosatom the possibility to boast cradle to grave care for nuclear projects.

When Rosatom gets involved in foreign projects, it secures large participation of companies that can be kept loyal. This includes sub-contractors from its own oligarch universe like Titan-2 (Hanhikivi, Akkuyu), or from other state-near corporations like Gazprom owned OMZ and its Czech daughter Škoda JS. When Rosatom is involved, either historically or gets involved, it becomes soon impossible to continue without it. This can be seen in Ukraine, where it proves to be impossible to continue the Khmelnitsky 3,4 project without some form of control by Russian involvement, and where Ukraine is facing stiff opposition to its decision to use Westinghouse fuel.

Because the use of Russian sub-contractors probably is cheaper than European ones, companies like Titan-2 may be seen as advantageous, because high costs and cost-overdraws are the Achilles-heel of the sector. On the other hand, Hanhikivi shows that because these Russian firms are not used to the European regulatory environment, this may also cause concerns about safety and severe delays. The Finnish nuclear regulator STUK concluded that not only the nuclear safety culture in Rosatom, but also in Titan-2 was not sufficient.

The saga's around the hiring of STUK chief Jukka Laaksonen and the Croatian company Migrit Solarna Energija in Finland (see 2.2) shows that one has to be very aware that Rosatom may infiltrate projects over different pathways in order to maintain or strengthen its control.

Rosatom also works on improving its image. It has discovered that the only political argument remaining in Europe for nuclear power is the climate discussion, and it has become very active in supporting initiatives that propagate nuclear next to the introduction of renewable energy sources. It not only sponsored several years side-events at the climate COPs, but also teamed up with Dutch wind company Lagerwey to become Russia's major player in the wind energy market. This is, of course, a unique possibility to turn swords (a nuclear company) into plough-shares (renewable energy), but given the tiny part that wind energy is of Rosatom's portfolio, it has to be taken with a grain of salt.

Last but not least, it must never be forgotten that Rosatom is not a 100% civilian state company, but a military-civilian hybrid. It is responsible not only for the Russian nuclear energy sector, but also for the nuclear weapon sector. For that reason, dual use of technology and material delivered – be it spent fuel, depleted uranium, nuclear technology – can never be excluded. Also, Rosatom's loyalties for that reason will always remain on the side of Russian state security over commercial interest. Rosatom equals the Russian nuclear deterrent.

4.3 Personnel dependency

In order to maintain control over projects, key functions are occupied by Rosatom functionaries. But next to that, because since the changes in the early 1990s, Rosatom has developed its technology largely in-house, projects become dependent in design, documentation and vital implementation on staff input from Russia – to a much larger extent than used to be the case before 1989 when the Warsaw Pact countries closely cooperated on the development of nuclear technology and Czech, Slovak, East-German, Hungarian and Bulgarian engineers already had learned Russian in school.

Currently, Rosatom tries to create a sufficient basis of local workers by training them in Russia. Students from Turkey and Egypt already are coming to Obninsk and other Russian universities to get basic schooling. In Finland and Hungary, it has become clear, however, that Rosatom is struggling with sufficient staff and sufficient quality of staff. In both cases, documentation delivered to the local authorities does not fulfil basic quality criteria, and in spite of engineering teams in St. Petersburg working around the clock, documentation cannot be delivered in time.

In Finland, language is a basic issue. Finnish engineers are used to working in Finnish or English, whereas Rosatom engineers work in Russian. The Finnish nuclear regulator STUK has found several times that Fennovoima has insufficient capacity to deal with the flow of information, partially because of this language problem.

In Hungary it has even become clearer that language has become a problem. Here, Rosatom has not felt it needed to switch to a multi-language system where English is the intermediate language, which is understandable given the lower level of English skills in Hungary compared to Finland. But not only do younger Hungarian engineers not speak Russian any longer, they are also not familiar any more with the Cyrillic alphabet, making it more difficult to assess documentation and implement it on a satisfactory level.

4.4 Dependency in nuclear oversight

Independent regulatory oversight of the nuclear sector is a vital element to keep nuclear risk under control. The obligation for this independence has been internationally worded in the Convention on Nuclear Safety[91] and the Euratom Nuclear Safety Directive.[92] In order to maintain such independence, nuclear regulatory authorities should avoid any conflict of interest with nuclear licensees or organisations promoting nuclear power, and have sufficient independent financial and human capacity and skills available to fulfil their mandate. This is not easy to implement in the day-to-day reality, especially when we take the difference in construction culture into account that we have seen in Western Europe and that in the former Warsaw Pact. In the first, it was deemed that a detailed preparation and concise oversight of preparatory documentation would help to reduce the risks from nuclear reactors. As a consequence, approved designs need to be implemented to the letter and line. The nuclear regulator will require high quality documentation and will

91 IAEA, *Convention on Nuclear Safety*, art. 8.2; http://www.iaea.org/Publications/Documents/Infcircs/Others/inf449.shtml

92 European Commission, Council Directive 2009/71/EURATOM Amended by Council Directive 2014/87/Euratom, art. 5.2; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0467

then oversee strict implementation with extensive procedural guidance in case implementation leads to changes in documentation. In the former Soviet system, a lot more was left to the implementation phase itself, creating the need for a very flexible regulatory oversight. Traditionally, regulators from smaller countries, with the exception of Finland, furthermore had to rely on relatively small authorities and because the nuclear environment is smaller, there tends to be a stronger link between nuclear licensees and the regulator in the form of personnel exchanges and revolving doors, larger than in large countries with a large nuclear industry like the UK, France and Germany.

We have seen in former Warsaw Pact countries, that there exists until today a remaining strong link with the Russian nuclear industry. Partially because senior staff has been educated in the Soviet Union, partially because the size of the regulatory bodies forces them to keep close links with the Russian nuclear industry in order to remain updated about the developments with the former Soviet fleet.

Already in an early stage, **Finland**'s regulator STUK expressed its concerns about the level of safety culture and the quality of documentation it was receiving from Fennovoima and Rosatom.[93] STUK is an independent regulator that has a large body of skill and capacity to deal with projects in a pro-active way, which means it has the capacity to carry out research on its own and on its own initiative. It also demands a basic level of quality of materials it needs from a licensee for licensing processes, and will send it back when this quality is insufficient. STUK furthermore has a reputation of independence that is in Europe only matched by the French ASN, in spite of the incident whereby former STUK chief Jukka Laaksonen was hired by Rosatom only days after his STUK retirement. It may even be assumed that current STUK director Peteri Tiipana guards STUK's independence with even more vigour in order to win back credibility.

93 https://yle.fi/uutiset/osasto/news/nuclear_agency_no_progress_in_safety_culture_at_fennovoima/10434573

STUK had earlier published a study on the issue:
Ylonen, Marja, Heli Talja, Nadezhda Gotcheva and Merja Airola, *Evaluation of safety culture of the Hanhikivi-1 project key organizations: Fennovoima, RAOS Project and Titan-2 - Final Report*, Helsinki (2017) VTT; https://www.stuk.fi/documents/12547/207522/1731883-loppuraportti-fh1-turvallisuuskulttuurin-riippumaton-arvio-2017-vtt-julkiset-osat.pdf

The situation in **Hungary** is very different. The nuclear regulator HAEA has less capacity at its disposal (financial and personnel) and acts more as a re-active regulator. It is depending on the input it receives from licensees. But it is also facing a lot more pressure from politics.

In December 2016 the Hungarian government tried to speed up the Paks II project by giving itself the mandate to go around HAEA set license criteria for projects related to construction of nuclear installations or management of radioactive waste.[94] Only after intervention by among others Greenpeace and pressure from the European Commission and the Convention on Nuclear Safety, this law was retracted. In a comparative assessment of the Finnish and Hungarian nuclear regulatory independence, the Vienna based Institute for Safety and Risk Studies found that the Hungarian HAEA needs to assess submitted documentation for the construction of new nuclear capacity within legally prescribed fixed time limits.[95] This is a strong reason for concern, given the problems currently seen in Finland with documentation quality, and given the current lack of human capacity and skills at HAEA. Arnold e.a. concluded: “The prescribed time limits may lead to undue pressure on the regulatory body to complete its decision-making process and thus compromise safety. STUK, for example, the regulatory authority of Finland, can evaluate without such time constraints.”

These experiences in Finland and Hungary also raise concerns for the already far proceeded Rosatom export project in Astravets, **Belarus**. Belarus never had nuclear power, and its nuclear regulator Gosatomnadzor is facing a very steep learning curve in an attempt to maintain independent oversight. It needs to lean strongly on the information provided by Rosatom (which, as shown earlier, according to the Finnish and Hungarian experiences is insufficient and of insufficient quality), on training by Rosatom, and support from the Russian nuclear regulator Rostechnadzor. Belarus responded to the increased critical remarks on this issue from the side of Lithuania

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94 Act CXLIII of 2016, § 14 (1) and (2); http://magyarkozlony.hu/hivataloslapok/ed5602bae3bbe7ea64f0c00119c5dcdffde61910/dokumentumok/69ee0fd67e37f09aff57cd7be072ddcb8b8f81d5/letoltes

95 Arnold, Nikolaus, Klaus Gufler, Michael Kraxberger, Nikolaus Müllner, *Independent evaluation of nuclear power plant project safety Looking at examples in Hungary and Finland*, Vienna (2018) Institut für Sicherheits- und Risikowissenschaften, Universität für Bodenkultur Wien; https://secured-static.greenpeace.org/hungary/Global/hungary/kampanyok/atomenergia/paks2/Independent_evaluation_of_NPP_project_safety.pdf

and the EU by starting the post-Fukushima stress test peer-review procedure in cooperation with the European Commission and ENSREG.[96] This procedure does not assess regulatory adequateness, but during the presentation of the peer-review report in Brussels, it became clear that there is still quite a gap between EU regulatory practice and that in Belarus. Also, Russia appointed one observer in the ENSREG peer-review team, and Rosatom sent a five person delegation to the Brussels presentation in order to influence important findings from the peer-review committee, among others concerning insufficient seismic robustness. This illustrates well the difficult position in which the Belarusian nuclear regulator finds itself.

In the Czech Republic, Slovakia and Bulgaria, we still see cases where the above mentioned differences in nuclear construction culture and close links with the former Soviet system influence the operation of independent nuclear regulatory oversight.

An infamous case in the **Czech Republic** is the Temelín unit 1 welding case, where political pressure led the nuclear regulator SÚJB to permit start-up of the reactor in December 2000 when there were still ongoing investigations into potentially highly risky illegal repairs to welding in one of the primary cooling circuits. Until today, SÚJB continues to prevent full transparency around this issue.[97]

Since then, we have been able to see several instances where the independence of the nuclear regulatory authority has come into doubt, among others by the participation of the chairwoman of the SÚJB, Ms. Dana Drábova, in the Czech state commission to establish the national energy policy, for some time even as vice-chair, her participation as candidate in regional elections and many instances in which she in the media propagated nuclear energy. The fact that this is not thematised in the country, and that no steps are undertaken to improve SÚJB's independence can be seen as a legacy of the time when authorities were not questioned.

96 http://www.ensreg.eu/sites/default/files/attachments/joint_press_release_4_july_2018.pdf

97 See for instance:
Haverkamp, Jan and Jiri Tutter, *Unsettling facts on Temelín – Factsheet, version 3.2*, Prague (2011) Greenpeace Czech Republic – available from jan.haverkamp@greenpeace.org

Majer, Dieter, *Potential weak spots in the primary circuit in Block 1 of the Temelin nuclear plant in the Czech Republic – Short advisory statement on behalf of the Alliance 90/The Greens parliamentary group in the Bundestag*, Wiesbaden (2013); https://kotting-uhl.de/site/wp-content/uploads/2013/09/Majer_-_statement_NPP_Temelin_1_-_2013_Aug_english.pdf

In **Slovakia**, we have seen how the nuclear regulatory authority ÚJD not only refused to implement two High Court decisions and two sets of findings from the Aarhus Convention Compliance Committee (ACCC) on lack of public participation and transparency[98], but pro-actively tries to prevent public participation in decisions around nuclear life-time extensions by highly visible and active participation in the Espoo ad-hoc working group on the issue. It is most striking to see the difference in attitude from ÚJD towards civil society and NGOs when compared with, for instance, that of the French ASN, the Finnish STUK, the Swedish SSM, the UK ONR or the Dutch ANVS. This bias against more openness and transparency translates in a relatively close relationship with the “nuclear village” - representatives from the nuclear industry.

4.5 Transparency and information

Since the accession of new member states to the EU in 2004, Rosatom has tried to participate in the EU debate about nuclear power. It participates in conferences like the European Nuclear Energy Forum (ENEF), the bi-annual ENSREG conferences, conferences of the OECD Nuclear Energy Agency and others.

It is much more difficult, however, to get a picture of dependency in transparency and information policy in indirect ways. Was Rosatom, for example, involved in contacts between Hungary and the European Commission concerning the art. 41 Euratom notification of the Paks II project, or concerning the investigations into illegal state aid for Paks II? Also the relationship between Rosatom and the European nuclear industry lobby organisation Foratom (that has no Russian national member organisation) is not very clear.

We have seen Rosatom become more outspoken in the climate debate, among others as an active participant of the Nuclear for Climate initiative, sponsoring side events at the Marakesh, Fiji (Bonn) and Katowice climate COPs. It also tries to profile itself as a renewable energy company, among others in a project to introduce wind energy in

98 See among others:
ACCC/C/2009/41 Slovakia –
https://www.unece.org/fileadmin/DAM/env/pp/compliance/C2009-41/Findings/ece_mp.pp_2011_11_eng_add3.pdf
ACCC/C/2013/89 Slovakia –
https://www.unece.org/fileadmin/DAM/env/pp/compliance/CC-58/ece.mp.pp.c.1.2017.13.e.pdf

Russia with the Dutch wind company Lagerwey. To what extent it financially backs initiatives into this direction remains unclear, however.

The Russian nuclear industry is still far more rooted in secrecy than other nuclear operators in Europe. This is partially because of the fact that Rosatom is a hybrid military-civilian corporation. But also the history of closed cities like the ones around the Zheleznogorsk and Mayak nuclear complexes is still continuing to today.

Russia has signed the Espoo Convention, but never ratified it, although it claims to adhere at least to its transboundary obligations. However, it did not organise transboundary public participation for, for instance, the EIA for its Baltiiskaya nuclear project near Neman in the Kaliningrad oblast. Russia never signed the Aarhus Convention on transparency, public participation and access to justice in environmental matters.

In Russia itself, it boasts its track record of transparency by referring to its stakeholders forum, where it regulatory discusses issues with civil society, including more critical organisations like the Social Ecological Union (FoE Russia) and Bellona. On the other hand, critical NGOs like Ecodefense, with offices in Moscow and Kaliningrad, and Green World, based in Sosnovy Bor and St. Petersburg, were declared “foreign agents” (though both organisations more or less successfully fight these allegations) and are regularly intimidated for their watch-dog function towards the nuclear industry.

What is clear, is that there is dependency in transparency and information policies in projects where Rosatom is involved. When Bulgaria submitted its Belene project in the mid-2000s to the European Commission for a viewpoint under article 41 of the Euratom Treaty, it was interference by Rosatom’s Atomstroyexport that prevented publication of the notification documentation. Even when the European Ombudsman came to the conclusion that more transparency should have been given, the European Commission so much feared its relationship with the involved parties that it refused to follow the Ombudsman’s friendly proposal for settlement.[99] Also the notification documentation for the Mochovce 3,4 project in Slovakia and the Paks II project in Hungary was not made accessible to the public, not even after blacking out

99 https://www.ombudsman.europa.eu/en/decision/en/11717

potential commercially confidential information or information related to state security.

5. Conclusions

Nuclear power is in Europe clearly on the decline. The European Commission calculated in its PINC study that if Europe were to upkeep its share of nuclear in the electricity mix, 90GWe of new capacity would have to be constructed before 2050 and 10 GWe of old capacity would have to be maintained past its technical lifetime. This scenario is highly unrealistic, and it is more likely to expect that the EU will only have around 5 GWe left over in 2050, from which 1 GWe would go off-line around 2060 and the rest before 2080.

That is, if there will not be a fundamental change in EU policy in favour of severely subsidising nuclear power. If the EU, with reference to Euratom, will allow for large subsidies, and if any countries are willing to take the financial risks attached, it is likely we will only see nuclear expansion in Central Europe. With the exception of Poland, that is likely to involve Rosatom. Combined with the ongoing dependency on Rosatom and related Russian corporations for life-time extension of the existing fleet, the ongoing love-relationship of Central Europe with nuclear means de facto an ongoing dependency on the former big brother.

There is little chance that EdF/Framatom or Westinghouse will be able to become active in the European market for new nuclear, because they are not capable of sharing part of the financial risk for over-subsidised new nuclear programmes. Korean and Chinese companies will only be able to do so when their respective governments will chip in to carry part of this risk. So far, only Russia has shown to be willing to take this pathway, relying on its already existing close and often personal relations in Central Europe.

It is not a surprise that we see the ongoing interest in nuclear power therefore mainly in former Warsaw Pact countries and Finland, while the only country still trying to deal with other investors and construction companies, the UK, is struggling to keep its plans afloat. The odd one out so far is Poland, which continues to communicate internally that it will not deal with Russia in nuclear business, while its energy minister vehemently defends a nuclear pathway. This may mean less dependency on Russia, but will have to be paid with larger financial risks.

The dependency on Rosatom can be seen today in the form of different forms of corruption, coercion and political pressure, as can be seen probably most clearly around the Hanhikivi project in Finland, a country that still has a relative transparent society with a strong independent national press. How relations are formed between Bulgarian, Czech, Hungarian, Slovak, or Ukrainian interest groups and Rosatom is far less obvious, because research journalism in those countries is simply not in a position to get a grip on this. But the re-entrance of nuclear into the Bulgarian political debate over people like Bogomil Manchev (CEO of Risk Engineering) and Rumen Ovcharov (from the social democrat former government party BSP), two people who faced allegations over mishandling the Belene case and who are well known for their short lines with Rosatom, is a good illustration that it is not commercial sense but personality politics that are leading. Similarly, the strange manoeuvring around the Ukrainian Khmelnitsky 3,4 project in Ukraine, in which the government tried to obscure Russian influence by moving it to the Czech based, but Russian owned Škoda JS, makes clear that any move forward for the nuclear village in Central Europe is because of its close connection to Russia.

The most worrying aspect next to financial bonding and political influence may be the influence of the short distance between the nuclear village and governance structures on the independence of the nuclear regulatory authorities. Nuclear safety relies fully on independent and transparent oversight. And it is important to notice that transparency and independence go hand in hand here. We see in all countries where Rosatom influence is large that this independence is under threat, with the exception of Finland, where the regulator itself cherishes transparency, and where independent media keep the watch-dog under close scrutiny. This could not prevent the scandal of the former regulatory chief moving to Rosatom, but at least this went not unnoticed and Finnish nuclear regulator STUK seems to do everything in its power to prevent that scandal negatively influencing nuclear oversight. In countries like Slovakia, where the nuclear regulator ÚJD actively blocks access to information, actively undermines public participation and the need for sensible environmental impact assessments, or countries like the Czech Republic, where potentially severe construction faults are turned under the carpet with active help of its nuclear regulator, or like Hungary, where the government tries to get its fingers in the conditions the nuclear regulator sets in licensing, it is of paramount importance that politics, civil society and the EU understand that digressions of that kind are resulting in larger risks on a nuclear accident.

It is clear that the long-term lock-in into Rosatom dependency is a crucial factor in the development of the nuclear industry in Central Europe. This lock-in happens as soon as the first investments are made and no matter how much window-dressing or actual changes to the projects are made, it remains a crucial factor. The Czech Republic was not able to loosen the grip of Rosatom on the Temelín nuclear power plant by introducing Westinghouse digitalisation, and after Škoda's break up and privatisation, Russian OMZ keeps a clear finger in the game. Similarly in the case of Mochovce 3,4 in Slovakia, where companies with traditional close links to Rosatom remain crucial in the implementation. In Belarus, even a European Union co-organised peer-review of the nuclear oversight cannot change the fact that the speedily ongoing construction of Astravets is completely controlled by Rosatom. This long term lock-in is also a clear risk for projects like Hanhikivi, Paks II and other potential future projects in Bulgaria, the Czech Republic and Slovakia. But also for the UK or Poland, if they cannot resist what may be for some a mouth-watering offer from Moscow in the form of the only way that they can realise their nuclear dreams.

In Turkey, Russia appears to use Rosatom in the Akkuyu project not only to provide some of its managers with a potentially nice holiday resort on the Mediterranean, but to open the door for close cooperation in other spheres like the war in Syria, control over alternative gas-routes from the Caspian Sea area, and other foreign policy goals.

It is clear that Rosatom's influence is depending on political priorities of its home country. We have seen that priority shifting from Bulgaria to the Baltiiskaya nuclear power plant in the Kaliningrad region to Belarus, Finland, Hungary and Turkey. Russia has only limited finances to invest in its foreign projects and the speed of development of projects it supports financially will be depending on political priorities. Currently, these priorities seem to move towards Egypt, later maybe Africa.

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This study has been written in commission for the Greens/EFA in the European Parliament. The assessment is written on personal title and any opinions and mistakes are the author’s.

Annex 1. Risk of necessary transboundary emergency response

Near border reactors are indicated by name; New projects under construction are indicated with a +; Plans for new projects (not yet under construction) are put in brackets; Plants past their initial technical design life-time are indicated with age.

Country affected	**Country of origin**	**Nuclear power station**	**Number reactors**	**Distance to the border of nearest NPP (km)**	**special risk**
Austria	Czech Republic	Dukovany	4 (+1)	32	nearest NPP to Vienna >33 yrs old
		Temelín	2 (+2)	48	
	Germany	Isar	1	63	
			6		
	Hungary	Paks	4 + 2	175	>36 yrs old
	Slovakia	Bohunice	2	54	>34 yrs old
		Mochovce	2 + 2	100	
	Slovenia	Krško	1	77	
	Switzerland		5	100	
Belgium	France	Cattenom	4	31	
		Chooz	2	3	
		Gravelines	6	30	
			55 + 1		
	Netherlands	Borssele	1	16	>45 yrs old
	Germany		7	194	
	UK		15 +2 (+8?)	152	
Bulgaria	Romania	Cernavoda	2 (+2)	35	
	Turkey		(+8?)		

Country affected	**Country of origin**	**Nuclear power station**	**Number reactors**	**Distance to the border of nearest NPP (km)**	**special risk**
Croatia	Hungary	Paks	4 + 2	70	
	Slovenia	Krško	1	10	Zagreb 30 km
Czech Republic	Slovakia	Bohunice	2	56	>30 yrs old
		Mochovce	2 + 2	119	
	Germany	Isar	1	90	
			7		
Cyprus	Turkey	Akkuyu	+2(+2)	100	
			(+6?)		
Denmark	Sweden	Ringhals	4	56	>44 yrs old
			4		
	Germany		7	107	
Estonia	Russia (Europe)	Leningradskaya	4 + 2	68	RBMK reactors >45 yrs old
			31		
	Finland	Loviisa	2	80	>41 years old
			2 + 1 (+ 1)		
Finland	Russia (Europe)	Leningradskaya	4 + 2	96	RBMK reactors >45 yrs old

Country affected	**Country of origin**	**Nuclear power station**	**Number reactors**	**Distance to the border of nearest NPP (km)**	**special risk**
			31		
	Sweden	Forsmark		54	
			5		
France	Belgium	Tihange	3	51	>43 yrs old
			4		
	Spain		7	170	
	Switzerland	Mühleberg	1	38	Fukushima type reactor >47 yrs old
			4		
	UK		15 +2 (+8?)	134	
Germany	Belgium	Tihange	3	58	>43 yrs old
			4		
	Czech Republic	Temelín	2 (+2)	56	
			4 (+1)		
	France	Fessenheim	2	1.5	>40 yrs old
		Cattenom	4	13	
		Chooz	2	95	
			50 +1		
	UK		15 +2 (+8?)	590	

Country affected	**Country of origin**	**Nuclear power station**	**Number reactors**	**Distance to the border of nearest NPP (km)**	**special risk**
	Switzerland	Leibstadt	2	0.2	
		Beznau	1	6	>49 yrs old
		Gösgen	1	20	
		Mühleberg	1	70	Fukushima type reactor >47 yrs old
Greece	Bulgaria		2 (+2)	245	
	Turkey		+2 (+8?)	475	
Hungary	Romania		2 (+2)	590	
	Slovakia	Mochovce	2 +2	37	
		Bohunice	2	99	>30 yrs old
	Ukraine		15 (+2)	380	
Ireland	UK		15 +2 (+8?)	208	
Italy	France		58 +1	119	
	Slovenia		1	129	
	Switzerland	Mühleberg	1	99	Fukushima type reactor >47 yrs old
			4		
Latvia	Belarus		+2	108	
	Russia (Europe)		35 +2	270	

Country affected	**Country of origin**	**Nuclear power station**	**Number reactors**	**Distance to the border of nearest NPP (km)**	**special risk**
Lithuania	Belarus	Astravets	+2	22	45 km from Vilnius
Luxembourg	Belgium	Tihange	3	64	>43 yrs old
			4		
	France	Cattenom	4	9	20 km from Luxembourg city
		Chooz	2	72	
			52 +1		
	Germany		7	153	
Netherlands	Belgium	Doel	4	3	>44 yrs old
		Tihange	3	38	>43 yrs old
	Germany	Emsland	1	20	
			7		
Poland	Belarus		+2	181	
	Czech Republic		6	120	>33 yrs old
	Germany		7	320	
	Slovakia		4 +2	139	
Portugal	Spain		7	103	
Romania	Bulgaria	Kozloduy	2	4	

Country affected	**Country of origin**	**Nuclear power station**	**Number reactors**	**Distance to the border of nearest NPP (km)**	**special risk**
		Belene	(+2)	7	
	Hungary	Paks	4 +2	63	>36 yrs old
	Ukraine		15 (+2)	228	
Slovakia	Czech Republic	Dukovany	4 (+1)	75	>33 yrs old
			2		
	Hungary		4 +2	132	
	Ukraine		15 (+2)	328	
Slovenia	Hungary		4 +2	174	
Sweden	Finland	Hanhikivi	+1	128	
			4 +1		>41 years old

Annex 2. Nuclear power projects in Europe

[separate Excel sheet - 20190102_EU_nuclear_reactors_short]