PINC 2016,
the Nuclear *Illusory* Programme

A reality check of the 2016 Nuclear Illustrative Programme presented by the European Commission
under Article 40 of the Euratom Treaty

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Executive summary

The Nuclear Illustrative Programme, PINC 2016 is the sixth presented under article 40 of the Euratom Treaty since 1958, and the first to present the nuclear vision of the new European Commission. The present note proposes a reality check of this vision, as it appears in PINC 2016 and the attached Staff Working Document, against the current evolution of nuclear power. It also discusses how this vision stands in the face of the analysis outlined in the previous illustrative programme, an update in 2008 of PINC 2007.

- Dramatic changes occured since this previous programme from an international perspective. While the decline of nuclear power, increasingly losing competition against rapidly expanding renewables, should be the starting point of any update of the Commission's vision, this trend is not even reflected in PINC 2016.
- Also, the growing role of renewables in Europe, and how it challenges the role of nuclear power in EU energy policy is not even reflected in PINC 2016, which on the contrary uses biased arguments to exagerate the contribution of nuclear power to energy security and climate mitigation.
- PINC 2016 then badly fails to account for the real status and trend of nuclear power in the EU, where no new reactor came on line and no new construction was started since PINC 2007, while 23 less are operating. Instead, the Commission introduces very ambitious, and seemingly unrealistic targets for maintaining most of the European nuclear capacity through 2050, combining new builds and a huge programme of lifetime extension, so-called long term operation (LTO).
- Safety issues, which appeared to be a major concern of the Commission in the previous PINC, are not anymore discussed, failing to account for the implications of the Fukushima disaster. The need for strong safety reinforcements of existing reactors, the preparedness and cross-border concerns attached to the consequences of major accidents, and the insufficient level of civil liability covered by operators compared to the cost of such a catastrophy are not seriously addressed.
- While the Commission acknowledges the difficulty for new nuclear reactors to compete and get financed on the European electricity market, it makes no amend for getting it so wrong when it set the economic case for nuclear power competitiveness in its previous programme. No real lessons are drawn from the financial disasters of EPR projects in Olkiluoto or Flamanville or the obstacles to the investment decision regarding Hinkley Point C.
- Instead of discussing the drifting of generating costs and clearly pointing to state aids involved, PINC 2016 is still using biased methodology to downplay the increase of costs and claim they could decrease in future, in denial that construction of new nuclear power plants is uneconomic. The Commission also clearly underestimates the costs and challenges of LTO programmes.
- The investment needs presented by PINC 2016 are a groundless mix of underestimated costs applied to overestimated projections. Investment needs in new reactors and LTO could be underestimated by one third and at least half respectively, making it even less likely that these investments are made.
- The Commission also appears to underestimate by more than half the possible costs for decommissioning and waste disposal, through a mix of low assumptions and omissions. It was a strong request of PINC 2007 that appropriate scheme garantee that operators will cover the long term liabilities. Insufficient estimates combine with an insufficient rate of constitution of funds and an insufficient security of the funds to put the European taxpayers at risk of taking over hundreds of billions of euros, a pressing issue that the Commission renounces to address.

Through misrepresentation of difficulties, lack of self-criticism for its past assessments and blindness to real challenges, PINC 2016 appears as a nuclear *illusory* programme. Against the evidence for a strong revision of its nuclear strategy, the Commission is puting the EU at risk of supporting unrealistic nuclear developments while creating more related problems.

Contents

1. Introduction

PINC 2016[1] is the sixth publication of a so-called *"nuclear illustrative programme"* by the European Commission since 1958. This periodical publication is due under article 40 of the Euratom Treaty, which counts on it *"to stimulate action by persons and undertakings and to facilitate coordinated development of their investment in the nuclear field"*. The main purpose of the PINC is therefore of *"indicating in particular nuclear energy production targets and all the types of investments required for their attainment"*. This review is not only about nuclear power plants but intends to cover the whole nuclear cycle.

This is more than a formal obligation. PINC 2016 is obviously the first one to be published by the new European Commission, under the leadership of President Jean-Claude Juncker and Vice-President Marcos Sefčovič. It therefore establishes their political vision regarding the situation of nuclear power worldwide and within the EU, its possible evolution, and the risk management, competitiveness and investments issues related to that evolution.

The situation of nuclear power has dramatically changed in the European Union since the previous illustrative nuclear programme, PINC 2007[2], which was published more than 8 years ago. This programme was itself updated one year later as PINC 2008[3] in the context of the second Strategic energy review. It is particularly interesting, while discussing the contents of PINC 2016, to put them in the perspective of the situation that was foreseen in PINC 2007 or PINC 2008.

The present note is an updated version of a preliminary analysis that was published on 14 March 2016, at a time when the final version of PINC 2016 was not available yet. This preliminary assessment was based on the draft version of PINC 2016 and the Staff Working Document (SWD) accompanying it that were provided to WISE-Paris for the purpose of this analysis. This final version of WISE-Paris' assessment takes into account the changes that occurred between the draft and final PINC 2016 and SWD[4], sometimes mentioning the most relevant modifications.

2. International perspective

It would hardly make sense to discuss the status and role of nuclear power in the EU without setting the stage of its overall evolution and prospect at an international level. This is furthermore relevant in the context, as PINC 2016 puts it, of *"the first [illustrative nuclear programme] presented by the Commission after the Fukushima Daiichi accident in March 2011"*.

2.1. Wishful thinking

PINC 2016 rightly states that *"the EU nuclear energy market needs to be examined in the global context, given the potential impact of developments in other regions on the EU nuclear industry, global safety, security, health and on public opinion"*. However, the SWD that is supposed to back PINC 2016 doesn't provide any background on this international evolution.

Nevertheless, PINC 2016 uses figures provided by the Nuclear Energy Agency (NEA) and the International Energy Agency (IEA)[5] to claim that worldwide nuclear-related cumulative investments

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[1] Communication from the Commission, *Nuclear Illustrative Programme*, presented under Article 40 of the Euratom Treaty for the opinion of the European Economic and Social Committee, COM(2016) 177 final, 4 April 2016.

[2] Communication from the Commission to the Council and the European Parliament, *Nuclear Illustrative Programme*, COM(2007) 565 final, 4 October 2007.

[3] Communication from the Commission to the European Parliament, the Council and the Economic and Social Committee, *Update of the Nuclear Illustrative Programme in the context of the Second Strategic Energy Review*, COM(2008) 776 final, 13 November 2008.

[4] Commission Staff Working Document accompanying the document Communication from the Commission Nuclear Illustrative Programme presented under Article 40 of the Euratom Treaty for the opinion of the European Economic and Social Committee, SWD (2016) 102 final, 4 April 2016.

[5] NEA / IEA, *Technology Roadmap, Nuclear energy*, 2015.

needs could reach € 3 trillion until 2050, foreseeing an increase of the number of countries operating nuclear reactors as well as of the global installed capacity by 2040 – although the Commission doesn't dare to commit to any more detailed prevision, apart from pointing to an increase of 125 GWe in China alone.

PINC 2016 pretends to ignore the fact that these are not forecast but voluntary results of a proposed 2°C scenario where nuclear capacity would almost triple by 2050, to reach 930 GWe. Leaving aside the ongoing discussion regarding the lack of realism of such high figures, it is clearly a misleading move from the Commission to present a voluntary prospective vision as if it were an ordinary business as usual forecast.

2.2. Declining trend of nuclear power

It is very disturbing that these claims are not put in perspective through an analysis of the *actual* current trend, especially when a perspective for decline had been introduced in PINC 2008. It stated for instance that *"ageing power plants are scheduled to be shut down in the next 10 to 20 years, which will reduce nuclear energy's share of total electricity generation"*, down from 15% in 2006 to less than 8% by 2030 *"if present policies continue unchanged"*.

This trend actually went on. By 2014, nuclear power already generated only 10.8% of the world electricity. The electricity generated by nuclear reactors worldwide peaked in 2006, and had fallen by 9% by 2014. The operational capacity of nuclear power plants went down from 368 GWe by 2006 to 336 GWe by mid-2015, with 41 less reactors operating[6]. The Commission fails to refer to any impact of Fukushima on the international trend for nuclear energy, This fall is nevertheless partly due to the consequences of this nuclear catastrophy in terms of permanent shut-down or long term outage of all 54 Japanese reactors, with only four of them back in operation since that time, of which two have been shut-down again by juridical decisions. However, the lack of a real dynamics in new build, apart from China, and the closure of ageing reactors also explain this trend, which is likely to continue.

2.3. Competition with renewables

Moreover, it should be emphasized that not much new momentum seems to be gained by nuclear energy programmes from climate change objectives. While the European Commission was clearly calling in PINC 2007, although implicitly, for new CO_2 abatement policies to back new developments of nuclear power, this effect remains very low, and PINC 2016 doesn't even refer to that perspective.

Altogether, the role of nuclear power remained quite marginal in "avoiding" greenhouse gas emissions worldwide. Using a method which takes into account the indirect emissions arising from the lifecycle of nuclear power on one hand, and the real emissions of the global electric mix that nuclear power substituted to through its development, WISE-Paris has calculated that its contribution peaked in 2000 with an equivalent of 6% of energy related CO_2 emissions avoided, now down to less than 4%[7]. This decline is mostly due to the effect of energy efficicency and the competitiveness of some renewables, which both provide bigger and faster emissions abatement for the same investment than new nuclear power. It is no surprise that nuclear power has not gained support through the momentum of COP21. An indicator of the trend is the fact that amongst the 161 INDCs tabled before, during or since COP21 in December 2015, representing 188 countries, only about ten explicitly and positively refer to nuclear projects[8], while probably more than two-thirds of them mention renewables as part of their portfolio of action[9].

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6 Mycle Schneider Consulting, *The World Nuclear Industry Status Report 2015*, July 2015.

7 WISE-Paris, *L'option nucléaire contre le changement climatique - Risques associés, limites et frein aux alternatives*, October 2015.

8 According to detailed accounting by WISE-Paris as of early December 2015. These are Argentina, China, Egypt, India, Iran, Japan, Jordan, Niger, Turkey, and the United Arab Emirates (while Israel, Korea, the Republic of Macedonia and Singapore mention nuclear power to exclude it or state their potential to start or develop it is limited). Members of the European

The complete reversal of the respective dynamics of nuclear power and renewables is precisely the most dramatic change that has occurred since PINC 2007, in terms of context for nuclear develpment. Although detailed and comparable figures are hardly available, *"it is clear that over this period [of 2004-2014] the investment in nuclear construction decisions is about an order of magnitude lower than that in renewable energy"*[10]. PINC 2016 doesn't reflect this situation at all.

The overall impression is that while PINC 2008 pointed to the risk of a decline of nuclear power as to reverse it by creating a new momentum, the new Commission's paper fails to discuss how much has changed. Any need for being prudent about the potential for renewables to ramp up, that could (wrongly) be used as a justification for backing nuclear power at that time, can no longer be used in the climate debate, making support for nuclear power increasingly ideological.

3. Role of nuclear power in EU energy policy

The growing role of renewables is simply acknowledged by the mention in PINC 2016 that the EU currently gets *"27% of electricity produced from nuclear energy and 27% from renewable sources"*. The share of nuclear power was one third at the time of PINC 2007, which didn't mention the role of renewables. Their contribution sharply rose to the same level as nuclear power, up from 15.4% of gross electric consumption in 2006.

PINC 2016 still emphasizes the role of nuclear power in EU energy policy, particularly for energy security and CO_2 mitigation. However, it doesn't seem as enthousiastic about the current and potential role of nuclear power in European energy strategy, compared to the Staff Working Document (SWD) which accompanies it.

3.1. Contribution to energy security

According to SWD, *"nuclear energy accounts for 28% of the domestic production of energy in the EU"* in 2013. This figure, which is not used as such in PINC 2016, corresponds to the share of nuclear power in *gross* energy production. This indicator traditionnaly overweighs nuclear energy compared to other sources, due to its very bad efficiency[11]. In fact, according to this indicator, nuclear power provides a bigger share of the overall energy production than that of electricity generation alone. It would seem more relevant to inform about the contribution of nuclear power to the satisfaction of energy needs through its share in meeting final energy consumption, which amounted to 5.8% in 2013. The reference to final energy consumption also makes all more sense in the context of 2030 targets which include, as the draft version of SWD noted, to reach *"at least 27% renewables share of energy consumption at EU level"* (this share being expressed in final energy). As this was actually the sole reference to renewables[12], they are not even mentioned anymore in the whole final SWD.

SWD therefore insists much more than PINC 2016 on the fact that *"nuclear energy also contributes to improving the dimension of energy security"*, refering to its capacity to generate continuously with relatively stable fuel and operating costs. However, it fails to address the security issue of uranium feeds. SWD emphasizes that uranium conversion, enrichment and fuel fabrication needs are mostly met within EU. It also basically argues that uranium imports needed to run reactors in Member

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Union are not accounted for, as they are part of the common INDC submitted by the European Union. It is interesting to note, in the context of PINC, that there is no reference to nuclear power in the joint European INDC.

[9] For instance, the World Future Council counted out of 158 INDCs that 108 include renewables, of which 75 specify renewables targets. See World Future Council, *What Place for Renewables in the INDCs?*, updated version, 12 March 2016.

[10] Mycle Schneider Consulting, *op. cit.*

[11] With two thirds of the heat produced in reactors lost in the process of generating electricity, nuclear power is practically the energy source with the lowest rate of conversion between primary and final energy. Therefore it weighs much more in primary energy balance of production than in final energy balance of consumption.

[12] Apart from a box discussing their negative role, because of their "intermittency", on electricity prices and reliability, that also disappeared in the final version. Occasional mentions of "intermittent sources of power" still appear in the final SWD, but they do not name renewables.

States are provided through diversified and secure agreements – however cleary downplaying security issues such as the 15% share supplied by Niger and its complex geopolitical implications.

It remains that with only 2% of uranium needs of EU reactors met by domestic mining (in Czech Republic and Romania), nuclear power could hardly still be considered as a domestic production of energy.

The combined use of primary energy accounting and failure to acknowledge for the dependency of nuclear power on imports is highly misleading regarding the actual contribution of nuclear energy to the energy security of the EU. This is exemplified by the ongoing debate in France regarding the evolution of energy independency, assumed in the official energy balance to be the ratio between its domestic energy production and energy consumption[13]. When expressed in primary energy, accounting for nuclear power as domestic production, the French energy independency rose from less than 25% before the introduction of the programme following the oil shock of 1973 to around 50% since the 1990s and until today; when expressed in final energy and discounting nuclear power which has gradually used imported uranium and uses no more French one since 2001, then the independency fell from around 30% in 1973 to less than 15% today.

3.2. Contribution to carbon mitigation

Similarly, the SWD insists on the role of nuclear power energy as a *"source of low-carbon electricity"*[14]. Again, it uses for that purpose a very distorted argument, which is not reflected by the Commission in PINC 2016.

The SWD refers to a report by the International Energy Agency (IEA) which sets a level of reduction of CO_2 emissions to reach worldwide between 2030 and 2050 in a 2°C scenario, and compares the pace that it implies to past achievements by France and Sweden, implicitly suggesting that developing nuclear power to the same extent than those countries at the same pace is required to meet climate objectives. It claims that the introduction of nuclear programmes resulted respectively in these countries in 5.4% and 6.2% average reduction per year of their carbon intensity (energy-related CO_2 emissions compared to GDP) between the late 1970s and late 1980s, in line with the rate of 5.5% which IEA says is needed over 2030-2050.

This is misleading for many reasons. The first one is that the development of a nuclear fleet was only part of the efforts contributing to the reduction of emissions (which, by the way, was not the purpose at that time). In France, for instance, the development of nuclear power up to a share of 75% of electricity generation roughly accounted for half the 30% decrease in energy-related CO_2 emissions between 1977 and 1987, the other half mostly coming from energy efficiency policies. The second is that this applies to an energy system starting with no nuclear power: replacing existing nuclear capacity does not bring further reductions. The potential in the EU for nuclear power to get emissions down is therefore reduced by its already significant share of nuclear power. The third and main reason is that the potential for renewables to contribute to mitigation policy is by no comparison greater than it was at the time when most of the French, Swedish (and European) nuclear fleet was developed (also acknowledging that this was for other reasons than climate policy). In fact, when it comes to investing in new power capacities, it is clear today that the most competitive renewables deliver better, faster and are cheaper than new nuclear reactors.

3.3. Evolution of energy demand

One argument that has been regularly used to back the development of nuclear power is the need to fulfill a supposedly ever growing electricity demand. The Commission used that argument in PINC 2007, where it explained that *"within the EU, despite constant efforts to improve efficiency,*

[13] Commissariat général au développement durable (CGDD), *Bilan énergétique pour la France pour 2014*, July 2015.
[14] It is nevertheless interesting to note that its characterization as a "reliable" source, which was emphasized in the draft version, has been deleted in the final one.

energy demand has continued to rise by 0.8% per year" and continued with the following forecast: *"the latest estimates predict an annual increase in EU electricity demand of 1.5% on a business as usual scenario"*. This served to justify a ramp up in nuclear programmes to avoid that more fossil fuel fired power fills the gap. PINC 2008 still explained that, *"under the PRIMES New Energy Policy scenario, (…) electricity demand growth is expected to be 8-9% over the same period"* (by 2020).

PINC 2016 fails to discuss how this forecast went wrong. Electricity consumption within EU didn't go up but slightly down, by 0.5% per year on average between 2006 and 2014[15]. The actual consumption stands at 3,010 TWh, almost 15% below the level of 3,540 TWh that PINC 2007 was projecting. The difference amounts to the equivalent of 65 GW of nuclear installed capacity generating with a load factor of 90 %.

The trend can be expected to continue. The EU committed to strengthen its energy conservation policies trough objectives of 20% improvement in energy efficiency by 2020, and later 27% by 2030. Actually, the gross final energy consumption of EU-28 went down from 1,825 Mtoe in 2005 to 1,666 Mtoe in 2013. Although the share of electricity in final energy consumption is expected to increase due to its reinforced role, e.g. through new uses like mobility (individual electric vehicles), the impact of efficiency is seen as remaining bigger than that of economic and demographic growth and new uses. Nevertheless, PINC 2016 still sets the perspective, without being more specific or providing any justification, that *"electricity demand is expected to increase over the same period"* (until 2050). This clearly sends a wrong signal of a need for more capacity, when overcapacity increasingly stands as a major issue on the European market (see below).

4. Status and trend of nuclear power in the EU

According to PINC 2016, a total of 129 nuclear power reactors are still operating in the EU, with a generating capacity of 120 GWe, in 14 Member States. The Commission doesn't provide information about the trend, which it could at least do by commenting the difference with the situation described in PINC 2007. There are actually 23 less reactors operating in the EU, in one Member State less than at that time.

4.1. No new build dynamics

This 15% drop in the number of reactors in less than 10 years is mostly a combination of shutdowns of ageing reactors and very slow progress of construction of new ones. In PINC 2007, construction of new reactors were counted by the Commission in Finland, France, and Bulgaria. It is striking that none of them came on line since then. The European Pressurized Reactors (EPR) being built in Olkiluoto in Finland and Flamanville in France were at that time planned to start operation respectively in 2009 and 2012. They are now both scheduled to start before the end of 2018, although both are still plagued with many problems that could result in further delays. Bulgaria had projects for building reactors both on the Kozloduy site, where a nuclear power plant already operates, and on a new site at Belene. Although some political discussions continue, both could not be listed as under construction anymore.

The update in PINC 2008 even included, besides those four reactors, two more units being listed as under construction in Slovakia. The construction of these two units in Mochovce had actually started between 1985 and 1987 and was suspended in 1993. Resuming their construction was already decided at the time of PINC 2007 but only took place in 2008-2009. They have now both been under supposedly active construction for at least 13 years and are still not complete.

The list in PINC 2016 still includes the two reactors being built in France and Finland, as well as those two units in Slovakia, but refers no more to constructions in Bulgaria. Overall, there are not more reactors listed as under construction in PINC 2016 than in PINC 2007. Moreover, the Commission fails

[15] EIA and Eurostat.

to acknowledge the simple fact that no new reactor has been ordered in the EU since Flamanville-3 in 2007, and that no new reactor has been connected to the grid in the EU since Cernavoda-2 in Romania the same year.

Even the list of Member States considering nuclear projects has shrunk between PINC 2016 and PINC 2007, with the Netherlands and the Baltic States no longer interested. No new country added to the list. This even more contrasts with the information provided in the PINC 2008 update. It refered to Romania being *"closed to notify their plans to complete"* Cenavoda-3 and 4, which has not happened, and Italy having *"view to constructing between 4 and 8 new NPPs"* by 2020, a plan that has been abandoned. Only eight of the already nuclear Member States are eventually identified by PINC 2016 as discussing new projects. These are up to some licensing stage in only three of them, Finland, Hungary and UK. In fact, the flagship project of the new nuclear programme in the UK, the construction of two EPR reactors at Hinkley Point, is still under review by its French proponent EDF, which has been regularly postponing its final investment decision during the past three years, although as much regularly comitting to make in the next weeks.

4.2. Life extension as a lifeline

The very low profile of new builds doesn't prevent the Commission from presenting ambitious targets for maintaining some of EU's nuclear installed capacity. In any case, new builds could not ramp up to the point of achieving this. Therefore, from PINC 2007 to PINC 2016, the Commission constantly insists on the key role for reaching this objective of extension of operation of reactors beyond their designed lifetime (also called long term operation, or LTO).

PINC 2007 introduced this issue by showing that the nuclear installed capacity in the EU would fall down to 20 GWe by 2030, using an assumption of 40 years lifetime for then existing reactors and no new constructions. The Commission then introduced a projected scenario where nuclear capacity would remain high, with 110 GWe by 2030, thanks to a mix of LTO and new builds that was left to be decided. PINC 2008 showed even more confidence in planned and possible programmes, illustrating a scenario where capacity would be maintained around 138 GW all along to 2030 with *"generalised lifetime extended to 50/60 years or equivalent capacity of new builds"*.

The ambition of PINC 2016 is comparatively reduced. The scenario it develops, *"based on information from public sources as well as reported by Member States under article 41 of the Euratom Treaty"*[16], points to a projected capacity around 105 GWe by 2030. Contrary to the previous illustrative programme, it encompasses a longer span, up to 2050, when nuclear capacity is foreseen to be maintained between 95 and 105 GWe.

Also, contrary to PINC 2007 and 2008 that left the issue open, PINC 2016 gets into specifying the respective role of LTO and new builds in its scenario. Unsurprisingly, LTO is playing the major role in the short to medium term: in 2030, roughly half the nuclear capacity is based on reactors operating in LTO, while less than 15% is based on reactors already existing today still operating without LTO, and around 35% is based on new builds. By 2050, reactors in LTO only still account for around 13 GWe, meaning that new reactors should amount to 80-90 GWe by that time.

4.3. Unrealistic plans

This level of new builds is highly questionable regarding the current trend. The SWD explains that two thirds of new capacity could be built in only two Member States, France and UK. Plans for new reactors in France have not even been politically discussed yet, although EDF regularly claims this to be its strategy. It remains to be seen, even if that would be the case, what would be its actual industrial and financial capacity to develop such a programme. They sould also be assessed in the context of the objective set by the 2015 Energy transition law of reducing the share of nuclear power in generation from 75% to 50% by 2025. In the UK, the commissioning of two EPR reactors to be

[16] This mention appeared in the draft SWD but has been suppressed in the final version.

constructed by EDF, key to the launching of the programme, is increasingly threatened by the decaying situation of EDF.

Nevertheless, the Commission programme accounts for 20 GWe to start operation between 2020 and 2025 (in addition to 4 GWe listed as under construction expected to start before 2020). This is strongly inconsistent with experienced construction time of 10 years or more (and 7.8 years on average in the overall history of nuclear programmes in EU countries), leaving aside the time needed for political decision and licensing prior to construction.

The LTO part of the Commission's illustrative programme might be as much challenging. It plans for the lifetime extension of about 20 years of at least more than half of the existing reactors. As SWD puts it, *"there is a high degree of uncertainty"* since *"only a small share of investments in LTO (…) have already been approved by national authorities"*. It is therefore really misleading that the reference scenario which SWD provides accounts for so much life extension and that the resulting figure is used in PINC 2016 without being discussed.

In the case of France, EDF has prepared for licensing of LTO, which will be based on a reactor-by-reactor reassessment starting with the first unit in 2019, and would be granted only for 10 years. But the process is still in its early stage. The French nuclear safety authority has still to publish its decision on the generic orientations of this case-by-case assessment, and has clarified that no LTO could be seen as acquired for the time being. The objective of bringing the share of nuclear power down to 50% by 2025 also brings some limitation, which SWD says was taken into account in the undisclosed French official scenario being used. It is not clear whether this scenario is realistic enough regarding this constraint. Meanwhile, the French Court of Auditors confirmed in its annual report that meeting this objective should lead to the closure of 17 to 20 of EDF's 58 units[17].

The ambition of PINC 2016 regarding LTO, and its lack of attention for less optimistic return of experience, is also reflected in the evolution of the European nuclear fleet since PINC 2007. At that time, the average age of reactors in the EU was close to 25 years. It is now close to 30 years. If the reactors fleet got older by 5 years in 9 years, it is not because of new builds, but mostly because of the shut down of reactors, on average amongst the oldest. This, together with the fact that no reactor in Europe (or worldwide) ever experienced operation over 48 years, calls for a much more cautious approach about 50 to 60 years lifetime extensions than that of the Commission.

5. Risk management

The Commission insists in PINC 2016 on improvements regarding safety and radioprotection requirements, considering that *"since the previous PINC update in 2008, the EU nuclear landscape has undergone significant changes"*. This mostly refers to the risk and safety assessments that were conducted after the Fukushima Daiichi catastrophy in 2011 through so-called stress tests, as well as *"the adoption of landmark legislation on nuclear safety, radioactive waste and spent fuel management and radiation protection"*.

5.1. Safety requirements

In fact, PINC 2008 very much insisted on this issue. At that time, the Commission showed high confidence in the capacity of nuclear energy to deliver reliable and competitive electricity. It therefore focused on the need to develop public acceptance, and the need to improve licensing processes to address *"a need for planning stability and for reduction of investment risks due to regulatory uncertainty for investors and other stakeholders"*.

As such, the Commission recommended in PINC 2008 that *"common reactor safety levels for existing NPPs and new build should be adopted"*. Furthermore, it recommended that *"only designs whose*

[17] Cour des Comptes, *Rapport public annuel 2016*, February 2016.

safety and security levels are equivalent to Generation III, or subsequent improvements should be considered in the EU for future new build".

The nuclear safety landscape has of course dramatically changed after the Fukushima disaster. Besides the specific causes of that accident, it revealed fundamental limitations in the defense-in-depth based designs when using the probabilistic approach to assess so-called realistic situations. This of course reinforces the need for the strongest requirements to be imposed on new reactors. But most importantly, it calls for reassessing the safety of existing ones, which was the purpose of the European stress tests. And then decide on either their shutdown – as Germany did shortly after March 11, 2011 with eight of its reactors, a move that is not reported in PINC 2016 – or reinforcement, an issue which the Commission barely discusses.

According to PINC 2016, the amended Nuclear Safety Directive adopted in 2014 *"brings the nuclear safety standards to a higher level [and] sets a clear EU-wide objective to reduce the risk of accidents and avoid large radioactive releases"*[18]. Moreover, the Commission stresses that *"early 2015, Euratom played a key role in ensuring the adoption of the «Vienna declaration»"*, by which Contracting Parties to the IAEA Convention on Nuclear Safety committed to improve safety standards. This is a very incomplete account of the Convention meeting, which was initially due, instead of a simple declaration, to modify the Convention so as to introduce the obligation for existing reactors to be reinforced up to a level satisfying post-Fukushima requirements (a position that was originally supported by EU, but could not actually be discussed due to the opposition, mostly, of the US and Russia).

Such a change would have been compliant with the recommendations made by the Western European Nuclear Regulators Association (WENRA) that safety levels of existing reactors should be raised to come as close as reasonably possible of those applied for Generation III designs, such as the EPR. It would also be consistent with the initial objectives of the stress tests.

The situation of nuclear safety in the EU is not evolving towards these standards. The stress tests proved very incomplete and the prescriptions which followed remain insufficient in many Member States compared to the stated objectives. Even in countries where these prescriptions have been the more ambitious and comprehensive, e.g. with the need to introduce a "hardened core" of robust safety equipments in French reactors, they are still waiting for being implemented[19]. Moreover, the stress tests did not cover the whole range of nuclear facilities, which they should have as some of them present a comparable or even superior potential of danger than that of reactors and can show even weaker designs when submitted to the same kind of stress tests.

In practice, the requirements applied to existing reactors and LTO are clearly not systematically compliant with the goal of raising the safety of the concerned reactors up to the highest possible level. The kind of softness in the application of hard principles is or instance badly illustrated by the decision to allow the restart of the reactors of Doel-3 and Tihange-2, in Belgium, although the defects found in their pressure vessels clearly leave no acceptable margins in the face of modern standards.

While PINC 2016 insists on the need to meet high safety standards, the Commission doesn't seem to make it strictly conditional to LTO or new builds. For instance, contrary to its own recommendation in 2008, it seems to leave the door open to lower standards when it says that *"capacity replacement investment up to 2050 will most likely be in the most advanced reactors, such as EPR, AP 1000, VVER 1200, ACR 1000 and ABWR"* – while something like "will have to be" could be expected.

[18] Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations.

[19] The technical options and designed robustness of the "hardened core" are actually still under review in France, their implementation not being expected to start earlier than 2018 and to be completed by 2023.

5.2. Preparedness and civil liability

Although the possibility of a major accident was already very clear before, it suffers no discussion since March 2011, when the world witnessed in shock the Fukushima Daiichi catastrophy. The lesson learnt is not only about the need to consider the possibility of such an accident on any nuclear power plant site. It is also about the size in space and time of such an accident, and the need to prepare for it, although obvioulsy no planning and training could ease the prospect of facing such a complex and dramatic situation.

This firstly raises strong concern regarding the blatantly insufficient level of emergency preparedness under current nuclear emergency planning in most, if not all of the nuclear Member States. For instance, the protection measures are often restricted, like in France, to a radius of around 10 km that corresponds to a scenario os serious accident much less severe than what the Fukushima plant experienced. The European nuclear safety and radioprotection authorities, WENRA and the Heads of the Radiological Protection Competent Authorities (HERCA), recommend that a radius up to 80 km should be considered[20].

An important consequence is that the worst consequences of a nuclear accident would surely not only remain a national matter. In fact, a large number of nuclear power plants within the EU are located less than 80 km or 100 km away from neighboring Member States, which increasingly tend to express concerns for the safety of the corresponding plants (Germany with Fessenheim in France, Germany and Luxemburg with Cattenom, the same and the Netherlands with the Belgian plants, Austria with Czech and Slovaquian plants, etc.). This also means that preparedness has to integrate the cross-border consequences of a possible nuclear accident, a development that the Commission should take charge of. On the contrary, PINC 2016 and SWD seem to ignore these growing cross-border concerns and the need to address them.

The range of consequences of the kind of nuclear catastrophy to consider also reinforced the concern for civil liability requirements applying to nuclear operators and their limited amounts compared to the consequences of such an accident. The issue was already discussed before, as shown in PINC 2008 recommended that *"a more coherent and harmonised liability scheme should be developed to ensure a comparable level of protection for citizens and to create a level playing field for EU nuclear industry"*. It is therefore very odd that this issue is not addressed anymore in PINC 2016 or its attached SWD.

The situation nevertheless remains very insufficient in EU Member States, where the level of civil liability of nuclear operators ranges from tens to hundreds of million euros. The Fukushima Daiichi catastrophy shows that a major accident could lead to unprecendented consequences within the EU. In France, the Institut de radioprotection et de sûreté nucléaire (IRSN) has estimated the direct and indirect cost of such a catastrophy for the French economy in the range of € 200 to 1,000 billion[21].

5.3. Waste management

PINC 2008 presented geological disposal as the preferred option of countries with a nuclear programme, while *"others prefer near-surface storage"*. The main obstacle for their implementation which it discussed were neither technical nor financial but socio-political issues, and particularly the difficulty to select a site. The countries with the most advanced programmes for geological disposal were Finland, where the disposal site had been chosen, Sweden and France. But even for other countries where decision to develop geological disposal had been made, site were far from being selected. Also, *"public acceptance and involvement in the decision-making process"* were seen as the

[20] HERCA, WENRA, *Approach for better cross-border coordination of protective actions during the early phase of a nuclear accident*, 22 October 2014.

[21] IRSN, *Méthodologie appliquée par l'IRSN pour l'estimation des coûts d'accidents nucléaires en France*, 2013.

way to move forward disposal projects. Commission considered harmonization as essential and had proposed directives *"to set up a Community framework for […] the management of nuclear waste"*.

The Spent Fuel and Radioactive Waste Directive[22] has been adopted since then. Some progress has been made in some countries regarding low-level and intermediate-level radioactive waste management, including the development of dedicated facilities. However, there was comparatively little progress for geological disposal plans. The Commission had set the objective of starting implementation of geological disposal in the concerned countries by 2020.

The most advanced countries are still Finland, Sweden and France. For these countries, start of operations is now officially expected between 2020 and 2028, although this would only apply to intermediate level waste for the first decades – and remains highly uncertain, at least in the case of France. The French process was subject to a national public debate in 2012 that was boycotted by most opponents, and concluded among other things with the need to slow down the process. As for the other Member States, no planned operation is officially foreseen to start before 2047 in Belgium, 2050 in Germany and Romania, and later in all the others. In many countries, discussions are still going and the principle of geological disposal could not be seen as decided yet. Therefore, the comment by the SWD that deep storage is now considered as a *"commonly accepted option"* is misleading, and hardly accounting for the problems encountered. The Commission nevertheless doesn't discuss this gap between the voluntary objectives and schedule that it has set and the real status of processes.

6. Competitiveness

When the Comission set its ambitious illustrative programmes in PINC 2007 and 2008, it was very clearly based on a strong belief in its economic case. This is obviously also one of the areas where things have dramatically changed.

6.1. Drifting of generating costs

PINC 2007 clearly put the economics of nuclear power as the main reason and key condition for its further development within the EU: *"the future of nuclear energy in the EU depends primarily on its economic merits, its capacity to deliver cost-efficient and reliable electricity (…)"*. However, the vision set by the Commission in PINC 2007 and 2008 for the future costs of nuclear power was strongly aligned with the figures then provided by the industry, which were already criticized for being fantasies instead of realistic assessments, which experience has now strongly confirmed.

For instance, PINC 2007 stated that *"nowadays a new nuclear plant involves an investment in the range of € 2 to 3.5 billion (for 1000 MWe to 1600 MWe respectively)"*. These are the figures that were used by the industry at the time, for instance in the case of the two 1,600 MWe EPR projects in Olkiluoto and Flamanville. Both are still not completed – therefore the official cost estimates could still rise – and their respective overnight construction costs are now estimated to reach € 8.5 and € 10.5 billion. The overnight construction cost of the EPR projects considered in the UK stands even higher, around € 12 billion per unit.

Similarly, PINC 2007 relied on a projected generating cost that it quoted from the IEA, writing that *"new nuclear power plants could produce electricity at a cost of less than 5 US cents per kWh, if construction and operating risks are appropriately managed by plant vendors and power companies"*. This, again, could compare with the current projected costs of the EPR reactors under construction or consideration, ranging from € 9 to 13 c€/kWh[23].

[22] Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

[23] When the buiding of a first EPR was introduced in the French law, in 2005, the official projected complete generation cost provided by EDF and endorsed by the Government was 28 € per MWh, lower than the current generating costs of

The Commission doesn't seem prepared to make amends for getting it so wrong. In fact, PINC 2016 does not only fail to acknowledge for the wrong forecast of projected generating costs and their evolution. It actually fails to discuss the issue of generating costs itself, rather focusing on issues such as financing schemes, standardisation and optimised licensing processes, all aimed at reducing the complete costs but not disclosing the importance of such a reduction.

6.2. Biased updates for new reactors

The detailed discussion of construction and generating costs is to be found in the SWD. The main topics addressed are those of the overnight construction costs and financial costs attached to the investment. The SWD is using a *"generic figure of overnight construction cost"* applying to a typical first of a kind reactor (FOAK) or a N of a kind reactor (NOAK)[24]. This ranges from 4,138 to 5,379 €/kWe for a single unit FOAK and from 3,807 to 4,949 €/kWe for a twin unit FOAK, and from 3,476 to 3,997 €/kWe for a single NOAK unit and from 3,145 to 3,617 €/kWe for a twin NOAK unit.

This is then compared to the projected construction costs of reactors currently being constructed or planned in the EU. Although these seem slightly inferior to the latest estimates publicly available[25], it is noted that these costs *"are in the high range of the calculations"* of a typical FOAK. In fact, they do not fall in the high range, but partly or completely above the higher estimate provided by the Commission – for two of the three single units listed and two out of four of the twin units projects. In particular, with a cost of 6,755 €/kWe, the Hinkley Point-C project in the UK falls 35% above the higher "typical" estimate. On the opposite, the only project to fall well within the Commission's theoretical range, with 4,500 €/kWe, is one in Czech Republic for which the estimate remains so raw that is is irrelevant for that matter, as the technology is still *"not chosen"*. This is consistent with the overall return of experience of nuclear projects, were costs globally increase as the projects come closer to concrete implementation.

It should also be noted that Olkiluoto-3 is the only one of the seven projects listed that could strictly speaking be considered a FOAK. However, contrary to the usual argument about gains from building series, its estimated construction cost is below that of the French and British EPR reactors. This is all the more consistent with the negative learning curve that has been experienced in nuclear history. SWD accounts for the analysis provided by IAASA of a tripling of overnight construction costs of French reactors between 1974 and the 1990s, *"in spite of some favorable conditions that include centralized decision making, high decree of standardization and regulatory stability"* – which could not be met so favorably today. However, SWD does not really discuss how this negative trend could be reversed in the future.

Finally, SWD discusses the important issue of financial costs to be added to overnight construction costs. These essentially depend on two factors: the real interest rates, which it assumes to range from 7 to 10%, and the construction time. The assumption used there is that *"there is a margin for reducing the construction time"* from the overall historical average of 7.8 years to 7 years for new projects. This is highly inconsistant with the overall trend, when historical data provided by SWD itself shows that the average duration of reactors construction in Europe went regularly up from one decade to the next, from 5.5 years in the 1950s to 11 years in the 1990s[26]. It is even more inconsistent with the evidence provided by reactors currently under construction, showing an

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amortized existing reactors. The latest estimates bring it up to 90 € per MWh at least. Similarly, the official projected cost of the Hinkley-Point C project was initially £ 24 per MWh, and the contract for difference is now set to £ 92.5 per MWh.

[24] The discussion on the difference between a FOAK and a NOAK was introduced between the draft, that only discussed the singularity of FOAK reactors (and where the concept of NOAK did not appear), and the final version of the SWD.

[25] For instance, the cost for Olkiluoto-3 would be between 4,942 €/kWe or 5,313 €/kWe (depending on a calculation based on gross or net electric capacity), to be compared with the figure of 5,100 €/kWe provided in SWD. Similarly, the cost of Flamanville-3 would be between 6,364 and 6,442 €/kWe, compared to 6,287 €/kWe provided in SWD.

[26] The average for the 1990s is not very significant, however, given the very low number of reactors completed over these years. The slight decrease to 10.3 years in the 2000s is even less significant, with even fewer completions during that last decade.

average updated planned construction time of more than 14 years (and even more than 21 years if strictly accounting for the span between construction start and planned completion in the case of Mochovce[27]).

The misleading assumption of using a construction time half of the current experience has an enormous impact on the overall investment costs for new reactors. According to SWD, the difference between 7 or 10 years of construction would result in an additional financing cost amounting to 17% of the overnight construction cost with an interest rate of 7%, and 28% with an interest rate of 10% (SWD doesn't even provide the equivalent figures for a construction time of 14 years)

SWD, and furthermore PINC 2016, fail to discuss the reasons for being so wrong in past projected costs and the root causes of cost escalation. It also fails to provide convincing evidence of its claim that future costs could decrease compared to those experienced with current projects.

6.3. Underestimates of long term operation costs

The documents of the Commission did not discuss the costs of LTO before PINC 2016. Nevertheless, the same escalate between official cost assumptions at the time of the previous illustrative programme and today could apply to them. It is actually at the time of PINC 2008 that EDF released for the first time information about a change of strategy shifting to LTO of its French nuclear fleet. In December 2008, during an "Investors' Day" at the City, in London, EDF explained that this would save it huge investments that would be needed for replacements, introducing then a figure of € 400 million for the 60 years life extension of a typical 900 MWe reactor. The latest estimate, published in February 2016 by the French Court of Auditors, rised up to € 1.7 billion by reactor (an even greater multiplying factor than between initial and current estimates for the Flamanville-3 EPR). It should be emphasized that this estimate is still based on official figures provided by EDF, which have separately been questioned as underestimating some of the costs (see below).

As for the costs of new builds, the costs of LTO are not discussed in PINC 2016, which uses assumptions provided by the SWD. The projected costs for LTO used by SWD are *"based on data publically available and on questionnaires addressed to the nuclear power plant operators"*. Although this is not explicit in the document, this probably means for instance, in the case of France, that the SWD is using the figure regularly published by EDF of € 55 billion for the "grand carénage", a term that describes an LTO programme which EDF plans to apply to all or most of its reactors. As shown by the French Court of Auditors, this figure actually only accounts for investments up to 2025 and does not cover all the related costs, and should therefore be increased to € 100 billion to comprehensively account for EDF's planned LTO programme[28].

The average cost for LTO that is provided by SWD amounts to 629 €/kWe plus an additional 63 €/kWe for post-Fukushima reinforcements. This represents a total of € 623 million for a 900 MWe reactor, or 2.7 times less than the figure provided by the Court of Auditors for the French reactors.

Besides the classical underestimate of their projected costs provided by operators, one reason for this huge difference might be the actual level of safety requirements that are assumed by operators in different countries. The costs remain subject to significant uncertainties, since most ot the LTO considered in PINC 2016 are still only operators' projects which needs to be approved by the national authorities. There might be both a gap between the operators a priori assumptions and the final requirements and a discrepancy in requirements between countries.

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[27] That is: 13 years for Olkiluoto-3 (construction started in 2005, completion is expected by 2018), 11 years for Flamanville-3 (construction started in 2007, completion is expected by 2018), and respectively 16 and 17 years of active construction, and 31 and 32 years of total duration for Mochovce-3 and 4 (construction started in 1985, stopped in 1993, resumed in 2008, completion is expected respectively in 2016 and 2017).

[28] Cour des Comptes, *Le coût de production de l'électricité nucléaire – Actualisation 2014*, Mai 2014.

The SWD stresses that LTO could only be granted through the demonstration of the plant's maintained conformity and the enhancing of its safety *"as far as reasonably practicable"*[29]. In addition, following the stress tests, post-Fukushima reinforcements are also introduced. However, the requirements set by safety authorities regarding the level of effort on maintenance and conformity, the level of enhancement and the reinforcements might very much differ between Member States.

In particular, the Commission choses not to refer to the objective proposed by WENRA that the level of safety to tend to that of new designs of reactors, so-called Generation-III or III+, such as the EPR. In France, where the Nuclear safety authority is refering to a similar objective, it stresses that the feasibility of LTO for the 34 reactors of 900 MWe, which is currently under regulatory review, is not certain, and the technical reinforcements required are still being discussed. A report by WISE-Paris, which was considered as a relevant contribution both by ASN and EDF, detailed the potential costs for a typical reactor depending on technical solutions fitting different levels of safety requirements[30]. It concluded that they could range from € 400 million in a scenario where safety is degraded to € 4 billion if safety is really upgraded to match the level of an EPR, these costs only applying to the nuclear part, and not including refurbishment of the conventional part that is included in LTO costs.

6.4. Market conditions

Although they underestimate the costs of new builds and LTO, PINC 2016 and the SWD emphasize the concern of the Commission with market conditions. The draft version of SWD seen by WISE-Paris stressed that achieving the climate objectives of the EU will *"require the redesign of the electricity market" – but this argument is not raised anymore in the final version*. Still SWD puts it that *"current investment conditions present a challenging environment for achieving the projections of nuclear new build"*, even citing a study on the role of carbon price concluding that *"under current investment conditions, none of the carbon price scenarios succeeded in making the construction of nuclear power plants profitable before 2025"*[31] based on market conditions alone. For that reason, it is suggested that *"the lower end of the projections is used as a reference in this SWD"*. The SWD foresees that a *"funding shortage"* could occur, depending *"on the cost of the most competitive technologies (…) and the wholesale market price of electricity"*, although it largely fails to put those two fundamental factors in perspective.

The Commission therefore welcomes the different financing models that are developed for new nuclear projects, based on a guaranteed Contract for difference (CfD) in the case of Hinkley Point or a cooperative agreement between large electricity consumers in the case of Hanhiviki in Finland. This position is consistent with the examination by the Commission of the scheme proposed in the UK, in which it concluded that it would not be an indirect State aid unduly distorting competition in the electricity market by refering to the goal of the Euratom Treaty to develop the use of nuclear power[32]. However, the case is still pending, as the strong criticism which this decision received led to the filing of complaints by some Member States as well as some energy companies. it could also be emphasized that despite a guaranteed tarif well over current market prices for 35 years and guaranteed favorable financial conditions by the British Government, EDF still seems to call for additional financing support from the French Government, which would reinforce the claims about the uneconomic nature of the project.

Meanwhile, neither PINC 2016 nor SWD recall how the situation they describe starkly contrasts with what the Commission projected in its previous illustrative programme. At the time, PINC 2007

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[29] It is worth noting that the term "practicable" has replaced in the final SWD the slightly more demanding term "achievable" that appeared in a previous version.
[30] WISE-Paris, *L'échéance des 40 ans pour le parc nucléaire français*, February 2014.
[31] The draft version of SWD was extending this vision up to 2030.
[32] Commission Decision of 08.10.2014 on the Aid measure SA.34947 (2013/C) (ex 2013/N) which the United Kingdom is planning to implement for Support to the Hinkley Point C Nuclear Power Station, C(2014) 7142 final cor.

discussed the competitiveness of new reactors compared to thermal plants on the basis of IEA projected costs. It roughly concluded that this competitiveness could be assured compared to gas-fired plants but could need a CO_2 price to be assured compared to coal-fired ones. The rising costs of nuclear new builds turn this assumption wrong. But most importantly, the competition with renewables, which was not even considered by the Commission then, is also getting lost by new nuclear power when compared to the most competitive ones, such as onshore wind power.

PINC 2007 was also forecasting that *"the era of cheap energy is probably over, mainly due to strong world demand and insufficient investment in production, distribution and transmission capacity over the last few decades"*. In 2016, the SWD blames low electricity prices. It also points to their volatility due to the "intermittency" of some sources of electricity (pointing without naming them to renewables), which are therefore made responsible for reducing the amount and predictability of the revenues of baseload sources of electricity, in particular nuclear power plants.

The Commission doesn't account for the fact that it is actually the lack of anticipation of the development of renewables and of the stabilisation of electric demand, and the failure of big utilities to adapt their strategies, that result in the current dramatic change of market conditions. The market analysis provided by the draft SWD about the need for market design has been deleted. It clearly appeared more concerned with protecting the existing system, and particularly the interests of operators of existing nuclear capacity, than regulating its change.

It is no surprise, from that perspective, that the Commission fails to discuss the profitability of LTO programmes. SWD underlines that *"extending the useful life of a reactor is generally more attractive for the operator compared to building a new facility since it generally means a lower capital investment"*. This is exactly the reason why nuclear operators in the EU massively develop LTO plans. But the fact that the investment is lower doesn't guarantee it is profitable. This will depend on the increase on generating costs of existing reactors undergoing LTO compared to the market prices offered for baseload generation.

On one hand, LTO might have a much stronger impact on generating costs of nuclear reactors than the Commission's projections suggest. Independent analysis in France has concluded that the complete generating cost could go up by 10 to more than 50 €/MWh, depending on the cost per kW and the extension granted (10 or 20 years)[33]. On the other hand, LTO is likely to reinforce the current trend to very low wholesale electricity prices, which is mostly the effect of the introduction of new variable renewable generating capacity without removing old baseload, including nuclear, resulting in over-capacity generally pressing down prices.

The likelihood that these trends make reinvesting in old nuclear non profitable is high. In France, EDF warned, although it is only beginning with LTO investments, that the wholesale prices are already below its generating costs. In the US, at least four reactors have already been shut down due to unprofitable lifetime extension cases[34]. Similar signals have started to appear in the EU, where Vattenfall and OKG have both announced in 2015 anticipated closure dates for two reactors compared to their licensed lifetime[35].

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[33] Global Chance, "Prolonger la vie du parc actuel : à quels coûts ?", *Les Cahiers de Global Chance, n° 35*, June 2014.

[34] These decisions were taken by three different operators in 2013 and concerned the reactors of Kewaunee, Crystal River, and San Onofre-2 and 3 which had all been granted approval for a 60 years life extension (but were shut down after respectively 39, 36, 31 and 30 years of operation). In addition, Entergy announced in October 2015 the anticipated closure for economic reasons of its Pilgrim reactor in 2019, although its 60 years license goes up to 2032.

[35] Vattenfall will close the two units in Ringhals respectively in 2018 and 2020 instead of 2025, due to *"declining profitability and increasing costs"*. OKG will close Oskarshamm-1 and 2 in 2017 and 2019, due to *"the lack of perspective for profitability in the short or long term"*.

7. Investment needs

According to PINC 2016, *"the total estimated investments in the nuclear fuel cycle between 2015 and 2050 are projected to be between EUR 650 and 760 billion"*. Based on all the above, this investment figure is a groundless mix of underestimated costs applied to overestimated projections.

7.1. Investment in reactors

The main part of the total investment costs lies with the need to invest in nuclear generating capacity. In the Commission's scenario, almost as much existing capacity is concerned by LTO programmes than new capacity is built by 2050. Taking into account the range of costs assumed in SWD, LTO would cost on average 4.5 to 7.8 times less per kWe than new build[36]. However, the Commission seems to use only the higher part of that range. New reactors therefore represent roughly 90% of the cumulative investments needs in nuclear capacity by 2050.

With a total cost of € 336 to 439 billion for 80 GWe[37], the cost assumption used by the Commission for the average cost of new build seems to range between 4,200 €/kWe and 5,490 €/kWe[38]. This is not fully consistent with the actual average cost that SWD finds for currently constructed or planned project, which stands at 5,375 €/kWe (average betwen a single and twin unit). The assumption seems even more optimistic when taking into account that the trend is still an increase in both the real and projected costs of new builds. The latest figures, coming from the Hinkey Point C project, rate even 25 % higher. Based on the cost of this project, the total investment for the construction of new capacity to operate before 2050 would amount to € 540 billion for the new capacity projected by SWD of 80 GWe.

A higher projection is also introduced in SWD, were the total new build cumulates to 90 GWe between 2015 and 2050[39]. The estimate of cost provided by SWD ranges in that high case from € 385 to € 500 billion[40]. This would correspond to an average cost of new build between 4,280 €/kWe and 5,550 €/kWe. Again, applying the current projected cost of Hinkley Point C to this whole new programme would bring its cost up to € 608 billion.

This likely underestimate of new build costs (and furthermore of the associated financial costs, as discussed above) clearly backs the Commission in overestimating the potential for such a developement. In other words, meeting the objective of new build by 2050 that is set by PINC 2016 might come with a significantly higher cost than what it forecasts – which, the other way round, strongly reduces the chances for such a development to occur. Taking into account current market conditions and their trend, this level of development would only happen through massive aid, such as generalising the contract for difference scheme, at the expense of most efficient low carbon options.

This is assuming that LTO programmes work as foreseen by the Commission to maintain the capacity in the short to mid term (before much new build could be delivered) which is as much arguable.

[36] This corresponds to a cost of 692 €/kWe for LTO and a cost range of 3,145 to 5,379 €/kWe for new build, between the Commission's lowest estimate for a twin NOAK and its highest estimate for a single FOAK. The ratio is from 5.5 to 7.8 for LTO versus FOAK.

[37] In SWD, the nuclear capacity installed by 2050 reaches 95 GWe in its low projection, of which 15 GWe are based on LTO of already existing reactors. The document also accounts for € 13 to 17 billion to be spent before 2050 on construction of new reactors needed to start after 2050 to maintain the nuclear capacity over that term. This additional capacity, bringing the total cost estimate to € 349 to 456 billion, is not included in the present cost analysis.

[38] It is troubling, when considering the cost per kWe assumption that implicitly lies beyond this calculation, that the global cost estimate remained unchanged in the final version of SWD, compared to the draft one, while the projected capacity in the low projection was adjusted from 83 GWe in the draft version to 80 GWe in the final one.

[39] In the high scenario, SWD plans for 105 GWe of total nuclear capacity by 2050, of which 90 GWe would therefore come from new build.

[40] SWD is not providing the detail to know whether this estimate includes the share of construction costs that could be spent before 2050 on reactors to be started after 2050, or not.

Although the SWD provides a very precise figure of € 46.9 billion for LTO costs by 2050 (of which 81% are to be spent between 2015 and 2030), with no margin of uncertainty, the Commission introduces such a margin, still narrow, in PINC 2016. LTO would cost between € 45 and 50 billion, with no explanation of whether this depends on the total capacity undergoing LTO and/or the average cost per kWe of LTO. In particular, neither SWD nor PINC 2016 provide the figure of the number of reactors or the total capacity that they assume to be prolonged through LTO.

Using the average cost of 692 €/kWe provided by SWD for LTO including post-Fukushima reinforcement, this would apply to 68 GWe, or more than 55% or the existing capacity, which amounts to a very ambitious industrial programme to be implemented over a very short period. The challenge is even higher when considering how much this cost might be underestimated. The total cost introduced by the Commission is less than half that estimated by the French Court of Auditors for the French fleet of 63 GWe – which itself is arguably still underestimated. In line with those findings, the total cost for maintaining 68 GWe could reach € 88 billion and up to the order of € 135 billion[41].

The difference lies mostly in the strength of requirements regarding the management of aging and the safety reinforcements, as well as the conformity and efficiency of their implementation. In other words, keeping LTO programmes in the cost range used by the Commission would not fulfill its own commitment for the highest possible level of safety to be maintained through LTO. Conversely, raising the requirements up to that level would increase the costs compared to those introduced by PINC 2016 and worsen the economic case for LTO, reducing the number of reactors effectively prolonged down to a much lower number than PINC 2016 plans.

7.2. Investments in the fuel "cycle"

In addition to investments figures for reactors, PINC 2016 is also discussing projected investments in the so-called nuclear fuel "cycle", mostly focusing on the back end.

Although the Commission acknowledged in the draft version that *"some investments will be needed in the front end of the nuclear fuel cycle by 2050 to help secure fuel supply, modernise EU fuel related facilities and maintain the EU technological leadership in this field"*, neither PINC 2016 nor the SWD are providing actual figures. On the contrary, the final version downplays the needs, pointing to a revised assessment that *"major investments in conversion and enrichment capabilities have been done in the past, and the focus in the coming years will be put in modernising them in order to maintain [this] leadership"*.

The detail in SWD, however, seem to remain unchanged. It estimates that uranium conversion capacities in France are sufficient to cover the needs of the EU, and that this will continue with the new Comurhex II facility, representing an investment of € 1 billion according to SWD[42]. Similarly, the SWD considers that uranium enrichment needs are sufficiently covered and will still be through the completion of the new Georges Besse II plant in France, representing an investment of € 4 billion according to SWD[43]. Then the SWD discusses the availability of fuel fabrication capacities. They are also seen as currently sufficient, but the document could not point to any project of new fuel fabrication facility, although existing ones would likely not operate all along until 2050. Altogether, additional investments for the maintainance and reinforcement of existing facilities in the front end of the nuclear fuel cycle and the renewal of fabrication capacities should be included and are missing in the analysis.

[41] Using an average cost in the range of € 1.3 billion per GWe, as figured out based on EDF data by the French Court of Auditors, to € 2 billion per GWe.

[42] It is interesting to note that the initial cost of Comurhex II was tabled by Areva as € 600 million. Also, the SWD notes that current conversion capacity would fulfill EU needs if working at full capacity for the EU without exports, but that it only operated at 70% in 2015. This stresses an issue with the competitivity of French conversion services that is not raised by SWD but actually threatens the profitability of this activity and therefore its availability in the long term.

[43] As for Comurhex II, this marks an increase compared to the investment initially planned for by Areva, at € 3 billion.

When it comes to the back end of the fuel chain, PINC 2016 stresses that *"in December 2014 European nuclear operators estimated that (…) € 130 billion [will be needed] in spent fuel and radioactive waste management, as well as deep geological disposal"* until 2050[44]. No reason is provided for the decrease by € 12 billion of that figure, compared to a total estimate of € 142 billion used in the draft version of SWD seen by WISE-Paris[45]. This includes various costs, which are not detailed by the Commission apart from those applied to geological disposal. The total should for instance include, if the concerned countries have provided official plans to pursue with their policy of spent fuel reprocessing, some costs related to heavy maintenance and reinforcement or replacement of the industrial complexes of Sellafield and La Hague, to which the same commets as for front-end facilities roughly apply.

But the main issue remains, at least from a political point of view, the investment in geological disposal. According to details provided by SWD based on National reports due under Council Directive 2011/70/Euratom, the total of projected costs for geological disposal sites as planned by Member States amounts to more than € 72.9 billion[46]. However, the total cost used in PINC 2016 could cover only a part of these projected final disposal costs, since most of the countries plan for their implementation at a later date than 2050 – but no detail of the calculation by the Commission is provided. Also, neither PINC 2016 nor the detailed SWD specify whether the figures they provide are discounted or undiscounted, which could make a major difference given the timescale of the considered expenses. It is assumed in the following that these relate to undiscounted investments.

The projected costs of geological disposal used by the Commission, based on operators data, are likely to be underestimated. The figure used for France, which accounts with € 25.9 billion for more than 35% of the global cost of geological projects, illustrates that bias. In January 2016, a decree was passed that fixed the projected cost of the French geological project, Cigeo, to be used for provisioning at € 25 billion[47]. This is still seen by most stakeholders as a very low figure. Previous to that decree, the French Agency for the management of radioactive waste, Andra had filed a comprehensive report which provided estimates in the range of € 30 to 35 billion. The ASN criticized Andra's findings as underestimates, mostly on the ground of some over optimistic technical assumptions, and that the calculation only applied to reprocessing waste and no spent fuel or nuclear material from the existing fleet[48]. Internal realistic cost calculations up to € 70 billion have leaked but have never been confirmed. Even keeping to the high range of Andra's underestimate, at € 35 billion, means a 35% increased compared to the cost used in SWD. As a matter of illustration, if applied to all geological disposal costs listed in the Commission's document, the same ratio would bring their total cost up to € 98 billion.

Although geological disposal and its cost are very sensitive issues, the main safety and economic concern for the short and mid-term, and in most cases up to 2050, will lie with the interim storage of spent fuel or, where necessary, reprocessing waste. By difference, SWD plans for costs relating to waste management others than geological disposal account for € 57.1 billion. This represent no less than a 23% decrease compared with the € 74.4 billion figure assumed a few weeks before in the draft version of the SWD, a difference that finds no explanation, as the data used are said to be the

[44] There is no explicit reason for the decrease by € 12 billion of that figure, compared to a total estimate of € 142 billion used in the draft version of SWD seen by WISE-Paris.
[45] This is even less understandable considering that the draft was already supposed to used the data provided to the Commission by December 2014.
[46] Not including projects in Bulgaria, Estonia and the Netherlands, for which cost figures are not disclosed.
[47] The € 25.9 billion figure used in SWD corresponds to that cost, as the document explains that the value established in the French decree is expressed in 2011 euros. The value used in the draft SWD, before the decree was taken into account, was even lower at € 21.3 billion. This increase by € 4.8 billion for the French project is the main reason – and the only one explicit – for the global increase of the cost estimate for geological disposal, from € 67.6 billion in the draft to € 72.9 billion in the published version.
[48] This is indeed a major shortcoming. The projected cost is based on the assumption that all the spent fuel arising from the operation from currently operating 58 reactors will be reprocessed, including MOX fuel, which is contrary to the evidence that spent fuel is stockpiling and no "closed" fuel cycle is in place or likely to be.

same. This shift makes it even less clear to what extent this cost used by PINC 2016 addresses the needs – when this would on the contrary deserve more detailed discussion. The issue there is double.

First, the current conditions of interim storage are to be questioned in terms of safety and security, having in mind the time span to be considered before the spent fuel or waste could be evacuated for disposal. Most of the interim storage capacity that is used now is either not designed for storage at all, as is the case of some desactivation fuel pools at reactors sites, or designed to provide robust storage for a few decades at most, as is the case of spent fuel pools at La Hague for instance. This situation will increasingly call for either replacing them by more robust interim storage facilities or strongly reinforce them.

The second point is that due to the pursuing of reactors operation, especially if LTO are largely granted in the future, and the postponement of disposal solutions, the needs for interim storage capacity will grow, calling at some point for the building of new facilities. In France, for instance, projections have shown that spent fuel pools at reactors sites and La Hague could be fully saturated as of 2025 or even before, now leading to the development of plans for a new centralized spent fuel storage facility, which seems to be in its design phase and could be filed for licensing by EDF in 2016.

7.3. Decommissioning costs

Finally, the Commission discusses the funding requirements for decommissioning, based on a statement similar to that for spent fuel and waste management that *"in December 2014 European nuclear operators estimated that (…) € 123 billion [will be needed] for decommissioning"* until 2050[49]. As for the costs of final disposal, both PINC 2016 and SWD seemingly omiss to specify whether the figures provided are discounted or undiscounted ones, although they are very likely to be undiscounted, at least for some of them (and for want of a specific explanation, assumed to be so in the following).

This figure is obtained by summing up estimated costs of decommissioning of nuclear power plants by country that are provided in the SWD. This includes *"reactors currently in operation and in shut-down mode",* which indicates that, surprisingly, the overall decommissioning costs used by the Commission do not cover those of other nuclear facilities, which can be really significant.

When looking at estimates for France, for instance, the cost of more than € 22 billion for 70 units should be completed with the decommissioning cost of facilities of the front end and back end of the fuel cycle, including La Hague reprocessing plants. The French Court of Auditors estimated in 2014[50] that in addition to the more than € 22 billions euros needed for EDF installations, AREVA and CEA facilities will cost near to € 12 billion to be decommissioned. This figure is considered by many as strongly underestimated, especially when compared to the decommissioning costs considered by the NDA for Sellafield and Dounreay facilities, also don't seem to be included in the total decommissioning costs provided by PINC 2016. The figures provided in PINC 2016 for the UK amount respectively to € 36.9 billion for reactors and € 24.1 billion for waste management, or € 60 billion together. This compares to the total figure for decommissioning and waste disposal provided by the Nuclear Decommissioning Authority (NDA) of more than € 150 billion (£ 118 billion), of which more than € 112 billion relate to the decommissioning, cleaning and waste management of the reprocessing site of Sellafield alone[51].

Also, the SWD notes that large discrepancies are to be found in estimated costs of decommissioning of reactors per unit, with an average of € 600 million per reactor but a range from € 300 million to € 1.3 billion, or 4.3 times more. The discrepancy is even more significant per kWe, ranging from

[49] The decrease by € 3 billion compared to the draft version of the SWD is obviously less significant that the one of radioactive waste management, but as much unexplained.
[50] Cour des comptes, *Le coût de production de l'électricité nucléaire – Actualisation 2014*, Mai 2014.
[51] NDA, *Nuclear Decommissioning Authority Annual Report & Accounts Financial Year: April 2014 to March 2015*, 2015.

300 €/kWe to 2,700 €/kWe, or a factor 9. The Commission would refer to differences in technologies and country specific decommissioning and waste management requirements to explain those discrepancies. Another factor is the role of small research reactors compared to power plants, as they are all counted in these figures. However, these do not reflect what is likely to be the main factor. It lies in the difference between a priori global figures prepared by operators, such as the cost used for France, which is basically built on the assumption of a 15% equivalent of the construction cost, and detailed figures prepared by public agencies based on operational decommissioning plans. This is the case of those provided by NDA for the UK, which are probably the soundest ones and appear to be the highest ones. To a lesser extent, the same shift from low a priori estimates to higher refined operational projections happened after the shut down of German reactors in the framework of the Energiewende. According to the SWD, the official figure for German reactors reaches 1,400 €/kWe, including decommissioning, clean-up and waste management but excluding final disposal.

Applying a medium range value of 1,300 €/kWe to the overall nuclear generating capacity to be decommissioned, or 153 GWe, leads to a global estimate of nearly € 200 billion for the decommissioning of nuclear reactors. A global estimate of € 100 billion could reasonably be added for the decommissioning of other nuclear facilities, including sites such as Sellafield in the UK, and La Hague and Marcoule in France, bringing the whole estimate to € 300 billion. In other words, the decommissioning cost provided by the Commission in PINC 2016 could reasonably be considered more than 2.4 times underestimated.

8. Unavailability of funds

The availability of funds will of course be crucial, although the huge amounts involve make it very hard to guarantee. This issue separate in two distinct problems with very different implications, regarding the investments for pursuing operation (lifetime extension and new builds) on one hand, and those for managing the liabilities inherited from this operation (decommissioning and waste disposal).

8.1. Limitations of new investments

The first one goes with the investments needed for LTO programmes and new builds. As discussed in previous sections, the rising costs, persistent risks on the completion of projects and the reduced perspectives of profitability make the availability of such investments increasingly uncertain. The Commission wishfully seems to consider that specific financial schemes such as those considered in the case of the British and Finnish projects would secure the availability of the required investments.

The problems encountered by the biggest utility and nuclear power supplier in Europe, EDF, to convince other than Chinese partners to take some stakes and to make its final decision of investiment regarding the Hinkley Point C project show the contrary. The amounts are so huge and the uncertainties so high that even subsidising schemes in disguise like the Contract for difference (CfD) and State guaranteed financial conditions still appear not sufficient to raise the funds. The project requests a € 16 billion net investment by EDF alone, a decision which the Trade Unions have said they would oppose as it threatens the comapny itself. An even clearer warning came in early March when the renowned Financial Director of EDF resigned due to its opposition to an investment that he thought the company could not sustain.

Although different schemes and situations could be discussed, this example illustrates the severe obstacles that investments in new nuclear projects face as their size, return period, risk and profitability uncertainties make them less and less attractive for investors compared to alternatives. The same could to some extent apply to LTO investments when considered on a big scale. The overall result is that it is likely that nuclear installed capacity decreases in the EU, and that it does so faster that PINC 2016 seems ready to consider. This will gradually deprive nuclear operators from revenues, when at the same time they will face increasing decommissioning and waste management expenses.

8.2. Insufficiency of dedicated funds

Therefore the situation is naturally more critical, with much more hasardous consequences, when it comes to investments needed to cover waste management and decommissioning costs. The availability of funds needs to be guaranteed to secure the related operations. This is normally assured through the regular building up by operators of provisions to reach the required level, taking into account discounting effects. The Commission insisted in PINC 2008 on the fact that *"the most significant external costs for nuclear power, i.e. costs for decommissioning and waste management, should be internalised in the electricity price"*, in line with its own recommendation[52]. However, it had noted in PINC 2007 that only *"in several EU countries the nuclear industry levies electricity surcharges to manage and dispose of the waste generated and to fund decommissioning"*, adding that *"the financial management method and availability of the funds vary between Member States"*. The Commission was therefore pressing for progress, emphasizing that *"it remains crucial that sufficient savings are set aside to finance decommissioning and waste"*.

Meanwhile, the 2011 Spent Fuel and Radioactive Waste Directive introduced, through its Article 9, the obligation for all Member States to *"ensure that the national framework require that adequate financial resources be available when needed"*. PINC 2016 therefore reiterates that *"funding has to be accumulated by the operators from the early years of operation and be ring-fenced to mitigate the risk of financial liabilities for governments to the extent possible"*. The change from the objective to *"avoid the risk"*, in the words used in the draft PINC 2016, to merely mitigating it, stands by itself as an early sign of renunciation.

The Commission then indicates that assets collected to form so-called *"available funds"*, as reported by the Member States, currently amount to approximately € 133 billion, or an average 52% out of € 268 billion of estimated decommissioning and waste management liabilities (which, as detailed above, correspond to € 123 billion for decommissioning and € 130 billion for waste management, of which € 72.9 billion for geological disposal and € 57.1 billion for other costs related to waste).

This should of course trigger a strong alarm by the Commission. But no such concern is expressed in PINC 2016. Nevertheless, the issue is furthermore pressing when considering the figures provided by the SWD regarding the share of electricity already generated: in principle, as provisions need to be collected by the operators through the selling of electricity, the amount of assets already accumulated should be roughly equal to the share of the overall electricity expected to be produced by the nuclear fleet that has already been produced. The balance, however, is strongly dependent on the discounting rate used, since the early provisions contribute eventually more than the latest ones, as they could in principle grow financially while new provisions are still collected through a levy on generation.

Nothing indicates in PINC 2016 or SWD what discounting assumptions are used, if they are used at all, as far as available funds are concerned. The SWD specifically discusses the issue of back-end provisions separately from that of dedicated funds, without establishing the connexion between the figures. The provisions constituted in the balance sheets of European nuclear operators were estimated in the draft SWD to reach a total of € 104 billion as of the end of 2014[53].

In the following, for want of proper explanations in SWD, the calculations remain focused on available funds, which are discussed and compared without introducing discounting assumptions. Keeping in mind that the interpretation could significantly depend on this factor, it is nevertheless interesting to discuss the level of available funds as it is presented by the Commission.

[52] Commission Recommendation on adequate financial resources for decommissioning funds, 28 November 2006.
[53] This number, as such, has disappeared in the final version.

According to SWD, in the case where all officially projected LTO would be granted, the electricity generated to date by the European nuclear fleet amounts to 64%, on average, of its expected overall production. No figure is provided regarding the share in the case LTO would not, or only partly be granted. A gross estimate is that projected LTO would roughly double the remaining lifetime of reactors, therefore their remaining production. The electricity already supplied would represent more than 75% of the lifetime electricity supply if no LTO were taken into account.

In other words, 48% of the available funds needed to cover the long term liabilities as estimated by the Commission remain to be constituted, over a period that will coincide with the selling of only 1/4th to 1/3rd at most of the lifetime electricity supply of the nuclear fleet. This should require a significant increase in the corresponding surcharge levied on nuclear electricity. The average ratio for the constitution of funds compared to electricity generation has been until now, as it could be drawn from SWD figures, of 4.7 €/MWh. It should go up to 7.6 €/MWh on average as from now under PINC 2016's assumptions of massive LTO, but triple to 15.2 €/MWh if no LTO was granted, and double to 10 €/MWh if only half the Commission's projected life extension would occur (needless to say, this required increase would in itself reinforce the risk that LTO is not profitable, so that further increase is required, etc.).

The huge uncertainty regarding the feasibility, acceptability and profitability of LTO, as mentioned in SWD but not reflected in SWD and PINC 2016 projections, is therefore resulting in a high risk that the funds constituted through the remaining lifetime of reactors to cover the costs of decommissioning and waste management fall very short of needs. Assuming that the average 4.7 €/MWh is maintained, a total of € 46 billion to € 83 billion could be missing, depending on the level of LTO.

8.3. Underestimate of long term liabilities

It could of course emerge that the missing amount is actually much higher, taking into account the very likelyhood that decommissioning and waste management liabilities are strongly underestimated by the Commission. It arises from discussions above that global costs for geological disposal could at least be estimated to reach € 98 billion, and decommissioning costs to reach € 300 billion. Even without considering any reassessment of the more diverse € 57.1billion related to other waste management costs, that were not discussed, nor any further drifting, this could bring the total liabilities to a rounded € 455 billion.

Should the average rate of constituting funds as nuclear generation remain at its level of 4.7 €/MWh, the amount found missing after the shut-down of reactors would mount up to an unbearable € 250 to € 285 billion. On the contrary, to constitute funds that bridge this enormous gap, i.e. that would eventually reach that level when the existing reactors are shut down, would require the rate of constituting funds to jump up to an average level of 20.5 to 41 €/MWh (depending on the level of LTO achieved).

This alarming finding should not be regarded as a stretched high estimate. It is on the contrary simply based on a more accurate and exhaustive accounting of the costs to be covered, but still using official central estimates – therefore not accounting for further uncertainties. As a matter of example, the figures that were used above when refering to NDA assessments relate to a central figure of £ 118 billion undiscounted, when the NDA itself recalls that *"considering this as a single figure however could lead to a false sense of certainty in the outcome and instead it should be considered within the identified uncertainty range of £ 95 billion to £ 218 billion"*.

These overall findings, applied to the European level, would of course need to be further discussed at national level to reflect significant discrepancies in the situation of Member States. As a matter of example, while the average provided by the Commission of future costs covered by funds is 52%, the level of available funds actually range from 4% to 83%. Similarly, behind the average 64% of lifetime electricity already produced, the share varies from 30% to 100% depending on countries. Moreover, Member States do not necessarily appear on the same side of both scales: the case of Lituania, for instance, where only 8% of funds are officially collected when no nuclear electricity is produced anymore, appears particularly alarming.

8.4. Unsecured provision mechanisms

The analysis at national level also allows for considering another very important factor that might contribute to a shortfall in the way operators will face their liabilities, which depends not only on the availability of funds, but also on the actual liquidity of the provisions. It should follow from the concern expressed by the Commission in the previous PINC and the implementation of the 2011 Directive that secured dedicated funds exist and are regularly increased in all concerned Member States. The reality is very different.

The scene, as it is set by SWD, mostly demonstrates a lack of any common rules, leading to a very diverse situation from one Member State to the next. The countries apply different principles for their method of collection, use different financial mechanisms, and rely on internal segregated or non segregated, or external funds.

Although it is not the purpose of the present analysis to go into detailed discussion of the situation of different countries, this laxity of rules clearly paves the way for some problematic or unacceptable situations, which the Commission however does not discuss. This could actually start with the lack of any dedicated decommissioning and waste management funds, as SWD points to be the case in Italy, where the transfer of liabilities from the operators of reactors shut down since 1987 to the public budget, which is against the principles that the Commission now wants to apply, is a clear warning that this risk exists.

The UK offers another, yet even bigger example of such a transfer. SWD considers the UK to operate on the basis of an external fund and assumes that 100 % of € 61 billion needs are available[54]. This is not quite accounting for the real situation in the country. There truly exists a Nuclear Liability Fund, which is dedicated to the liability of 14 AGR reactors and one PWR currently operated by British Energy, majority owned by EDF, who sets the corresponding liability to £ 12.1 billion for decommissioning and £ 8.5 billion for waste management. The Fund was valued at £ 9 billion as of March 2015.

However, this only covers a minor part of the overall nuclear liabilities in the UK, the rest of it being the 26 Magnox reactors plus a few prototype units, and essentially the Sellafield site. These liabilities have been taken over by the NDA, which doesn't operate through a fund. On the contrary, most of its budget is based on the annual income that it receives from the Government. In that respect, the draft SWD appeared to be deliberately misleading regarding the current level of provision and the security of the financing when it called to *"consider[s] that NDA obligations are 100% available funds, since these will be paid from the UK National Budget" – an assessment that has been toned down to saying that these obligations are "fully backed by existing funds" in the final version.*

Another problem that is not addressed by the Commission is the possible inconsistency between the nature of the assets and the availability of the separate funds that are constituted either as internal segregated ones or external ones. This is illustrated by the case of France, where for instance 11% of the internal segregated fund accumulated by EDF is actually made of half the grid assets of RTE, which is still a 100% subsidiary of EDF.

Finally, another concern is with the non-segregated internal funds, and the risks that these could eventually be diverted by the operators from covering the costs they were dedicated to. This is clearly a matter for debate now in Germany, where the companies could hijack the constituted funds to press the Government for taking over the risk of increasing future costs, as discussion went on regarding the transfer of decommissioning funds to an external one. According to SWD, available

[54] This point is not totally clear, as this figure is somehow contradicted by the indication in another table of SWD that 76% would be covered.

funds amount to € 38 billion out of € 45.7 billion needed. This final cost has been challenged, as an auditing commissioned by the German Ministry of Economy concluded that the costs could go up to € 77 billion. However, the Government used the argument that the current net assets of the concerned companies, combined, are worth around € 83 billion to conclude that they are in a position to meet the costs.

These numerous problems highlight the risk that provisions for the decommissioning and waste management are not secured enough to guarantee that operators will eventually bear the responsibility for the full costs, and that in any case funds will be available to cover these costs, especially when they turn out to be higher than most current plans account for. While this should appear as a priority concern for the Commission if it were keeping in line with the requirements it set back in PINC 2007, the way this is presented in PINC 2016 is on the contrary clearly downplaying the concerns, turning a blind eye on what yet is an increasingly pressing issue.