NUCLEAR MONITOR

September 20, 2017 | No. 851

A PUBLICATION OF WORLD INFORMATION SERVICE ON ENERGY (WISE) AND THE NUCLEAR INFORMATION &RESOURCE SERVICE (NIRS)

Dear readers of the WISE/NIRS Nuclear Monitor,

In this issue of the Monitor:

- A detailed report by Jan Haverkamp on nuclear financing models.
- A summary of the 2017 edition of the World Nuclear Industry Status Report.

Feel free to contact us if you have feedback on this issue of the Monitor, or if there are topics you would like to see covered in future issues.

Regards from the editorial team.

Email: monitor@wiseinternational.org

Monitored this issue:

Financing Models for Nuclear Power Plants

The following is an overview of a briefing paper on nuclear financing models, written by Jan Haverkamp for WISE International. Jan is an expert consultant on nuclear energy and energy policy for WISE, Greenpeace Central and Eastern Europe, and Greenpeace Switzerland, and vice-chair of Nuclear Transparency Watch.

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1. Introduction

Nuclear power is globally in decline. Although the last two years have seen an increase in new connections to the grid, the trend of decline of installed amount of reactors only had a short reprieve due to a glut of temporary halted constructions in China after the Fukushima catastrophe.[1] In 2016, only three new reactor projects started, two in China, one in Pakistan.[2] The coming years, based on the estimates of the IAEA[3], will see a further decline.

One of the reasons is that nuclear reactors, having to fulfil ever growing safety requirements because of the shocking impacts of the Three Miles Island, Chernobyl and Fukushima catastrophes, are increasingly expensive to construct and to maintain. Reactor construction costs under US$5000 per installed kiloWatt electrical output (US$5000 / kWe) are only reported from state projects in China and the KEPCO-built second generation reactors in the Union of Arabic Emirates. In both cases the cost quotes are not very transparent and it is unclear whether this includes all costs.

Reactors of the generation III+ currently under construction in Russia, the US, Finland, France, the UK, Belarus, Turkey and the EPR and AP1000 projects in China all are over the US$5000 / kWe mark for overnight investment, with the Hinkley Point C project in the UK topping with more than US$7500 / kWe. With that, nuclear power has basically priced itself out of the market. The three main sources of renewable energy, on-shore wind, industrial scale photovoltaic and since this year even off-shore wind all deliver lower electricity cost-prices than these nuclear projects. Especially in markets with a weak electricity infrastructure – where the choices for type of grid and grid management still have to be developed – nuclear power introduction or expansion poses a large financial risk.

In this briefing I will list a few historical examples and some conclusions on the different financing models behind them. They cover virtually all the possibilities of how large risk large scale infrastructure projects like nuclear power stations can be financed. Key in all these models is the financial risk for the investors. This risk depends on several factors that should be taken into account and that are listed in part 4.

2. Some historical examples

2.1 Belene, Bulgaria (market and corruption based)

The Belene nuclear power project in Bulgaria started in 2002 as a re-start of construction of an old project from the mid 1980s that was halted in 1990 and cancelled in 1992. After the re-start of the project by announcement by the Prime Minister of that time, the former king Simeon Saxecoburgotski, the project was handed in a by corruption-botched open-tendering procedure to the Russian Rosatom group. Owner of the project was for 51% the Bulgarian state utility BEH and 49% the German RWE as strategic investor. Original construction costs were to be €3.2 billion (US$3.8 billion). RWE left the project in 2010 after it had become fed up with the fact that BEH was developing the project with Rosatom behind the back of RWE and cost increases that the project had seen. The Bulgarian government cancelled the project in 2012 after an assessment by HSBC showed that construction cost estimates already had ballooned to €10.15 billion (US$12 billion). Bulgaria lost an arbitration court case in 2015 for cancellation of this contract and had to pay US$600 million in compensation for large equipment already produced for the project. That equipment (two reactor pressure vessels, four steam generators and several emergency water vessels) was delivered to Bulgaria at the end of 2016 and early 2017 and is currently stored at the Belene site without further purpose.

The project had to be financed under liberalised market conditions. Initially 13 OECD based banks showed interest in financing the project in the form of project loans (mainly to BEH) or corporate loans (mainly to RWE). Nevertheless, confronted with the risks of the project (financial and reputational – especially because the project was sited in a seismic active area where 120 people had been killed in an earthquake in 1977 less than 12 km away), all 13 banks withdrew their interest. These include top-names like UniCredit, Deutsche Bank, Commerzbank, Societé General and others. The financial advisor to the project, BNP Paribas, the only bank that also provided a start-up loan, withdrew from the project as soon as its advisory contract had ended and called its loan short in 2010 because the project group had not kept to the contract conditions.

After the Belene case, banks basically stopped considering project loans as vehicle for financing nuclear construction projects.

2.2. Mochovce 3,4, Slovakia (market corporate funding and bonds)

The Mochovce 3,4 project is a bit of an odd-one out. The construction of the two early-second-generation reactors started in 1985 and was stopped in 1991 due to lack of funds. Plans to restart the project appeared in 2006 in a construction in which the Italian utility ENEL had taken control of 66% of the former Slovak state utility Slovenské Elektrarne (SE), with the state holding the remaining 34%. One of the conditions of this privatisation was the finalisation of construction of the Mochovce 3,4 project. Because already quite a bit of construction work had been done, it was impossible to change to another design. Complications concerning safety caused severe delays and it is now expected the reactors will come on-line in 2018 / 2019, while costs have soared to €5.4 billion (US$6.4 billion) for a mere 880 MWe of capacity.[4]

Mochovce 3,4 was initially to be financed largely by project financing from banks and other institutional investors. After having been informed by NGOs about the attached risks, project financing failed and banks resorted to corporate financing schemes whereby SE had to promise that the financing would not be used for Mochovce. This did not matter for SE, of course, which used the corporate funding to finance its other operations (according to one observer, its “cleaning ladies and such”) and it could invest the saved expenditure into the nuclear project. When the banks came under fire for this indirect financing of Mochovce, the largest consortium supporting SE withdrew its financing relations. In the meantime, ENEL issued bonds – over which banks have less control – for its total international investment programme, from which the Mochovce 3,4 construction was only a small fraction that was not even mentioned in the bond prospectus because it did not add significantly to the total risk of the bond (only around US$3 billion out of a total over US$25 billion). With that, it secured the cash-flow for the ongoing construction.

When ENEL changed in 2013 its corporate orientation away from fossil fuels and nuclear, it wanted to sell its stake in SE. The Slovak government, fearing that withdrawal of ENEL also would mean withdrawal of the entire management of SE and with that basically crash the Mochovce 3,4 project, arm-twisted ENEL to keep 30% of its SE shares until Mochovce 3,4 would be operating for six months. ENEL sold 36% of the shares to Czecho-Slovak oligarch company EPH and still finds itself bound to bringing Mochovce 3,4 online. Given the low price that EPH had to pay for the ENEL shares, ENEL basically wrote off its investments into SE and the nuclear power station.

Mochovce 3,4 thus largely has been financed by a write-off of debt by the Italian utility ENEL. The still outstanding €500+ million investment appears to be a problem, because the market is still unwilling to take the risk in the form of further project or corporate loans.

2.3 Olkiluoto 3, Finland (turn-key price and Mankala model)

The Olkiluoto 3 project was to be the first EPR reactor from the French Areva group. The initial costs for the single 1658 MW reactor were estimated at €3.4 billion (US$3.8 billion). The project was financed in a construction called Mankala. In this, the owner and operator of the reactor is a purpose company called TVO, whose owners finance the project at the rate of shares owned and after completion are entitled to shares of electricity produced against cost price according to the portion of shares owned. This direct delivery is without VAT. The owning companies can then either use the electricity themselves or trade it further on the market. This model delivers a stable electricity price for the operation time of the reactor.

The second characteristic of the Olkiluoto 3 project is a turn-key price. That means that whatever the construction costs, TVO only will have to pay €3.4 billion. Additional costs have to be covered by the constructor, in this case Areva.

In the end, Olkiluoto 3 appeared to be far more complicated to construct and far more expensive. Currently, it is foreseen that instead of the originally foreseen date of 1 May 2012, it will go on grid at the end of 2018 or early 2019 at a cost of at least €9.6 billion (US$11.4 billion). There were severe arbitration cases between TVO and Areva in which Areva tried to recuperate part of the extra cost and TVO tried to recuperate part of its losses due to late delivery of the project. These cases are still ongoing. The project brought the French state company Areva to the edge of bankruptcy and it had to be bailed out by French state utility EdF and the French state itself. Since Olkiluoto 3, nuclear vendors are extremely wary of offering turn-key project set-ups.

The French project by EdF in Flamanville (where EdF is also the constructor, hiring Areva only for the equipment), has shown a similar overdraw of time-line and costs, which has put EdF into very large financial trouble, one of the reasons for the increase of its debts to unsustainable levels.

2.4 Hinkley Point C, UK (guaranteed feed-in tariff and other guarantees)

Having learned the lessons from the Olkiluoto 3 and Flamanville projects, EdF requested strong guarantees for the first nuclear project in the UK after three decades. In order to build two EPR reactors at Hinkley Point C in Somerset, EdF got an inflation-corrected price guarantee of £92.5 per MWh for 35 years after grid connection of the project in a so-called Contract for Difference scheme in which it will receive the difference between market price and this so-called strike price when the strike price is higher than the market price, and will have to pay the difference back to the UK state treasury in case the market price comes above the strike price. The strike price of £92.5 / MWh (US$120 / MWh) is more than twice the current wholesale market price.

Other low-carbon sources were to get similar contracts for difference with their own strike-prices. Different than for the case of nuclear, however, these strike prices are to be set in a tender procedure. As a result, current strike prices for on-shore wind and solar PV are already under the wholesale market price, and even off-shore wind strike-prices are well under the £92.5 set for Hinkley Point C.

Next to the guaranteed price, EdF also received a government loan guarantee for around £10 billion, and a political guarantee that the UK would reimburse all lost profit in case the project is halted before the end of its technical lifetime of 60 years.

Because the strike price is so far above market prices and because the perspective of market prices also on the longer term is that they will remain more or less stable due to the decreasing costs of renewable energy sources, the enormous subsidy that Hinkley Point C will be receiving remains under heavy criticism. Total estimates for this subsidy are currently hovering around €23 billion (US$29.4 billion).

On the other side, EdF has problems generating sufficient cash flow to construct Hinkley Point C. The profit-guarantee deal with the UK government is perceived as too good to hold true in the long term by much of the financial markets and because EdF is struggling in its home market (because of needed upgrades to its ageing nuclear fleet in France, the botched Flamanville project and the takeover of failing Areva), its credit rating has been severely downrated and it has problems bringing together finance for construction. For that reason it has teamed up with Chinese nuclear utility CGN in the hope that CGN will be able to take over up to 33% of the project. This deal depends on CGN receiving the possibility from the UK government to build its own reactors at Bradwell.

All in all, criticism of Hinkley Point C and calls to drop the project are growing while EdF has started construction on the project.

2.5 Akkuyu, Turkey (BOOT)

Turkey has made a deal with Russian Rosatom to have up to four VVER 1200 reactors built at the Akkuyu site on the South-East Turkish Mediterranean coast. Total costs are estimated at €20 billion (US$23.8 billion). This project is agreed as a so-called BOOT project: Russia is committed to Build, Own and Operate the project and Transfer the spent nuclear fuel to Russia.

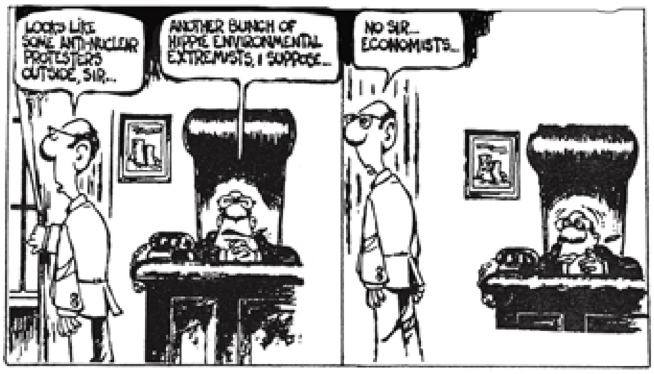
As builder and owner of the project, the complete financing risk is on the shoulders of Rosatom. Construction is to start in 2018 and the first reactor is to come online in September 2023 to coincide with the 100th anniversary of the modern Turkish republic.

Rosatom has already come into problems with the financing of this project, as it is itself depending fully on state budget funding from the Russian state, which has seen a sharp decrease in income over the fall of oil prices in recent years. As such, Rosatom is to be reorganised in the coming years and should become in 2020 independent of the Russian state budget, meaning that it will have to be able to cover its losses with profits from other branches of operation. Until now, investments were part of the annual state budget and independently from that, incomes fell to the state budget.

Now that that situation is going to change, Rosatom is currently looking to get 49% outside participation in the project, mainly from Turkish firms that have a stake in it. One of the interested parties mentioned is the Turkish Cengiz-Kolin-Kalyon consortium, one of Turkey's main construction firms with close links to the current AKP Party of president Erdogan and with a controversial history in other large-scale projects.

Because financing of this project depends on Russian state finances, the priority of investible cash flow will depend on political priorities. This might easily lead to delays and related cost increases. In a recent case, the Baltitskaya project near Neman in the Russian Kaliningrad enclave, the project was cancelled because it had lost its political priority after Germany declared it would not take electricity from it and Lithuania had cancelled its new build plans in Visaginas after a negative referendum in 2012.

Turkey also could face problems with the "T" in BOOT. In spite of its agreement, Russia has a ban on import of radioactive waste. It is allowed to import spent nuclear fuel for reprocessing, but resulting wastes, according to the law, have to be returned to the country of origin. The question is whether Turkey will be perceived legally as the country of origin or whether the Akkuyu project is basically seen as a piece of Russia on Turkish soil.



2.6 Astravetz, Belarus / Roopur, Bangladesh / Paks II, Hungary (sovereign loan)

The Astravetz project in Belarus, the Roopur project in Bangladesh and the Paks II project in Hungary are largely financed with the help of sovereign loans between Russia and the recipient country. These loans are given under a low interest rate, but with very severe penalty clauses in case of non-performance. In the case of Hungary, Russia lends €10 billion (US$11.9 billion) of the foreseen €12.5 billion (US$14.9 billion) total costs against an EU LIBOR +1,5% rate but with a 150% penalty in case of non-performance. With this, Hungary has been made strongly dependent on Russia for the foreseeable time.

An assessment by the financial analysts CANDOLE Partners from 2016, commissioned by Greenpeace Hungary, furthermore showed that the costs of the Paks II project were so high that under normal market circumstances, the project would not be able to make a positive return.[5] In spite of this, the European Commission, which considered the sovereign loan instrument to be state aid, accepted financial support under certain conditions at the start of 2017.

2.7 Hanhikivi, Finland (hybrid model)

The Hanhikivi project in Finland is still in its initial phase. This is a hybrid of the Mankala model, market financing and Rosatom driven BOO. In order to reduce dependence, by law, the project had to be over 60% owned by shareholders from the EU or the EEA. Rosatom owns 34% of the shares in the project company Fennovoima and is also the builder of the project. It obtained the shares from German company E.On, after E.On decided to drop the project because of bad financial perspectives and its own turn away from nuclear power following the German nuclear phase-out. Nine percent of the shares had not been taken up, however, and EU ownership had fallen just under 60%.

In order to meet the legal obligations, Fennovoima accepted a new owner, Croatia-based Migrit Solar, for 6% of the shares. It appeared, however, that Migrit was a front-company for Russian oligarchs with relations to the Russian firm Titan 2, the main contractor and Rosatom partner for Hanhikivi. It was also deemed impossible that a company with capital of €26,000 would be able to finance around €500 million in a nuclear project. After this had been discovered, Migrit had to withdraw. In reaction, the Kremlin put the Finnish state utility Fortum under pressure to take these shares. It basically threatened to have Fortum's Russian assets worth around US$9 billion taken away from them. Under that threat, Fortum reluctantly accepted participation in the project.

The participants in the Mankala construction are to find finance for their participation on the market. Because of the financial risk of the project, several of them would like to leave – among others the Municipality of Helsinki, which is participating with another municipality in one of the shareholders of Fennovoima. If this shareholder would leave the project, EU ownership would once again fall under 60%, threatening the license.

It is also questionable whether the participants will be able to get sufficient funds for their participation, because banks will look at the total risk pattern of the project.

3. Different financing models

3.1 Liberalised market versus regulated market

It is slowly becoming clear that nuclear power cannot be financed in liberalised markets. The overnight costs of construction deliver too high electricity prices. This is already virtually independent of interest rates for the necessary capital, but mainly related to the high construction costs *per se*. These construction costs depend on the high level of nuclear safety that needs to be guaranteed, which means that there is little space for cost reductions. Also, because of the high up-front capital costs, national differences in regulation, and site-specific differences, it appears to be virtually impossible to create economies of scale and each new build project appears to be as expensive as the first of the kind. Everywhere where the state makes clear that nuclear projects cannot count on subsidies or other forms of financial support, projects are cancelled. This included recently the Czech Republic (Temelin 3,4), Bulgaria (Belene restart II), Sweden (plans for new capacity), the Netherlands (Borssele 2), Slovenia (Krsko 2) and others, including several projects in the United States.

Countries that are currently constructing new nuclear still have a largely regulated market (Hungary, Slovakia, Belarus, Bangladesh, India, China, UAE), or have reintroduced regulation instruments (the UK (Contracts for Difference, state guarantees), Finland (Mankala)).

Others with a regulated market have shied away from the enormous financial risks for the public purse as well as other risks that are attached to nuclear projects (for instance Philippines (Bataan), Vietnam, Indonesia, Taiwan, South Korea).

Conclusion: New nuclear projects have no chance in liberalised markets, because they have become uncompetitive. In regulated markets, they can only be introduced with a large amount of state aid and other guarantees that socialise risks, whereas potential profits often remain privatised (for example the UK and France).

3.2 Who carries the risk?

A basic question in financing models is:
"who carries the risks?".

In a turn-key contract, the risks for time overdraws, budget overdraws and mistakes is carried by the construction company. This happened in the case of Olkiluoto 3 in Finland. The client – the operator – only carries the risk of lost income due to potentially late delivery.

Also in the case of BOO(T), the loss risk is on the table of the construction company, who also is the owner of the project. How large that risk is depends in this case in how the electricity prices are regulated. Rosatom negotiated a guaranteed price for part of its output from Akkuyu in Turkey, which reduces risks as long as construction cost and time can be kept under control.

In the case of Hinkley Point C, the French operator EdF negotiated a deal in which in principle it is guaranteed a profit between 10% and 15% on the investment without running too much of the risk itself. This risk is carried by the UK government and the British rate-payers in the form of guaranteed prices, a government guarantee for part of the construction costs and a political guarantee not to axe the project before the end of its technical lifetime. Still, there are a host of risks that remain on the shoulders of EdF, leading to a severe credit downrating after the contract was signed.

In the case of sovereign loan financing, the risk is largely on the shoulders of the recipient country and the state budget. For countries with a relative small economy like Hungary, that risk could theoretically make the country insolvent when the worst comes to worst (in this case a short-call of the Russian loan with interest and penalty after a failure to re-pay the first tranche).

The risks are there (see part 4), and when construction is finished, the construction costs mean that someone has to pay for the difference between real costs of nuclear power and what the market – regulated or liberalised – will pay for the electricity.

3.3 Market based loans

When financing of nuclear construction has to be financed through the market, there are three types of financing available: project financing, corporate financing and bond financing.

These loans are sometimes supported by (sovereign) export bank guarantees, like the US ExIm Bank. Such support leads to lower interest levels, but does not intervene too much with the other risks that are discussed in this briefing. Blocking these kind of export guarantees, like recently successfully done for instance for German Hermes guarantees for involvement in new nuclear build projects, will increase construction costs.

3.3.1 Project financing

In project financing, banks and other investors provide finance for the project against the project itself as collateral. This is the highest level of risk for financiers, which means that on one hand interest rates will be relatively high, enlarging the costs of the project; on the other hand, investors are more critical about the risks attached to the project. These not only include financial risks (the risk of not returning the loans and interest), but also reputational risk.

After the debacle of the Belene project in Bulgaria and the loss of control over the risks in the Mochovce 3,4 project in Slovakia, banks and other institutional investors have basically stopped project financing of nuclear construction projects. These loans are also the most vulnerable for public campaigning, because the link is direct and visible.

3.3.2 Corporate financing

EdF (Flamanville and Hinkley Point C) and Slovenské Elektrarne (Mochovce 3,4) are examples where corporate financing is used to secure the cash-flow for the construction of new nuclear capacity. The collateral for loans is the entire company and for that reason interest rates are lower than in the case of project financing, which reduces the already far too high costs of the project somewhat. However, the risk for the utility is much bigger – if the project fails, the entire company will bleed. Also, it appears to be possible for anti-nuclear campaigners to explain that investments made over this line still end up in the nuclear project and therefore there is still an increase in the reputational risk for the involved banks / investors. This led in the case of Mochovce 3,4 to a cancellation of an €850 million (US$1 billion) corporate loan to Slovenské Elektrarne.

3.3.3 Bond financing

Bonds can reduce the risk a bit further, and it is more difficult to link the name of banks to the management of bonds. In the case of Mochovce 3,4, ENEL decided to bring the project inside a much larger bond issuing in the United States that was oriented on the general investment programme of the company. Because the Mochovce 3,4 project was only a small part of the entire investment programme, it was not mentioned in the prospectus, so investors were not aware of the special risks attached to this programme and those risks were more or less hedged by the return on the other investments. Even where ENEL later had to basically write off its entire investment into the finalisation of Mochovce 3,4 (the over-largest part of the total investment), this did not influence its bottom line too much. This does, of course, not make Mochovce a cost-effective investment, but rather an invisible one, largely cross-financed in the end by the clients of ENEL.

3.4 BOO(T)

BOO stands for Build, Own, Operate. The BOO financing model was introduced by Rosatom in order to get the construction contract for a four-reactor nuclear power station in Turkey. It has since used the model in different forms in Hanhikivi (Finland) and proposals for other projects. The advantage of this model for the recipient country is that it is not running any risk because of delays and budget overdraws. In the case of Akkuyu in Turkey, the BOO agreement is linked to a guaranteed price for part of the delivered electricity (the guarantee of return for the investor Rosatom). This price is higher than the market price in Turkey, but it is also stable. The rest has to be sold on the market. That means that Akkuyu most likely is going to run a loss, but that loss will be in the books of Rosatom and not on the shoulders of the Turkish rate or tax payer.

The reason for Rosatom offering such a model is therefore not economical but purely political. Turkey basically has sold part of its sovereignty over the site of Akkuyu to Russia for the period of around a century and Russia perceives the inevitable losses as a good political investment.

The T in BOOT stands for Transfer. In the initial agreement between Turkey and Russia, Russia promises to take back the spent fuel from Akkuyu. Currently that is not allowed under Russian legislation, which only allows import of radioactive waste for reprocessing, with return of resulting wastes to the country of origin. It is to be seen to what extent Turkey will have to take care of the radioactive waste of Akkuyu, or whether Russia will consider that its own property and sovereign responsibility.

3.5 Fixed prices (Contracts for Difference) and guarantees

The instrument of fixed prices was initially used to spur the development of innovation of renewable energy sources in countries like Denmark, Germany, Spain, Portugal and the Czech Republic. So-called feed-in tariffs were successfully leading to a steep decrease in production costs of wind turbines, photovoltaic cells, concentrated solar heat power and geothermal energy. The philosophy behind this support is that nascent technologies cannot compete on the market yet and a guaranteed return of investment will accelerate innovation.

Nuclear energy is not a nascent technology, however. It has ripened over 70 years of development and during that time has always benefited from subsidy streams that dwarf the amount of money invested over the last decade in renewable feed-in tariff systems.

The United Kingdom was desperate to restart nuclear construction and came with the model of guaranteed feed-in tariffs for nuclear. They called it Contracts for Difference and in order to prevent these from being squashed under EU law on market discriminatory grounds, they installed them for all low-carbon generation, argued with the necessity to meet CO2 reduction targets – a common goal for the EU. The so-called strike prices – the guaranteed feed-in price – were to be different per project. For renewable energy, they were to be valid for a period between 10 and 15 years (depending on project and generation source), for the first nuclear project at Hinkley Point C in Somerset it was to be for 35 years. With the Contracts for Difference, the government guarantees the strike price. As long as the market price is under the strike price, the government pays the difference to the utility, when the utility gets on the market a higher price than the strike price, it pays back the difference to the government. The strike price for Hinkley Point C was set at £92.5 per MWh (US$120 / MWh). This is between two and three times the current wholesale market price for electricity in the UK, which means that if the market is still offering this price level when Hinkley Point C comes on grid, the government may have to pay as much as US$55 / MWh to operator EdF as compensation. Although it is, of course, impossible to predict electricity price levels in, say, 2040, the difference today is so large that it can be expected that also in the longer term Hinkley Point C will have to be paid for the difference rather than paying itself.

The Contracts for Difference – in spite of the high level – were not sufficient to compensate the risk that EdF was taking with the construction of Hinkley Point C. The UK government had also to guarantee part of the investment costs and give a political guarantee to compensate for all lost profit in case the reactor for whatever reason other than mismanagement by EdF is to be closed before the end of its technical lifetime of 60 years. In this way, it was initially thought that EdF would have a reasonable return on investment of around 10 to 15%. Of course, the terms of the Contracts for Difference are inflation corrected.

It is important to note that Hinkley Point C is also a BOO project – EdF is constructor, owner and operator. We have already argued that that puts a large risk on the shoulders of the operator, which in the case of EdF is not compensated by any political gain as in the case of Rosatom. That is the reason that the UK government had to offer a financial set-up that would hedge the risks for EdF as much as possible.

The Contracts for Difference model puts the risk for delays and budget overdraws fully on the plate of the constructor/operator, similar to a turn-key project. In order to spread that risk, EdF sought and won permission to seek participation of 30% by Chinese nuclear utility CGN in the project. At the moment, investment cost estimates have already risen by 15% against the initial already very high ones. When estimates rise further, it is to be seen whether EdF will be forced to seek more support or might lose the support from CGN it already gained.

The United Kingdom also gave a credit guarantee for €10 billion (US$13 billion) of the investment costs. When EdF has problems covering its investment cash-flow, it is likely to call on this guarantee, which enables it to benefit from lower interest rates.

3.6 Sovereign loans

Because of the sheer impossibility to have new nuclear projects financed by the market, and the far too high risk of Contracts for Difference and other subsidy schemes for their much smaller state budgets (in comparison with the UK), countries like Belarus, Hungary and Bangladesh are financing their new nuclear projects with a sovereign (country to country) loan from Russia with a credit guarantee from the Russian export credit bank. In this way, they can benefit from relatively low interest rates, but they become, of course, financially dependent on Russia.

Because of the currently low interest rates world-wide and especially in Europe, the interest benefit is not very large. The sovereign loan leaves the risk not to be able to get sufficient return on investment in the hands of the recipient country. That means that one way or another, the investment needs to pay off market-wise, or the state becomes liable. In the case of Paks II, the financial analyst group CANDOLE Partners calculated that there is no way that the project can become market viable.[5] The only way for Hungary to make this work is then either to regulate its electricity market in such a way that the consumers of Paks II electricity will pay higher rates than in the surrounding markets (market closure and regulation leading to a competitive disadvantage) or that the difference is covered by the state budget (which will lead to higher taxes).

4. Risks to be taken into consideration

4.1 LCOE

Levelised Cost of Electricity. The nuclear lobby loves to argue that nuclear can compete with other sources on the basis of LCOE. There are a few problems here, however. The LCOE is always calculated on the basis of pre-construction estimated costs (what I would call the advertisement costs), which appear to balloon during construction. The LCOE does not always include remediation costs, financial decommissioning uncertainties and financial back-end (waste) uncertainties. Then they are for new Generation III and III+ reactors calculated on the basis of 60 years of operation on a load factor of around 94%. Given the fact that there is no practical experience with modern Generation III+ nuclear reactors, there is a certain risk in assuming such a high availability factor, when average availability factors in the industry so far are 5 to 10 percentage points lower. The current fleet furthermore shows a slow but certain reduced load factor for ageing reactors, which means that the average availability is going down over time, which also influences the LCOE. On top of that, the LCOE is very dependent on financing costs and over a long period that is very difficult to estimate, whereas the LCOEs of for instance renewable alternatives are calculated over a much shorter life-span (up to 25 years, often 15 years), which gives less uncertainty. The LCOE does not include costs caused by non-foreseen incidents – including those in other reactors of the same, a similar or even completely different design anywhere on the globe (often resulting in lower availability factors). Conclusion: LCOE is an indicator, but not a very precise one and compared to alternatives, the uncertainties all are to the disadvantage of nuclear technology.

4.2 Market development

The instrument of Contracts for Difference, but also many of the calculations behind the return on investment for sovereign loan financed projects, is based on predictions of market development. These are more often than not based on an increase of electricity price, resulting from a decreased availability of fossil fuels and increased carbon price. However, already today in countries with high renewable penetration (Denmark, Germany, Portugal, Sweden, Norway) we see that the steadily falling prices of renewables are influencing the spot market and increasingly also the wholesale market. There is a good case to make for the expectation that electricity market prices will remain stable for quite some time to come. To be on the safe side, most serious financial analysts therefore do not imply a strong increase of electricity prices.

4.3 Risk of severe nuclear accidents

Fukushima has once again shown that an accident in one nuclear reactor means an accident for all nuclear reactors. Most nuclear reactors in the world faced extended shut-down periods to learn lessons from the Fukushima catastrophe and most of them needed additional investments in risk reduction. The entire Japanese fleet was shut down for years and only a fraction of the original fleet will return to service. This has put most of the utilities in Japan in huge financial trouble. It is impossible to predict if we ever will see a similar catastrophe. The chance of it can definitely not be excluded. And if it happens, it will also influence the financial picture of every other nuclear reactor. And, of course, for the reactor(s) and investors directly involved in the accident, the financial picture will be devastating. Still, the chance of another nuclear accident somewhere in the world is never included in financial assessments of new nuclear reactors.

4.4 Breaking time schedules, cost overdraws, unexpected costs

As far as I could assess, no nuclear project since the Chernobyl catastrophe has been delivered on time and on cost. Even recent claims concerning Chinese and Korean construction projects do not hold up. Sometimes because basic information (initial construction time and cost estimates) is not available, sometimes because there are known delays in those projects as well.

Although it is not always clear to everybody, longer construction times do mean higher costs – if only because of loss of electricity production, but also because of longer necessity of personnel and machinery, storage costs, etc.

Apart from that, delays are often symptoms of problems during construction – problems that include changes in design, replacement of parts or even larger parts. These also lead to extra costs.

Next to that, there are delays because of regulatory demands. These inevitably lead to changes in design and therefore also extra costs. An example is the need for improved robustness of the reactor building and auxiliary buildings against seismic influences. The Hungarian Paks II reactor will have to withstand a ground acceleration of 0.34 g. The original design as implemented in Leningradskaya II (Sosnovy Bor) and Astravets (Belarus) only foresees robustness against 0.12 g ground acceleration. Such an adaptation is major and will require redesign, more concrete and rebar, and more equipment. Simply for that reason, Paks II cannot cost the same as Astravets. Who is going to pay those costs is another question. It can be a risk for Rosatom, but that might translate in cost increases down the line for Hungary. The cost increases in the Belene project in Bulgaria were partly due to understatement of real costs from the side of Rosatom, partly because of necessary redesign of parts on the basis of requirements from the nuclear regulator and the specific site characteristics.

Next to cost increases during construction, there are unforeseen cost increases during decommissioning that will have to be covered by the operator, unforeseen cost increases in waste management, and updates and changed insights regarding how liabilities need to be covered.

Concerning the latter, currently in most countries nuclear liabilities are capped at an amount of between around US$50 million to US$3 billion. The real costs of the catastrophe at Fukushima are in the order of magnitude of US$200 billion or more, and the French nuclear research institute IRSN estimated the costs of a severe accident in France at over US$400 billion. In the three years after Fukushima, around US$100 billion of cash flow was needed for compensation and clean-up work, which was largely covered by the state. In case such insights are politically translated into more adequate allocation of liabilities and necessary financial reserves (or insurance levels) for operators, this might increase operational costs considerably and undermine the return on investment.

The issue of suppliers' liability is one that is formally excluded, but every time there is a severe accident, it is revisited. Suppliers' liability is an issue that can suddenly come on the table and confront nuclear suppliers with a very large risk.

4.5 Political risks (inc. international relations and dependency issues)

The example of Rosatom shows clearly that cash-flow for international investments is dependent on political priority. When there was tension between Turkey and Russia because of the downing of a Russian aircraft that had flown through Turkish air space, investments directly stopped. That would be a very definite risk for any participant in the project (like the Turkish companies interested in taking a 49% stake in Akkuyu, but also for their financiers). In general: the more political the project, the larger the risk for extra delays and related cost increases, including the risk of full abandonment of the project.

Also, the level of dependence on one player – either political, commercial or financial – introduces risk. The virtual bankruptcy of Areva led to new delays for Olkiluoto 3 and Flamanville 3. Also, too large dependency on one bank can lead to extra costs and/or delays – many large infrastructure projects ran delays during the banking crisis of 2008.

4.6 Influence of proliferation developments and security risks

The issues of nuclear weapon proliferation and nuclear security are seldom discussed in public. Nevertheless, every incident in which nuclear material or key-knowledge disappeared (for instance the case of the Pakistan scientist Abdul Qadeer Khan) and every incident in which, for instance, terrorist subjects have been related to nuclear installations (for instance recently in Belgium) will be leading to adaptations in the operation of nuclear power stations. Every major incident may lead to the need for large investments.

4.7 Contract and financial model risks

Unclarities in contracts have also led to large increases in costs. An example is the construction contract for the Belene nuclear power plant, which appeared not to include the costs for turbines.

Also issues about exchange rates and inflation correction can suddenly increase costs. There was unclarity about which inflation rate should be calculated for the Belene project – the Russian (several tens of percents) or the Bulgarian / Euro inflation rate (only a few percent).

Changes in the financial model can also lead to delays and extra costs.

4.8 Reputational risks

When a project has vulnerabilities, this can have a negative backlash on the reputation of financiers and investors. It can shed doubt on due diligence and lead to downgrading of credit ratings. Environmental organisations can highlight issues like seismic risks, lack of transparency, safety weaknesses, lack of independence of the nuclear regulator and others that may harm the reputation of any company or bank related to the project.

4.9 Conclusions about risks

Every financier should and in many cases will be highly aware of the risks of nuclear projects. The more market dependent, the more important the above-mentioned risks will be. But also state actors have to be aware of their credit ratings – for instance the French credit rating was influenced by the poor credit ratings for Areva and EdF after a host of scandals.

Still, this awareness is hardly ever complete. It is especially lacking with institutions that have been embedded in the industry for too long (for example the bank BNP Paribas – formerly the largest nuclear bank in the world – needed to be confronted with information about nuclear related risks in two campaigns before it became more aware of them), or when the issue is new to key decision makers. There is always a lack of awareness of the depth of the risk factors in the nuclear industry. Bankers and politicians too often hide themselves behind "but there are risks in everything".

For those reasons, it makes sense to increase the risk-awareness among all key stakeholders in the nuclear decision lines: managers, bankers, and politicians.

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World Nuclear Industry Status Report 2017

The 2017 edition of the World Nuclear Industry Status Report (WNISR) has been released. It includes:

- a comprehensive overview of nuclear power plant data, including information on operation, production and construction.
- an assessment of the status of new-build programs in current nuclear countries and in potential newcomer countries.
- an assessment from an equity analyst view of the financial crisis of the nuclear sector and some of its biggest industrial players.
- a Fukushima Status Report with an update on onsite and offsite issues, and the latest cost evaluations of the disaster.
- focus chapters providing in-depth analyses of the nuclear industries in France, Japan, South Korea, the United Kingdom and the United States (while an annex provides country-by-country overviews of 25 other nuclear countries).
- a Nuclear Power vs Renewable Energy chapter providing global comparative data on investment, capacity, and generation from nuclear, wind and solar energy.

Here are some highlights drawn from the report:

Global overview:

- Global nuclear power generation increased by 1.4% in 2016, due to a 23% increase in China.
- Ten reactors started up in 2016, of which half were in China. Two reactors were connected to the grid in the first half of 2017 – one in China, one in Pakistan (by a Chinese company) – the first units to start up in the world whose construction started after the Fukushima disaster began.
- Three construction starts in the world in 2016 – two in China, one in Pakistan (by a Chinese company) – down from 15 in 2010, of which 10 were in China. One construction start in India in the first half of 2017, none in China or in the rest of the world.
- The number of units under construction declined for the fourth year in a row, from 68 reactors at the end of 2013 to 53 by mid-2017, of which 20 are in China.
- There are 31 countries operating nuclear power plants. These countries operate a total of 403 reactors (excluding 33 reactors in Japan, and six in other countries, classified as Long-Term Outages), 35 fewer than the 2002 peak of 438. The total installed capacity of 351 GW is down 4.6% on the 2006 peak of 368 GW. Annual nuclear electricity generation reached 2,476 TWh in 2016 – about 7% below the historic peak of 2006.
- The nuclear share of the world's power generation remained stable over the past five years, at 10.5% in 2016 after declining steadily from a historic peak of 17.5% in 1996. Nuclear power's share of global commercial primary energy consumption also remained stable at 4.5% – prior to 2014 the lowest level since 1984.

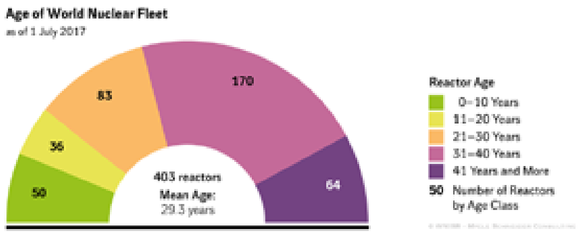
- The average age of the world operating nuclear reactor fleet continues to rise, and by mid-2017 stood at 29.3 years. Over half of the total, or 234 units, have operated for 31 years or more, including 64 that have run for 41 years or more.
- Only two newcomer countries are actually building reactors – Belarus and UAE. Further delays have occurred over the year in the development of nuclear programs for most of the more or less advanced potential newcomer countries, including Bangladesh, Egypt, Jordan, Poland, Saudi Arabia, and Turkey. Vietnam abandoned its new-build project due to slowing electricity demand increases, concerns over safety and rising construction costs.

Lifetime Projections:

- If all currently operating reactors were shut down at the end of a 40-year lifetime – with the exception of the 72 that have passed the 40-year mark – by 2020 the number of operating units would be 11 below the total at the end of 2016, even if all reactors currently under active construction were completed. In the following decade, between 2020 and 2030, 194 units (179 GW) would have to be replaced – almost four times the number of startups achieved over the past decade.
- If all licensed lifetime extensions were actually implemented and achieved, the number of operating reactors would still increase by only five, and adding 16.5 GW in 2020. By 2030, 163 reactors would have to be shut down and the loss of 144.5 GW would have to be compensated for.

Closures, Construction Delays and Cancellations:

- Russia and the U.S. shut down reactors in 2016, while Sweden and South Korea both closed their oldest units in the first half of 2017.
- Election of a new President in South Korea, who closed one plant and suspended the construction of two more, puts hopes of the national nuclear industry to expand and export into jeopardy.
- Thirteen countries are building new reactors, one less than in WNISR2016, as the construction of Angra-3 in Brazil was abandoned following a massive corruption scandal involving senior project management.
- There are 37 reactor constructions behind schedule, of which 19 reported further delays over the past year. China is no exception, at least 11 of 20 units under construction are behind schedule.
- Eight projects have been under construction for a decade or more, of which three for over 30 years.
- WNISR2016 noted 17 reactors scheduled for startup in 2017. As of mid-2017, only two of these units had started up and 11 were delayed until at least 2018.
- Between 1977 and 1 July 2017, a total of at least 91 (one in eight) of all construction sites were abandoned or suspended in 17 countries in various stages of advancement.



Source: WNISR 2017.

Deep Financial Crisis for Nuclear Utilities:

- After the discovery of massive losses over its nuclear construction projects, Toshiba filed for bankruptcy of its U.S. subsidiary Westinghouse, the largest nuclear power builder in history.
- AREVA has accumulated US$12.3 billion in losses over the past six years. French government has provided a US$5.3 billion bailout and continues break-up strategy.
- The large quality-control scandal at AREVA's Creusot Forge further erodes confidence in the industry.
- Share-value erosion and downgrading by credit-rating agencies of major nuclear utilities. In Europe, energy utilities Centrica (U.K.), EDF, Engie (France), E.ON, and RWE (Germany) have all been downgraded by credit-rating agencies over the past year. As of early July 2017, compared to their peak values during the past decade, the utilities' shares had lost most of their value: RWE –82%, E.ON –87%, EDF –89%, Engie –75%.
- In Asia, the share value of TEPCO as of early July 2017 was 89% below its February 2007 peak value. Toshiba saw its share value shrink to a quarter of its 2007 peak level. Chinese utility CGN over the past year and a half never recovered from the 60% loss of its share value compared to the peak in June 2015. The Korean utility KEPCO, the only major nuclear utility to reach its peak share value in 2016, has lost 37% of its value over the past year following tariff cuts, increased operating expenses and the temporary shutdown of four reactors.

Fukushima Status Report:

- Six years after the Fukushima disaster began, the Japanese Government started lifting evacuation orders in order to limit skyrocketing compensation costs. The total official cost estimate for the catastrophe has doubled from US$100 billion to US$200 billion. A new independent assessment has put the cost at US$444–630 billion (depending on the level of water decontamination). Only five reactors have been restarted.

Renewables Distance Nuclear:

- Globally, wind power output grew by 16%, solar by 30%, nuclear by 1.4% in 2016. Wind power increased generation by 132 TWh, solar by 77 TWh, respectively 3.8 times and 2.2 times more than nuclear's 35 TWh. Renewables represented 62% of global power generating capacity additions.
- New renewables beat existing nuclear. Renewable energy auctions achieved record low prices at and

below US$30/MWh in Chile, Mexico, Morocco, United Arab Emirates, and the United States. Average generating costs of amortized nuclear power plants in the U.S. were US$35.5 in 2015.

Small Modular Reactors:

- WNISR2017 provides an update of the 2015 assessment of the status of Small Modular Reactor (SMR) programs around the world. While one SMR in China is scheduled for startup in 2018, global interest in the technologies has faded. Some of the most promising designs (SMART in South Korea and mPower in the U.S.) have not found any buyers. While SMRs were meant to solve the size issues (capacity and investment) of large nuclear plants, they are affected by the general decline in interest in nuclear new-build.

Nuclear Finances:

- In 2017, an increase in electricity-generation overcapacity in developed economies is expected, with demand not fully recovering, electricity prices should continue in a backwardation curve, as future prices are below current levels until 2019.
- Renewable investment is expected to continue, focusing on offshore wind for Europe, while onshore wind and solar for the U.S., and developing economies seem dominating.
- Demand on mature markets is not expected to increase fast enough – if growing at all – to cover the additional capacity to be installed, increasing the market oversupply.
- Hence, lower prices would put further pressure on nuclear operators in 2017 as their margins should continue to decrease given that their production is normally hedged for the year at a lower price level, reducing the profitability of the assets. Due to this, on the nuclear side, all operators expect lower profits in 2017 from a reduction in the hedging prices (at constant production levels).
- Going forward, 2017 will be an interesting year as multiple decisions (both financial and regulatory) are expected on nuclear reactor developments with Flamanville EPR (France), NuGen (U.K.), KEPCO's APR1400 (UAE), CGN's EPR (China), SCANA's and Southern Co's AP1000s (USA), Hinkley Point C EPRs (U.K.), and Olkiluoto-3 EPR (Finland). The path 2017 may bring to nuclear operators could reveal what can be expected for the sector in the coming years: whether a brighter light shines at the end of the tunnel or whether that's the headlight of an oncoming train.

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Full report online: www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2017-HTML.html

PDF: www.worldnuclearreport.org/IMG/pdf/20170912wnisr2017-en-lr.pdf

WISE/NIRS Nuclear Monitor

The World Information Service on Energy (WISE) was founded in 1978 and is based in Amsterdam, the Netherlands.

The Nuclear Information & Resource Service (NIRS) was set up in the same year and is based in Washington D.C., US.

WISE and NIRS joined forces in the year 2000, creating a worldwide network of information and resource centers for citizens and environmental organizations concerned about nuclear power, radioactive waste, proliferation, uranium, and sustainable energy issues.

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ISSN: 2542-5439