NUCLEAR ENERGY: WHY SUCH AN OBSTINACY?

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France has pressured the European Commission to add nuclear energy as "green energy" in the European taxonomy[1], which was acted upon at the beginning of February 2022, against the opinion of many EU member countries, and despite the non-respect of the obligation not to have a negative effect on any of the other criteria than greenhouse gas emissions[2]. On this momentum, President Macron has confirmed his desire to build 6 to 14 new EPR2 nuclear reactors in France by 2050[3]. In doing so, France becomes one of the few democratic countries in the world to so strongly promote nuclear power as a cornerstone in the fight against climate change.

The other democratic countries, for the most part, have a diametrically opposed appreciation of nuclear power, well summarized by the recent communiqué (6/01/2022) of 4 major officials and experts in nuclear regulation and safety[4], namely :

- an extremely expensive option,

- with a time frame that is much too long in relation to the climate emergency,

- the financing of which can only be provided by the States and not by the financial market because of the magnitude of the risks involved,

- and in any case limited to the few countries that have the political, industrial and organizational conditions to guarantee a minimum of security in the face of civil exploitation and military non-proliferation.

Admittedly, France is a special case, having invested heavily in this energy for the past 50 years, and having equipped itself with the heavy infrastructure necessary to produce the fuel, build the power plants, operate them in conditions of safety that are in principle satisfactory, reprocess the irradiated fuel, store the waste, and be at the forefront of R&D. But is this enough to invalidate the points summarized above?

The cost. For the EPR-2, the investment costs retained by RTE in its recent prospective study[5], i.e. a range of 4,500 - 5,800 €/kW, are "posted" costs[6], very far from the only cost known today in France, that of the Flamanville plant (12,000 €/kW according to the Cour des Comptes). A quick look at the past in France shows that, historically, the real costs of nuclear power have been much higher than the "posted" costs. The investment cost of nuclear power (PWR) "posted" in 1973 by the PEON[7] Commission was 1017 FF/kW, whereas the scientific literature of the time favored a range of 1500 - 1700 FF/kW based on American experience[8]. Afterwards, according to the Report of the Cour des

[1] Neutralité carbone : la nouvelle taxonomie verte européenne | Gouvernement.fr
[2] Taxonomie verte : ce qui est climato-compatible et ce qui ne l'est pas (actu-environnement.com)
[3] President Macron's speech, Belfort, 10/02/2022
[4] statement_communique_nuclear_climate_06.01.2021v2.pdf (nuclearconsult.com)
[5] RTE, *Futurs Energétiques 2050*, Octobre 2021
[6] The "posted" cost is an ex-ante cost estimated by engineers, not a cost based on actual industrial experience
[7] PEON : Production d'Electricité d'Origine Nucléaire
[8] IEJE, *Alternatives au Nucléaire*, PUG, 1975

Comptes (2012)[9], the real investment cost was 1166 € of 2010 per kW, hence the equivalent of 1520 FF of 1973, 49% higher than the initial estimate. In addition, there is a 44% difference between the operating and fuel costs observed in 2010 (22 €/MWh[10]) and those announced by the PEON Commission in 1973 (19.8 FF/MWh). Given the experiences of Flamanville and Finland, it is likely that this tendency to underestimate future costs, both for investment and operation, will be repeated tomorrow with the EPR-2. If the historical experience of cost drift were to be repeated with the EPR-2 (i.e. real costs in the range of 7000-9000 €/KW), it is a safe bet that nuclear power would be economically disqualified, whatever the scenario chosen by RTE.

The delays. The RTE study shows that in France, with all the nuclear infrastructure in place, we can only hope to connect the first EPR-2s to the grid in 2035 at the earliest, and that in any case, nuclear power will not be able to produce more than half of the electricity needed in 2050, the target date for carbon neutrality. However, the new deadline for the connection to the grid of the Flamanville EPR recently announced by EDF (2023), as well as the setbacks recently observed on the Chinese EPR[11] and, even more recently, on the PWR reactors of the N4 (the most recent 1450 MW power plants at Chooz B and Civeaux) and P'4 (1350 MW, Penly) models, lead to the conclusion that the maximum contribution of nuclear power to French electricity production envisaged by RTE for 2035 and 2050 is overly optimistic. And what about other countries, especially in Europe, with little or no such infrastructure? If we assume that the EU will consume around 4000 TWh of electricity in 2050 (2800 TWh in 2019), and if we consider the objectives set by the member countries in terms of energy transition, it is likely that nuclear power will not be able to contribute more than 10-15% of the electricity consumed in the EU at that time, with the remainder (85-90%) having to be provided by renewable energy. This shows where the real industrial and financial stakes are imposed by the climate calendar. All the more so since the capacity of renewables to produce almost all the electricity required by that date has been demonstrated[12].

Financing. The signs are numerous and convergent to show that without massive support from the State and public money, the development of nuclear power could not be financed in any case. No private financial actor is ready to finance such investments without a strong financial guarantee from the State. The reasons for this are now well known: financial risk due to the size of the investment in the face of uncertainty about profitability, financial risk due to the technological risks (from prolonged shutdown to accident and permanent shutdown), exorbitant cost of insurance[13]. This has three main consequences: an inevitable drain on the taxpayer, a distortion in the conditions of competition between electricity production technologies, and a crowding out of other investment opportunities to be financed from public funds. This is obviously the case in France, where the State holds 84% of the capital of EDF, which holds 75.5% of FRAMATOME, and 70% of ORANO, and is its own insurer in the event of a nuclear accident. Hence the fact that the decision to build new nuclear reactors is ultimately taken by the State and not by EDF. However, given the size of the national debt (116% of GDP, 3rd quarter 2021), as well as that of EDF (42 billion euros at the end of 2020), it is

[9] Cour des Comptes, *Les coûts de la filière électro-nucléaire*, Janvier 2012

[10] Cour des Comptes, op cit

[11] Shutdown of the Taishan EPR due to damaged fuel cladding, suspected link with vibrations in the reactor vessel (source: Criirad, quoted by Actu-Environnement, 29/11/2021)

[12] AIE-RTE*, Conditions et prérequis en matière de faisabilité technique pour un système électrique avec une forte proportion d'énergies renouvelables à l'horizon 2050*, AIE, 2020

[13] Beyond the cost of the reactor itself and the loss of production in case of an accident, it is of course the cost of the consequences of a nuclear accident on the whole society that is considerable (cf Platts, Nucleonic Week, 15/12/2012), so considerable that only the State can really take care of it, as shown by the United States with the "Price Anderson Act, 1953", Japan (Fukushima), the former USSR (Chernobyl) or France.

almost unthinkable that the State could finance alone a significant part of the colossal investments that a revival of nuclear power would imply. Hence the French pressure in Brussels to include nuclear power in the taxonomy and thus allow it to benefit from the funds dedicated to the energy transition.

Geographical coverage. Some twenty countries in the world have shown a willingness to develop nuclear energy, but with great disparities in terms of their actual technological, financial and organizational capacity to do so. Among the countries with the greatest capacity in this field and the most likely to have a major impact on the world market for nuclear power plants are China, Russia, South Korea, India, Pakistan, Turkey and the United Arab Emirates[14]. In August 2020, there were 54 reactors under construction in 19 countries[15] (including France, the UK and Finland). The IAEA envisages a global capacity in a very wide range for 2050, 350 - 874 GW in 2050[16] (402 GW in 2020)[17]. In other words, using the high assessment of the IEA, the contribution of nuclear power will not exceed 6500 TWh in 2050, equivalent to 24% of the world electricity production in 2020, and therefore probably less than 10% of the world electricity production in 2050, if this production continues to grow at the same rate as over the last 30 years. In other words, because of this low potential geographical coverage, it is obvious that nuclear power could only marginally contribute to the solution of the climate problem by 2050.

None of this is really new, and all of it is necessarily known to all those, in good faith, who are really involved in energy issues. So why is there such an obstinacy in France to promote nuclear energy as a solution to the energy transition, both on the part of the industry and the public authorities? On the industrial side, the stakes linked to the EPR, for Framatome as well as for EDF, are such that we can understand their eagerness, as the State's cover is de facto offered to them, even if we can legitimately question the export prospects. On the other hand, on the State side, things appear to be much more complex. It is true that the industrial system linked to nuclear energy is powerful and influential, but the State controls a large part of it. However, in reality, this State control does not really seem to apply to the technical and economic arguments put forward by the companies, despite the fact that the State has the capacity for analysis and expertise, both internal and external, that allows it to make a sound judgment. The most likely explanation is the intertwining of civil and military nuclear power, both at the R&D level (very costly in terms of public funds) and at the industrial level (manufacture of nuclear components, enrichment, reprocessing), within what is known as the military-industrial nuclear complex. Without sharing the burden between the civilian and military sectors, one may wonder about France's ability to finance the maintenance and development of its military nuclear arsenal, in particular the engines of nuclear submarines and aircraft carriers. Similarly, if France were to give up nuclear deterrence, it is likely that the State would show much less enthusiasm for promoting the civilian development of this energy. If this is the case, it would be preferable to make this clear, and the debate on the role of nuclear power in the energy transition, which will necessarily be opened following President Macron's speech of February 10th, 2022, would be greatly clarified.

[14] Enerdata, *World Civil Nuclear Strategies,* Mars 2021
[15] Enerata, op cit
[16] Enerdata, op cit
[17] See also WNISR (World Nuclear Industry Status Report), www.worldnuclearreport.org