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The disaster of the European nuclear industry

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The "European Pressurized Reactor (EPR)", once proclaimed to be a new impetus for the nuclear renaissance, turned out to be a disaster, characterized by safety deficiencies and cost explosions. The EPR construction sites in Flamanville, Olkiluoto and Hinkley Point C have already proved to be total failures even before their completion. Years of delays in commissioning, serious safety deficiencies and skyrocketing construction costs characterize the projects. The further construction of these reactors could be secured only by means of multi-billion Euro state rescue packages. The EPR is a clear example of the failed nuclear industry, which causes extreme costs and is thus incapable of competing with renewable energy. The current push for the development of a European fourth generation nuclear reactor will be a similar disaster to EPR's and should therefore be stopped as soon as possible. This synopsis summarizes arguments, why a further expansion of nuclear energy should be stopped in order to avoid continuous cost explosions and billions of Euros in public debt, especially in light of significantly cheaper renewable energies.

In 1992, Germany and France (Siemens and AREVA¹) launched the design process of a so-called third generation of nuclear reactors. A novel type of pressurized water reactor (European Pressurized Reactor, EPR) was developed.² The EPR was supposed to be inherently safe. In 2006, the French nuclear reactor builder AREVA predicted a worldwide nuclear renaissance in which AREVA would sell around 200 EPRs.³

To date, however, the history of the EPR is nothing more than a story of unfinished pilot projects that are still failing to deliver electricity even a decade after construction began, tremendous cost overruns, court cases over electricity contracts that were not fulfilled, and unsolvable technical problems. The nuclear companies involved and the states supporting them are also struggling with massive scandals, deficits in safety-relevant components, frauds, falsifications and other legal issues.^{4 5} Increased risk of terrorism are being ignored. Not a single EPR reactor construction was completed by the end of 2017, let alone the sale of 200 EPR reactors.

¹ On 23 January 2018 „AREVA“ changed its name into „Orano“. The majority of its reactor business was sold to state-owned company EDF. As the described developments are based on decisions made by former AREVA, it will be considered via this name in the following synopsis.

² De Vulpillières (2016)

³ Massemin (2017b)

⁴ Massemin (2017a)

⁵ Kotting-Uhl (2017)

The EPR project thus turns out to be one of the largest money pits ever, bringing AREVA and EDF to the brink of bankruptcy, similar to what the US-Japanese nuclear reactor builder Westinghouse had experienced in 2017. The EPR causes an additional debt for AREVA and EDF in excess of tens of billions of Euros. Both companies can only survive with multi-billion Euro taxpayer subsidies, which in turn increase the French national debt. The national debt of France is one of the highest in the EU, with all the known dangers to European financial stability. The EPR is thus not only a threat to the financial stability of the companies and the French state involved, but even for the EU as a whole.

EPR construction sites in the European Union: Olkiluoto, Flamanville, Hinkley Point C

The serious economic and technical grievances characterize the EPR reactor construction sites in the EU in Hinkley Point C (UK), Olkiluoto (FI) and Flamanville (FR).

In 2007, the British subsidiary of the French state-owned EDF told the UK citizens that the EPR reactors in **Hinkley Point C** would provide the first electricity by Christmas 2017, in combination with the obviously false claim that without these reactors the lights would go out. By the end of 2017, there was no talk of that. The start-up date has been postponed until 2027.⁶

The problem-prone French EPR project in **Flamanville** is also ten years old. Groundworks started in 2007. The reactor was supposed to provide electricity by 2012. Now its start-up is not expected before 2020.⁷

More than 12 years have passed since the start of EPR construction at the **Olkiluoto** site in Finland. AREVA started with the construction in 2005 with commissioning expected by 2009. The would be operators, a Finnish joint venture group, are now suing AREVA for the loss of billions of profits. Since 2009, AREVA and the Finnish investor Teollisuuden Voima (TVO) have been in court about the damage caused by electricity contracts that were not fulfilled.⁸ The originally envisaged costs and construction schedule for these AREVA projects went totally out of control, and there is no prospect of a reliable completion date. The original cost estimates of 3 billion Euros have now more than tripled to about 10.5 billion Euros at Flamanville and 8.5 billion Euros at Olkiluoto.^{9 10 11 12}

The nuclear industry in France

The developments in the French nuclear industry serve as an example of the state of nuclear industry worldwide. The real total costs are hidden and imposed either to ratepayers or taxpayers.

⁶ The Times (2017)

⁷ Le Figaro (2017)

⁸ Nuklearforum Schweiz (2017)

⁹ Nucleopedia (2015)

¹⁰ Nucleopedia (2017)

¹¹ Streck (2016)

¹² Le Figaro (2017)

Currently the problems of the EPR projects seem almost unsolvable: The serious flaws in the bottom and lid of the EPR reactor pressure vessel in Flamanville cannot guarantee safe operation. On the other hand, laborious replacements of the defective components would make commissioning impossible before the contract deadline of 2020. This will lead to the failure of the EPR construction at Hinkley Point C for contractual and financial reasons, with incalculable financial consequences for AREVA and EDF including the potential for financial ruin. The French nuclear regulatory authority ASN is facing a huge decision to either accept the contamination of Europe by the threat of a nuclear catastrophe or to push AREVA and EDF into bankruptcy.

Despite massive cost overruns, there are extremely dangerous safety deficiencies at the Flamanville construction site, which are being accepted for financial reasons.

The French nuclear regulatory authority ASN is formally independent, but is effectively under control of the French Ministry of the Environment. For the first time in history, the regulator has now approved the operation of nuclear reactor components, which it explicitly deems to have "diminished safety". This concerns two system-relevant defective parts from the AREVA metallurgy site Le Creusot: the bottom and the vessel head of the Flamanville reactor pressure vessel (RPV). Both are measurably too unstable due to carbon inclusions in the forged steel. There is a high risk that during operation a crack will open up to a rupture. This would cause the fuel rods fall dry, resulting in a meltdown similar to Fukushima. The vessel head, which would be operating under "specific control" until it has to be replaced in 2024, would be a temporary risk according to ASN.¹³

This replacement will be much more complicated and expensive, if one has to deal with irradiated material, compared to a replacement before the first chain reaction. In addition, there is a potential risk for the subsequent operation of the plant: steel and concrete of the containment building have to be cut open for an additional temporary transport opening in order to install a vacuum lock through which the replacement vessel head will be introduced into the building.¹⁴

The risk of the second flawed component, the RPV bottom, has been underestimated in the public perception: the bottom is already firmly welded within the RPV. A complete new vessel would have to be installed to meet the nuclear regulatory requirements. That would be the end of the EPR, with all consequences.

With the decision to allow a – temporary – use of the defective parts, the nuclear regulator ASN remains under the enormous pressure of the nuclear industry on the one hand, which wants to see their flagship Flamanville reactor succeed and wants to sell its reactors worldwide in the future. On the other hand, ASN has to guarantee the safety of the people in Europe, which is impossible with vital components identified as deficient. However, the current defective situation is to be tolerated for economic and political reasons. In addition military reasons obviously play a role, which will be discussed below.

¹³ Autorité de sûreté nucléaire (2017a)

¹⁴ Autorité de sûreté nucléaire (2017a)

The fact that ASN is acting under pressure from such constraints is shown by two further aspects: First, there was no independent technical institute charged with material testing of the French Areva reactor, but a German subsidiary, Areva Erlangen. But this did not lead to Areva losing the license. The reactor manufacturer agreed with the supervisory authority ASN on additional material testing, which then - as described above - ultimately led to an approval.¹⁵

Second, it is proved by ASN's handling of another deficient component, which like Flamanville's two RPV domes, head and bottom, is one of the most problematic that have ever left the Areva Creusot forge.¹⁶ This is about a steam generator, which was installed in 2012 in block 2 of the nuclear plant Fessenheim. This plant was shut down immediately after the inferior steel quality of the steam generator became known on 13.6.2016 and is still offline today. In contrast to Flamanville 3, Fessenheim 2 is at the end of its lifetime, which apparently facilitates the withdrawal of the operating license.¹⁷ These are further indications that ASN applies double standards and does not act consistently rationally and independently.

Flamanville also has an impact on Hinkley Point C, in the United Kingdom: An avalanche of cost will roll towards EDF and its co-investors if Flamanville is not completed and fully operational by December 2020, as well as producing electricity according to its design beyond trial operations. If this is not achieved before the UK Credit guarantee cut-off date, this UK government credit guarantee for Hinkley Point C would be cancelled.¹⁸

The approval of Flamanville's commissioning despite the known deficiency of parts is a gross violation of standards by the French nuclear regulator ASN, as it was not deemed approvable to put material into service that is previously known to be defective and non-standard-compliant in such a highly sensitive area.

ASN's approval to put the Flamanville reactor into service was also a precondition for the European Commission to clear the proposed acquisition of AREVA's reactor section by EDF.¹⁹

Hinkley Point C in Great Britain

The UK has violated international law by refusing to give neighboring countries a possibility to take part in a transboundary Environmental Impact Assessment (EIA). The UK was required to make up for this missing trans-border EIA after this breach of law was made public.²⁰

¹⁵ Autorité de sûreté nucléaire (2017a)

¹⁶ Autorité de sûreté nucléaire (2017a)

¹⁷ Autorité de sûreté nucléaire (2017a)

¹⁸ World Nuclear News (2017a)

¹⁹ World Nuclear News (2017a)

²⁰ World Nuclear News (2017a)

According to the current legal situation, on-site construction work must be suspended until this EIA is completed. But this is not the case. There is a risk that the entire subsequent EIA procedure will be rendered absurd because the continuing construction creates material facts that can no longer be undone. In addition, Hinkley Point C - unlike the EPR Olkiluoto 3 in Finland - appears to be relying on purely digital control technology for its reactor protection, which is significantly susceptible to failure and terrorist digital attacks.

In February 2013, it became known that the costs of nuclear clean up of the Sellafield site had already amounted to nearly £70 billion at that time. Every year about £1.6 billion are added on top.²¹ An outrageous sum, which has no service in return such as power generation, merely accounts for contaminated site disposal. Other nuclear sites certainly will not cause as high amounts of cleaning costs as Sellafield, but in future large amounts of post closure costs will have to be paid for any nuclear site.

However, the UK government is holding firm to the construction of the new EPR Hinkley Point C, even though an unpublished government study has shown that wind and solar power would generate electricity at half the cost of the planned Hinkley Point nuclear power plant.²² In case of renewable energies, no nuclear clean up costs arise, running into billions. The UK Government included the cost estimates of 2016. Meanwhile, the construction costs of all nuclear projects worldwide have risen during their construction periods far beyond the originally estimated costs whereas costs of renewable energy technologies keep dramatically falling year by year.

The driving force behind the UK government's affinity to nuclear technology is the cross-subsidization of the military nuclear program. In a comprehensive study the scientists Emily Cox, Phil Johnstone and Andrew Stirling, (SPRU, University of Sussex) have proved in detail, what is openly communicated by the military, but vehemently denied by the energy sector: the maintenance of the civilian nuclear program is a financial relieve for the defence budget.²³ This cross-subsidization of the military nuclear programs by "civil nuclear energy" also applies to many other states.

The EPR is not inherently safe

One of the fundamental demands and claims for the EPR is its alleged inherent safety.

But, nuclear safety experts Steven Sholly and Wolfgang Renneberg have shown that serious accidents are not "practically eliminated" for the EPR, as required by the Western European Nuclear Regulators Association for the safety of new nuclear installations and as the term inherent safety would imply.

They clarify that, even if everyone could agree what "practically eliminated" and a "high degree of assurance to be extremely unlikely to arise" mean, if probabilistic arguments (based on probability

²¹ World Nuclear News (2017a)

²² World Nuclear News (2017a)

²³ Cox, Johnstone & Stirling (2016)

calculations) are used then the probabilistic safety assessment (PSA) has to be complete to give a basis for the judgment. The PSA for Hinkley Point C is evidently incomplete since it has no probabilistic assessment of either seismic hazard or seismic core damage frequency and containment performance."²⁴

State dogma, falsified documents, huge debt and terrorism risks

The renowned nuclear expert Mycle Schneider recently called the French nuclear industry a "state dogma that has been there for five decades" and the clique of politicians and businessmen as a "technocratic elite without democratic control" .²⁵

At a parliamentary hearing a few months ago, the French Economics Minister Bruno Le Maire openly called AREVA a "state affair". He spoke of "systematic concealment" and "bad governance of a public company" and a " lack of state control" .²⁶

In April 2016, 430 documents, showing irregularities, were seized by investigators at the AREVA site Le Creusot where large castings for nuclear power plants are produced. The documents included manufacturing protocols that have obviously been falsified. As a result, several nuclear power plants had to be shut temporarily and tests were ordered for further 6,000 documents.²⁷

In December 2016, inspectors from various countries visited the Creusot forge and expressed their concern about the quality control issues that had already been discovered in 2014 by the French Nuclear Regulatory Authority ASN there and about the falsified documents²⁸. A report by the UK Nuclear Regulatory Commission (ONR), published under the Freedom of Information Act, confirmed that the corrective actions required by ASN have not yet been implemented.

In September 2016, it was revealed that an employee of the forge "produced a production record without controls". The falsification was neither discovered by Areva's quality control on site, nor by Areva's independent third party investigators or by EDF-inspectors. The international inspections have also uncovered the use of corrective fluid - such as Tipp-Ex - in the workshop of the forge, which is prohibited in this place.

In his November 2017 article, Detlef zum Winkel writes - based on statements by the former Creusot manager J.-F. Victor, who presented detailed insider insights into the fraudulent machinations²⁹:

²⁴ Sholly & Renneberg (2014)

²⁵ Arte (2017a)

²⁶ Public Sénat (2017)

²⁷ Massemin (2016)

²⁸ Vaughan (2017)

²⁹ Zum Winkel (2017b)

“AREVA seems to have included purchase prices into the business books, which in fact were not paid at all, and used the differences to write off other loss-making businesses or legacies. The businessmen who played along in this game, were certainly rewarded for that. As a result, AREVA was able to maintain the image of a successful and expanding company, while its financial situation was in fact already desperate. Current situation is even worse.

Le Maire threatened in front of the French parliament, should that if this waste of taxpayer money continues, he would “beat his fist on the table”. However, instead of damaging the National Assembly's furniture, he could also ask Justice Minister Nicole Belloubet, why the prosecutor's office is still reluctant in the Creusot Forge case, since the Minister of Economics confirms the suspicion of Victor.

Sooner or later, the legal system will have to deal with Creusot Forge, and perhaps with the unprecedented approval process for the European pressurized water reactor.

The financially disastrous situation of the state-owned EDF and AREVA, as well as other nuclear companies in and outside the EU, is the cause of unacceptable safety deficiencies: The documentary "Terror - Nuclear power plants in sight"³⁰, broadcasted by French-German television channel Arte on December 5, 2017 showcased massive safety deficits of nuclear power plants in various European countries. Nuclear power plants are not sufficiently protected against aircraft crashes. Greenpeace activists were able to ignite fireworks at a French nuclear plant site near the fuel cooling installations with only 30 cm-thick walls and roofs, made of thin corrugated iron.³¹

This lack of protection of the numerous fuel cooling installations worldwide is problematic. The highly radioactive fuel can melt, if not cooled properly.

In October and November 2014, two thirds of all French nuclear power plants were targeted by drones about 30 times. The reprocessing plant in La Hague, as well as a plutonium factory in Provence region and the naval base for nuclear submarines in Brittany were among the targeted sites. Not even army helicopters could intercept drones. Companies and authorities could not prevent this provocation and downplayed the incidents. Neither the penetrators nor their motives could be sufficiently clarified. Amateur drones can currently carry dozens of kilograms, including explosives. So it would be easy to attack e.g. one of the totally inadequately protected cooling installations filled with fuel rods.³²

Terrorist and cyber attacks on nuclear facilities become increasingly likely. The so-called "AIR GAP system", a self contained digital communication system without connection to the internet is considered to be an insurmountable safety barrier, also by EDF. But this is a false sense of security, as an internal attacker or supplier could still log in via a USB flash drive or CD to perform acts of

³⁰ ARTE (2017b)

³¹ Mertins (2016)

³² Zum Winkel (2017c)

sabotage.³³ Even hacking a Wi-Fi network is now almost a child's play. The continuous nuclear transports across Europe also pose a major accident- or terrorist risk.

In the meantime EDF has accumulated a debt of 61 billion Euros³⁴, AREVA 10 billion Euros in debt. The French state had to grant AREVA 4.5 billion Euros as state aid, EDF could only be rescued by a 3 billion Euros capital increase. (*Arte, 1:38:40 onwards*)³⁵ The operators definitely would have to focus on safety as an absolute priority, but with this high debt ratio, the security measures needed to protect the plants and the population from terrorist attacks and accidents can no longer be adequately financed.

Is this what the nuclear war of the future looks like?

In the following quotation, Detlef zum Winkel describes an even more frightening scenario: the dogma of nuclear deterrence by means of nuclear weapon possession, which has been advocated for decades, can no longer function in the face of increasing terrorist threats. This dogma is even turned against itself: states that possess nuclear facilities enhance their own vulnerability in an unprecedented way.

"Of course nuclear facilities are also military targets and extreme weak points of the national defense. Therefore, military personnel should be among the first to push for their elimination. But they don't do so because these civilian nuclear facilities belong to the logistics of the atomic bomb. Nuclear power plants cannot be defended in case of war and are vulnerable to terror attacks. A nuclear disaster would cause enormous damage, spreads fear and terror among the population and bind state resources. An aggressor would not even need nuclear weapons to attack these facilities, conventional ones would be sufficient. A group of terrorists or malicious software could attack a nuclear power plant without leaving traces who the perpetrator was afterwards. Is this the nuclear war of the future? There are many indications that the superiority of a nuclear status, believed by almost all military commanders, would prove to be a mistake, and that states without nuclear technology are better off from a military perspective."

Unclear liability issues and outdated nuclear power plants

However, there will be further high costs for the French Atomic State and its companies EDF and Areva. For example, Brussels is working hard to harmonize European liability law for nuclear accidents. France lags far behind states like Germany when it comes to the amount a nuclear company is liable for accidents.

The Institut de Radioprotection et de Sûreté Nucléaire (IRSN) in February 2013 estimated the damage caused by a nuclear event in France of the scope of the Fukushima accident at some 430 billion Euros. Germany currently has a liability cap up to 2.5 billion Euros, covered by a joint fund financed by the

³³ ARTE (2017b)

³⁴ Capital.fr (2017)

³⁵ Arte (2017b)

nuclear power plant operators. The upper liability limit in France is around € 90 million. Shouldn't this amount have been harmonized urgently in a common Europe? ³⁶

In addition, the vast majority of nuclear power plants in Europe and the world represent further incalculable risks, that are increasing due to the aging of the power plants and the associated embrittlement of materials. All over the world, the ever-increasing costs of nuclear power plant decommissioning, dismantling and (final) storage of radioactive waste have to be added to this.

EU research on the fourth generation of nuclear power plants is an indirect admission that there are currently no inherently safe reactors, not even the EPR.

Currently, unimpressed by international developments and under the guise of increasing security, research is being carried out in Karlsruhe at the KIT (Karlsruhe Institute of Technology) and the Joint Research Center Karlsruhe (JRC) on the fourth generation of nuclear power plants: on so-called "fast reactors", including liquid salt reactors, fast breeder reactors and small modular reactors (SMR). ³⁷

These small modular reactors (SMR) are supposed to be built in factories in assembly-line series in the future. They can also be installed on trucks, rail carriages or ships ready for use and are therefore mobile, easy to hide or kidnap. Thus, they are also particularly vulnerable to terrorist attacks of completely new dimensions. But regardless of such obvious risks the International Atomic Energy Agency IAEA recommends small modular reactors as suitable for nuclear newcomers among developing and emerging states and organizes workshops for this purpose. ^{38 39}

In Germany (and not only there) there is an additional, previously ignored danger related to the regulatory authorities: small modular reactors can, under certain conditions, be categorized as "mobile installations" under the Atomic Energy Act §7 (5) thus making it unnecessary "to publish an announcement of the project or to give an interpretation of the documents and that, therefore, there needs to be no discussion of objections".

The EU is also funding Thorium Liquid Salt Reactors (MSFR) in the framework of "SAMOFAR" project, which have an integrated reprocessing capacity and are thus capable to continuously withdraw weapon-grade uranium-233. ⁴⁰ In case of market maturity of these technologies there would be proliferation and terror risks of unprecedented scale. In the "SAMOFAR" project a total of 11 European partners are involved, besides JRC Karlsruhe and KIT also EDF and AREVA. Poland is already trying to

³⁶ Umwelt-Energie-Report (2015)

³⁷ International Atomic Energy Agency (2017)

³⁸ World Nuclear News (2017)

³⁹ Nuklearforum Schweiz (2015)

⁴⁰ SAMOFAR (2017)

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get the EU funding to implement the "Dual Fluid Reactor", a version of thorium liquid salt reactor, which seems to be particularly suitable for separating weapons-grade uranium-233 in a pure form.⁴¹

The financial and safety disasters of the EPR are exemplary of the global nuclear industry

The catastrophic developments with cost explosions and decades of delays surrounding the EPR can also be found in many examples in other nuclear reactor types and other nuclear companies around the world. All of these can only be kept artificially alive with big amounts of subsidies against the increasing competition from renewable energies. The EPR disaster should finally be noted as such and the expansion plans, as well as the development of new reactor types of the fourth generation of nuclear power plants should be terminated in the EU and globally.

Renewable energy is much cheaper, faster to install and without safety and security problems. Renewable energies in combination with storage systems can provide complete security of supply, even without a base load.⁴²

All ongoing investments of hundreds of billions of Dollars in global research, operation and subsidy of nuclear power will only waste more money and create significant new safety and security problems, but will not solve energy problems.

It is time for the many proponents of nuclear energy to finally face this and stop misinforming politicians, the public and the media about allegedly safe and cheap atomic energy, as they will not be able to stop the decline of the nuclear industry for electricity supply. Tony Seba described this in a nutshell in his book "Clean Revolution":

"The end of nuclear will mean the end of a popular deception – that the "civilian nuclear" industry as a viable industry. We will have to pay to clean up the nuclear mistake for generation to come in places like Sellafield, Chernobyl and Fukushima. But make no mistake, nuclear is already obsolete. The nuclear industry is imploding, because it is too expensive, too dangerous and too dirty. Let this zombie go before it does more irreversible damage to the living."

(Tony Seba, 2017, "Clean Revolution 2030", p. 171).

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⁴¹ Ruhrkultur (2017)

⁴² Energy Watch Group (2017)

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