NUCLEAR POWER IN EUROPE'S LOW-CARBON TRANSITION: A DIFFICULT DEAL

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Is decarbonised energy growth without nuclear power truly a realistic aim for Europe? This matter can only be settled once we understand what carbon neutrality means and have examined the differences between different European Union countries' electricity mixes. It appears that pursuing nuclear will require some form of concerted organisation. In this article, Claude Fischer Herzog proposes an Energy Solidarity Pact that respects the choice of nuclear States and promotes cooperation between them so as to build a European nuclear industry.

Will the European Union (EU) be capable of responding to the needs of the climate, industry and solidarity all at the same time by relying on the major changes in the ways we produce and consume energy? It has set out its ambition to be the world's first "climate neutral continent by 2050", and is offering Member States a "Green Deal". The aim is to encourage them to slash their overall energy consumption to half of 2005-levels, whilst increasing electricity production to meet society's changing energy needs. Electricity will be produced by a mix that is set to include less and less nuclear: 15% by 2050 and 0% by 2100, and more and more renewable energy: 80% by 2050 and 100% by 2100[1]. But are these targets realistic? (Read: European Union, climate and energy 2030: Part I) and (European Union, climate and energy: Part II). Renewables are intermittent and need base load capacity. Germany, which has decided to abandon nuclear and coal, is set to develop a high level of electricity production based on natural gas. Is this the model that the Commission wants to impose upon Member States? Shouldn't it show respect for Member States choosing to follow their own electricity decarbonisation path and also support those choosing to use nuclear power, as it does for those relying solely on renewables, generously aided by income guarantee schemes?

The zero-carbon target is very ambitious and will be all the more difficult to achieve if efficient low-carbon nuclear technologies are gradually excluded from the rapidly expanding electricity sector. Indeed, we are living in a “new electric era” with our lifestyles and production methods becoming increasingly electrified, and we will need much more electricity in the energy mix. This electricity will have to be decarbonised, and aiming to reduce or even eliminate nuclear power altogether (when its share currently stands at 25%) is a paradoxical choice.

The 2050 scenarios presented by the European Commission (EC) that are most favourable towards nuclear power contemplate a nuclear capacity of 100 to 120 GW. Given the phase-out policies of some countries, and the decommissioning of existing reactors, meeting this target will require a significant increase in new-build projects all across Europe. The European Union must start to make the right decisions now to guarantee its future, while the nuclear ambitions of half of the Member States (see part 1) are being held back by those who do not want them. They are lobbying the Commission to exclude nuclear power from the taxonomy [2] that would give it the support and public guarantees it needs to finance investment in the sector.

The way that the electricity sector is organised and regulated, which has been liberalised since the end of the 1990s, does not allow for investments in high CAPEX (capital expenditure) technologies such as nuclear power solely through the price signals of the markets, which are at hourly intervals (Read: Electricity markets, complexity and limits of liberalising electric industries). Nuclear power is not like other commodities; it is a public good necessary for the climate and for prosperity in Europe. Changes in market rules are needed to facilitate and finance new types of investments, as we will go on to see. But it is precisely on this type of issue where opposition is growing between Member States. Should we not move towards an energy solidarity pact that respects States’ decisions and promotes the complementarity of different electricity mixes? How can we organise cooperation between the nuclear States to build a European industrial sector that contributes to our energy security and our competitiveness in the face of competition from Russia and China? Societies must be able to participate in energy policy choices that meet climate and economic recovery objectives: how can we ensure that people take ownership of nuclear energy by overcoming the age-old divide between those who are “for” and those who are “against”?

1. Status and outlook for nuclear reactors in the European Union

At the beginning of 2021, the EU's nuclear power plants represented almost 105 GW with 126 reactors in operation in 13 countries, plus those in the United Kingdom and Switzerland. They accounted for about a quarter of all electricity, see Table 1.

Table 1. Europe’s nuclear fleet (EU and others) in 2019. [Source: © IAEA. Annual report 2019, page 133.]

Country	Number of reactors	Installed power (MW)	% of national electricity production
France	56	61,400	70.6

United Kingdom	15	8,923	15.6
Spain	7	7,121	21.4
Belgium	7	5,930	47.6
Germany	6	8,113	–
Sweden	6	6,869	34.0
Czech Republic	6	3,932	35.2
Switzerland	4	2,960	36.1
Finland	4	2,794	34.7
Hungary	4	1,902	49.2
Slovakia	4	1,814	53.9
Bulgaria	2	2,006	37.5
Romania	2	1,300	18.5
Slovenia	1	688	37.0
Netherlands	1	482	3.1

Some countries, such as Italy, Austria and Ireland, have long been opposed to nuclear power and no longer have any reactors on their soil.

In the wake of Fukushima, Germany and Belgium voted to phase out nuclear power, as did Switzerland outside the EU. Spain is expected to complete its nuclear phase-out at the end of its reactors' life span, around 2035, as is Sweden, whose nuclear phase-out was voted on in a referendum in 1980! These four countries have 24 GW in 2021, i.e. 20% of European capacity.

In addition to the United Kingdom, twelve EU countries are keeping the nuclear option open: Bulgaria, Croatia, Czech Republic, Finland, France, Hungary, Lithuania, the Netherlands (recently), Poland, Romania, Slovakia and Slovenia.

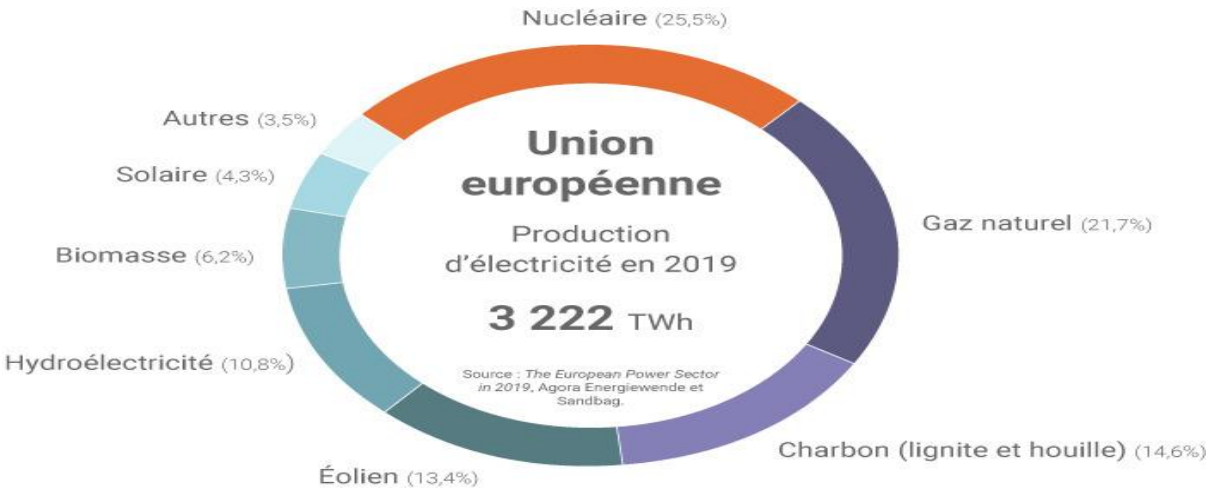
Nine countries are adding or planning to add new reactors to their existing plants: one is preparing to enter (Poland), and two (Lithuania and Slovenia) have no actual plans, but are not ruling nuclear out. Six of these countries (Hungary, Czech Republic, Slovakia, Bulgaria, Poland, Romania) are in Central and Eastern Europe. Currently, six reactors are under construction in three countries (France, Finland, Slovakia). If we add the United Kingdom to this list, their total capacity comes to 7.3 GW.

2. For carbon neutrality: drastically reduce fossil fuels and develop nuclear power

What exactly are we referring to when we advocate zero carbon in the energy sector? The energy mix? The electricity mix? We actually need to look at the energy balance as a whole (Read: Energy and climate, constructing climate policies). At European level, the final energy balance consists of 80% fossil fuels and 20% electricity [3]. This means that the zero-carbon energy target would be unattainable without prioritising the objective of drastically reducing fossil fuel consumption!

Furthermore, the belief that we can achieve the energy and ecological transition by asking Europeans to reduce their energy consumption by half through greater energy efficiency is simply unrealistic. Entering an era of "degrowth" would mean having to change drastically our economic model and our lifestyles. Assuming that we can reduce our overall consumption, we will in any case need (as all scenarios are pointing to) much more electricity in the energy mix to reflect the changes taking place in industry and agriculture, transport and construction, but also those of the digital revolution, which represents an enormous challenge (since the digital sector will account for about 14% of total electricity consumption in the future). It is therefore not a question of consuming less electrical energy and, even if improvements can be made, it is wishful thinking to bet everything on energy efficiency in industry, services and housing, for which the rate observed over the last 20 years would have to be multiplied by 5 to 6. It would mean producing more decarbonised electricity, which is far from guaranteed if we reduce nuclear power.

Within Europe's electricity production, fossil fuels still account for 34%, while the share of "decarbonised" electricity comes to 66%, of which 25% is nuclear, 21% intermittent renewables (IRES - wind and solar), 13% hydropower and 6% bioenergy [4].



European Union – electricity production in 2019 – 3,222 TWh

Nuclear (25.5%), Natural gas (21.7%), Coal (lignite and hard coal) (14.6%), Wind (13.4%), Hydroelectricity (10.8%), Biomass (6.2%), Solar (4.3%), Others (3.5%).

Figure 1. Breakdown of EU electricity production between fossil fuels and low carbon technologies - [Source: © *Connaissances des Energies* – Decarbonising the electric system: progress but nothing should be taken for granted]

In the light of these figures, we observe that the problem of decarbonisation is not primarily between nuclear and IRES (even if that is a problem too), but rather between fossil fuels and decarbonised sources, see Table 2. Most **energy uses** are still **non-electric**, whether we are referring to buildings and industry for **heat** production (**essentially gas and fuel oil**) or in **transport** (oil). The solution is therefore to electrify these uses, directly or even indirectly via the production of low-carbon hydrogen by electrolysis, provided that the electricity or hydrogen is not produced using fossil fuels.

Table 2. CO2 emissions per electricity sector in gCO_2/kWh. [Source: *Base Carbone* © ADEME]

Sector of electricity production	**Emissions (gCO2/kWh)**
Nuclear plants (in France)	6
Hydroelectric power stations	6-10
Wind (on- and off-shore)	6-10
Biomass (wood waste combustion)	32
Geothermal	38
Solar photovoltaic	55
Natural gas thermal	443
Oil-fired thermal	730
Coal-fired thermal	1058

The objective of achieving zero carbon in the electricity mix with 100% RE in the future electricity mix, as certain European scenarios are suggesting for 2100, is problematic on several fronts. First of all, what is the purpose of replacing nuclear power with IRES in countries such as France that have nuclear power plants? (Read: In a carbon-neutral world,

can we do without nuclear?). This would mean replacing “decarbonised” with a “decarbonised” providing a much inferior service (because it cannot be controlled and is at the mercy of erratic weather patterns). But above all, it is well-documented that intermittent renewables will have to be backed up by a continuous and modulable basic energy source... and if it is not nuclear, it will be gas. Gas is less polluting than coal, but it emits 75 times more CO2 than nuclear power in terms of electricity production and its various uses. Furthermore, it emits methane, another greenhouse gas, taking into account the leaks during extraction [5].

Germany, which has already closed eight nuclear power plants, has decided to close the remaining nine by the end of 2022. It has reopened coal and lignite mines and built new thermal power stations which it has committed to closing by 2038, and to replace them with gas-fired power stations, acting as a back-up to intermittent renewable energy sources. [6] (Read: Germany: the feasibility of an electricity mix based on intermittent renewables). This is also what Belgium had in mind when it voted to close its 7 nuclear reactors by 2025 and replace them with nine gas-fired plants. Gas will be transported from Russia via Germany with the Nord Stream 2 pipeline, and via southern Europe with the Turkish Stream. Gas projects are huge in Europe and make us fear that a new RE/gas electricity mix will be imposed upon countries that do not opt for nuclear. Some countries want to steer clear of this contradiction as the example of the Netherlands shows. The Netherlands based its energy economy on natural gas after discovering very large gas fields in 1965, which enabled them to connect 98% of households to gas (Read: Natural gas: the formation of a major industry in the 20th century: part I and part II). Because of the earthquakes associated with extraction, they are now considering developing a programme to install 7 GW of nuclear power from 2025, thus choosing nuclear safety to assist renewable energy development as opposed to the risks posed by gas [7]. Poland (which does not want to increase its dependence on Russian gas) wants to be able to reduce its current electricity production from coal (80%) by developing a nuclear park with 6 reactors [8].

3. The disparity of the electricity mix between Member States: respecting diversity

Natural stores of renewable resources create disparities that make it ineffective to impose supranational electric RE development targets upon Member States. Not all countries enjoy the same geographical advantages. The wind does not blow in the same way everywhere and the sun does not shine as brightly everywhere [9]. What is the value of the injunctions imposed by the Commission upon States if they are subsequently disregarded? In order to reach 40% of IRES by 2030 at European level (objective set in 2019 on the basis of the objective of a 32% share of RE in 2030 in the energy sector as a whole), the Member States that have wind and sun will be able to contribute more effectively to this common objective and in a less costly manner than the others. Indeed, they will be able to rely on guaranteed price subsidies which do not reflect the market value of IRES production and which do not take into account the costs incurred in the system.[10]. As the OECD-NEA studies show [11], the costs incurred in the system by each MW of IRES grows rapidly once an IRES share of 30-40% is reached. These system costs come both from additions to the transmission and distribution networks, and from the need for back up for controllable generation equipment (existing nuclear and gas capacity, installation of flexible gas turbines) and hydraulic and

battery storage to store surplus IRES in off-peak hours. Other forms of flexibility will be necessary because batteries for storing surplus electricity during periods of high wind or sunshine do not work with very large quantities of electricity, or for photovoltaic energy, over a long period, between summer and winter.[12] (Read: The breakthrough of electrical storage. What techniques does it use? What is its economic function? What does the future hold?). In the end, these system costs, which are not paid by IRES producers, will be passed on to consumers via the transmission and distribution service price of the network operators who have to pay for the balancing services and system services resulting from the increasing intermittent production.

In addition to these system costs, there is also the cost of de-optimising the electricity mix compared to a situation where the development of RE is not driven by long-term revenue guarantees (feed-in tariffs) but results from the same market price incentives offered to other non-RE technologies. On the one hand, the priority of credits granted to IRES production on the electricity markets as soon as they are produced leads to increased volatility in the hourly market price (between 300 € and 0 € per kWh, or even negative prices due to the lack of sufficiently flexible producers in the controllable fleet), see Figure 2. And above all, these "zero marginal cost" forms of production lower the average price across the year and reduce the number of outlets for conventional equipment. This is to the detriment of controllable equipment (nuclear, combined cycle gas power plants, flexible gas turbines). It is becoming increasingly difficult for existing equipment to depreciate and even to recover operating costs, resulting in premature closures. Operators are being deterred from creating new equipment not only by the volatility of market prices, but also by the risk of not making a return on their investment, given declining market prices and a smaller-than-expected market for basic equipment. IRES production developed on the basis of subsidised revenues reduces the revenue prospects of non-IRES equipment, including new nuclear, which is then prevented from accessing these schemes.

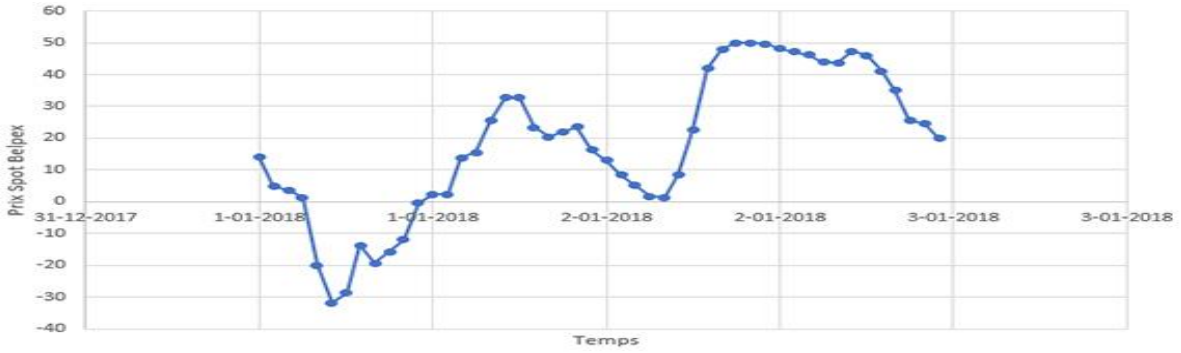


Figure 2. Highly volatile prices on the wholesale electricity markets, e.g., in Belgium. [Source: © Ventdesud, https://www.ventsdusud.be/8-news/162-prix-elec-negatif]

4. A discriminatory system for IRES which costs taxpayers dearly

The system has proven to be highly discriminatory between conventional controllable production and IRES production. Whatever their production, whether it is windy or not, whether it is sunny or not, intermittent producers always receive the same revenue per MWh, whether they all produce at the same time, sending the market price spiralling downwards (which means that their production has little economic value) or whether they only produce

at 10% of their capacity (giving them a higher market price). Being remunerated by a tariff (or a fixed income per MWh) over 20 years is a subsidy that comes at a cost and it must be financed somehow. In France, it is paid for by both the consumer and the taxpayer, on the one hand through the CSPE, a tax on electricity consumption that finances the cost of all the public services imposed on energy companies (including the IRES part of the CSPE), and on the other hand through the "carbon part" of the TICPE tax on fossil fuel consumption. The total comes to 7 billion euros per year to the benefit of IRES producers alone, paid by residential and tertiary consumers, who also indirectly pay for the system costs in the transport and distribution tariffs.

Granting priority to IRES (photovoltaic panels, wind turbines, batteries) has led to an uptick in imports of equipment and products. Producing them in Europe would require imports of metals (copper, etc.) and strategic minerals (lithium, cobalt, vanadium, etc.) which are found mainly in China, Africa and Chile; access to these resources is in itself a new source of geopolitical tension which must be taken into account. Furthermore, we cannot afford to overlook the fact that the development of IRES, which requires a great deal of space (unlike nuclear power), is beginning to stoke up major social opposition, which is reflected in political and legal obstacles (in France, 70 wind farm projects are currently going through the appeal process). This means that local public rejection is not the sole preserve of nuclear power and could severely curtail the development of onshore and offshore wind power capacity, as is already being seen in Germany and even in Denmark, one of Europe's pioneering countries (Figure 3).

LE FRESTOY-VAUX

Vent de contestation autour du projet d'implantation de six éoliennes

Nordex France avance des compensations financières importantes pour les deux communes concernées par le projet. Les habitants promettent un comité de lutte.

Le principe d'une étude de faisabilité, concernant l'implantation d'un parc de six éoliennes, réparties à parts égales entre les communes de Rubescourt et Le Frestoy-Vaux, a été adopté par six voix contre cinq dans cette dernière commune. La première adjointe, Angélique Cagny, a voté contre, expliquant ainsi son vote, avec amertume : « *C'est un sujet trop sensible, un dossier trop technique pour être abordé sans réflexion préalable !* » Deux élus, concernés par le projet, n'ont pas participé au vote, tandis que deux autres se sont abstenus. Les élus de Rubescourt n'ont quant à eux émis aucun vote, pour le moment.

Les éoliennes implantées à 700 m des habitations

Vendredi dernier, en séance de conseil municipal, Marc Serra, représentant la société Nordex France (constructeur et développeur d'éoliennes), était venu présenter le projet. Lequel a suscité questions et réactions parmi les élus, mais aussi dans le public, venu en nombre assister à la réunion. Le fait que les éoliennes soient implantées à 700 mètres des habitations a mis hors de lui un habitant du village, qui promettait de mettre en place prochainement un comité anti-éolienne.

L'intervenant a été pressé de questions sur les conséquences des éoliennes sur la santé, sur la dépréciation du prix des terrains et maisons situés en périphérie, sur le bruit, sur l'environnement, etc. Rompu à cet exercice, Marc Serra s'est montré rassurant et a mis en avant un atout majeur : « *Les retombées fiscales ne seront pas négligeables pour la commune, qui recevra 6 000 euros par éolienne et par an. Et votre communauté de communes touchera, elle, 44 000 euros par an. En plus, nous remettrons en état vos chemins communaux et améliorerons votre éclairage public. Nous ferons appel à des sous-traitants locaux, pour un marché allant de 420 000 à 1 200 000 euros.* »

Ces promesses alléchantes ont déclenché un vote positif pour six élus, mais n'ont pas convaincu les autres personnes présentes, qui promettaient de se manifester lors de l'enquête publique qui sera organisée dans le cadre du processus d'implantation. Lequel devrait mettre plus de cinq années avant que le vent ne souffle sur les pales des éoliennes…

Le projet comporte six éoliennes. (Photo d'illustration)

Un constructeur bien implanté

Nordex France, troisième constructeur d'éoliennes en France, en a déjà implanté 6 500 dans l'hexagone. Fort de plus de 200 salariés, il dispose de centres de maintenance à Crévecœur-le-Grand, Laon (Aisne) et bientôt à Doullens (Somme). Chaque éolienne, d'une puissance de trois mégawatts, pèse 500 tonnes. Elles sont posées sur une dalle de béton de 13 mètres de large sur 3 mètres de profondeur.

De notre correspondant
LUCIEN DIANI

Figure 3. Contested wind turbine sites. [Source: *PCF Oise* – Turmoil around the project to build six wind farms]

5. Creating the conditions for pursuing nuclear in Europe

Creating an electricity mix without nuclear power would mean condemning the European (especially French) nuclear industry and contemplating its disappearance at a time when a nuclear renaissance seems to be taking shape worldwide. It should be noted that nuclear power in Europe represents 800,000 jobs, thousands of companies, a fleet of 126 reactors

across 13 countries, with almost 105 GW of installed capacity in 2021. The European Union should not, as it has done for other high value-added industries, leave the field wide open for China and Russia, or even to the United States, acting very aggressively on the world reactor market by offering very favourable financing conditions.

On the contrary, we must anticipate and plan investments to renew Europe's nuclear facilities and prepare for the future. The European Commission itself has estimated the cost of doing this at 400 billion [13], which represents a significant sum. But the trade-offs are also significant and ought to be given due consideration. In the general interest, investments in nuclear power are good for the climate, good for the production of affordable, controllable basic electricity, good for the security of supply and energy independence of countries and good for employment. Investors should not be looking for short-sighted profitability and public authorities should be able to come up with incentives that reward operators and investors for the very social and collective benefits that these investments provide. The costs/benefits of projects should be measured accordingly, internalising external costs and with favourable discount rates, whether this is to extend power plants' life span, replace end-of-life plants with new production capacity, manage spent fuel and final waste (the type that cannot be reprocessed) (Read: Producing and managing the radioactive waste of electro-nuclear industries and The storage of nuclear waste) or whether it is used for R&D for safety, digital technology in the sector, generation IV (fast neutron and molten salt reactors) (Read: Molten salt reactors and fast neutron reactors), or training for nuclear professions.

In France alone, the major refurbishment plan to extend the power plants' life span is estimated at 50 billion. This significant investment will ensure 10 to 20 years of additional operation for 32 nuclear units, which will be very profitable. From this point of view, we might question France's decision to close 12 reactors after Fessenheim, when they could operate for another ten years, thus ensuring the security of the network to meet the growth in demand, and in the knowledge that IRES have very little chance of being used, given mounting opposition. As for the EPR and new nuclear power, whilst the learning curve is costly with the 1600 MW Flamanville 3, it guarantees France's nuclear future with the project of 6 new EPR2[14] and in Europe with the Olkiluoto plant in Finland, Hinkley Point and Sizewell in the United Kingdom and future projects in Poland. Other reactor projects are underway in Hungary (VVER), the Czech Republic, Slovakia, Romania (Candu) and the Netherlands. They will not all be French EPRs, but will be generation III reactors. Small Modular Reactor (SMR) projects, small reactors of 200 to 400 MW, will be able to meet the diversified needs of the territories, as in Finland or Estonia, which are intended to supply the heating networks of cities that are currently supplied by coal. (Read: Small modular reactors).

6. Promote the financing of heavy investments with deferred profitability

Nuclear electricity (like all electricity) is a public service of general interest. But nuclear projects come with heavy investments and a deferred return, and companies, whether public or private, cannot assume the costs and risks alone in a market context unsuited to this type of investment [15]. The electricity market is a time-stepped market with prices aligned with the operating costs of the last plant called to meet hourly demand. It is not compatible with investments in high-CAPEX equipment, lengthy construction times and long payback periods. Prices are volatile and make it difficult for investors to see the value of investing. A high and credible long-term CO2 price would be needed to raise and stabilise the hourly market price.

The CO2 trading scheme does not really offer this due to the lack of a floor price to act as a minimum tax on MWh produced by fossil plants, which would give more value and revenue to nuclear MWh. But the Commission refused to introduce such a floor price when recently reforming the permit system.

For investment in new plants to be given the go ahead, nuclear investors must be able to benefit from public guarantees on their long-term revenues, in the same way as wind or solar PV projects (Read: Energy markets: covering risk). The electricity market requires reforming in such a way that allows for long-term revenue guarantee contracts between the investor in a nuclear project and the State, similar to the existing remuneration supplement contracts for wind or solar PV projects by way of derogation from EU State aid rules. These derogations for renewables are finalised in the regulation entitled "Guidelines on State aid for environmental and energy protection" which does not cover nuclear production equipment, and which therefore needs to be broadened [16].

There are several possible options. Firstly: the CfD or Contract for Difference. This is a top-up mechanism planned for Hinkley Point C in the United Kingdom. It guarantees remuneration of 92.5 pounds/MWh for 35 years with a supplement to the market price [17]. Another possible system is the State purchasing MWh of equipment at a "Regulated asset based" (RAB) price; this is the full remuneration spread over the equipment's life span and at a rate based on the operator's actual costs with an assured rate of return on capital as for the regulated tariffs of the transmission and distribution networks. This makes it possible to transfer most of the construction and operating risks to the State and to slash the borrowing rate to very low levels. The cost per MWh is very sensitive to this rate, so it is a win-win scenario: financing at low rates promises cheaper electricity which benefits everyone. This arrangement could be applied in the UK for the Sizewell C project. A third possibility that the Czech Republic intends to implement for its two reactor Dukovany II project is a power purchase agreement (PPA), which is a private contract between the nuclear producer and the State, or a company representing the State, which buys the electricity at cost (calculated with a specific rate of return) and then sells it to an electricity company that is looking to invest. This PPA is coupled with a public loan covering 70% of the investment at zero interest during construction and 2% after commissioning. In Finland, the "Mankala" model is a type of production cooperative bringing together operators, distributors and large industrial users who buy electricity at cost price, but it is not certain that competition rules would allow such an arrangement, which would bring together several competitors and be seen as a cartel. Other possible models exist in the absence of investors: partners taking a stake in the capital. For example, Rosatom will take a 34% stake in the capital of Fennovoïma in Finland, or will lend 10 billion in Hungary for a new power plant in Paks [18]… In the UK, the Chinese invested 8 billion in the Hinkley Point project in exchange for the sale of a Hualong reactor.

Today, in order to set up such arrangements, nuclear investors need the green light from the Commission's DG Competition, as was the case for the Hinkley Point C *Contract for Difference* in the UK, and as could be the case in France if CfDs are put in place for future EPR projects, unless the State Aid Regulation (currently being adjusted) is amended to include nuclear projects. This can only be done under pressure from the Member States pursuing the nuclear option with determination. With nuclear being included in the Regulation as a decarbonised

technology, Brussels' controls over these arrangements would become a formality, as is the case for the remuneration top-up contracts for RE projects.

Figure 4. The Flamanville EPR. [Source: © EDF, L'EPR]

7. Including nuclear in the taxonomy

In parallel, it is essential for nuclear power to be included in the taxonomy, the list of decarbonised activities which was the subject of a first Commission delegated act published on 21 April 2021 (which still needs to be ratified by the Council and the Parliament); they will benefit from labels and the possibility of accessing privileged "green financing" thanks to public guarantees, which will send out strong signals to banks and market investors. Under pressure from the Greens and States such as Germany and Austria, nuclear technology does not appear on the list because it generates radioactive waste that could be harmful to the environment. The European Commission commissioned a group of experts from the JRC (Joint Research Centre) which delivered its report with positive conclusions: "There is no science-based evidence that nuclear energy does more harm to human health or to the environment than other electricity production technologies..." [19]. The report - which is being evaluated by two other groups of experts (Euratom, Article 31 and Health) will go to DG FISMA (Taxation) before the Commission proposes a complementary delegated act where nuclear (as well as gas which is not part of the first delegated act) could be included. France has argued for the adoption of the rules to be postponed so that nuclear can be dealt with in a stand-alone text, respecting the taxonomy's principle of technical neutrality. Despite an urgent call from seven Heads of State and Government to ensure a level playing field for nuclear power without excluding it from climate and energy policies and benefits [20], the Commission has not agreed to review its timetable. But the battle is far from won, and organisations such as PNC-France are intervening to ensure that the nuclear States mobilise and put pressure on the Commission to integrate nuclear power into the complementary delegated act [21].

Rather than giving into doubts about solutions for the sustainable and responsible management of spent fuel and nuclear waste, the Commission ought to have forced Member States to implement them [22]. Solutions for closing the cycle, forged over the last few decades, are risk-free. In France, a whole industrial sector has been created in the circular economy with the storage, processing and recycling of plutonium through the use of MOX fuel in generation III reactors (and at a later stage perhaps in fast neutron reactors) and tomorrow molten salt reactors which will consume the waste they produce.

Figure 5. The CIGEO underground storage project [Source: Andra].

CIGEO (Figure 5), the future geological disposal centre, has been the subject of research for 30 years, has seen three laws passed to have it approved and opened, and has been subject to in-depth safety studies by the French Nuclear Safety Agency (ASN) and its technical support institute, IRSN (Read: Nuclear safety). By deciding to open it up, France would be joining the ranks of Finland and Sweden, which have led the way by announcing the opening of storage centres in 2022 [23] and which act as 'models' in Europe.

8. An energy solidarity pact and enhanced cooperation

Not all countries are equal in terms of geographical or technological assets. They must be able to decide on their facilities and infrastructure according to their natural resources and their industrial and technological know-how [24], with complete independence and without the threat of being held back by other Member States. They ought to be able to make their decisions as part of a European policy of solidarity that aims to develop cooperation by coming together and making optimal use of the ways in which different countries with different energy mixes complement one another. However, the development of nuclear power, which is in the general interest of the Community, is being hindered by those States that do not want it in their own country and are trying to impose their choice upon others by influencing the Commission.

How can we enable States that continue to opt for nuclear power to cooperate by sharing the challenges of R&D and training and by sharing in the expenditure of building power plants? An energy solidarity pact with a view to structuring cooperation between nuclear States would be a good solution, based on the principle of sovereignty over the choice of energy mix, which is enshrined in the Treaties (Article 194(2) TFEU) [25]. This principle must be reflected in the Commission's respect for technological neutrality, which is not the case when nuclear power is discriminated against whilst granting priority to the unbridled development

of IRES, which benefit from State aid and guarantees in the sustainable technology taxonomy. The principle of technological neutrality must be underpinned by a principle of diversity which would be at the heart of the European Energy Solidarity Pact so as not to exclude any low-carbon technology and to allow them to coexist in the EU's integrated energy system. Following this logic, the Commission's target of 15% nuclear power by 2050 should be raised to 25-30% as an indicative target, and the target for the development of renewable energy sources should be lowered so as not to explode the system. Nuclear power cannot be imposed upon those who do not want it, but the Commission and the European Council must create the right conditions for different low-carbon energy sources to coexist in the electricity market and, better still, build a common energy policy in the general interest of all Europeans.

This solidarity pact could facilitate the development of enhanced cooperation or cooperation that comes with variable geometry. For example, nuclear countries could agree to share safety costs and produce common nuclear licences, as is the case with the KELPO project in the Nordic countries [26]. The countries that have no other choice but to continue to use coal and gas in power generation or industry could share the costs of R&D in CCS (carbon capture and storage) and the development of transport and storage infrastructure for carbon sequestration.

There is a major battle to wage to overcome the divide between “for or against” nuclear power. To triumph, societies must be able to take ownership of the issues and challenges associated with nuclear power, and participate in the collective choice of a decarbonised mix, rich with all the assets of the Member States, meeting the objectives of climate protection and economic and industrial development, as well as the objectives of independence and solidarity in Europe.

To find out more:

- For a revision of the European energy strategy (sent to national and European institutions at the end of Les Entretiens Européens in Helsinki) :https://www.entretiens-europeens.org/wp-content/uploads/2019/12/supplement-leen-dec-2019-fr.pdf
- “Nuclear in France”: https://www.entretiens-europeens.org/wp-content/uploads/2021/03/Suppl%C3%A9ment-de-La-Lettre-des-EEN-Mars-2021.pdf
- “The future of nuclear in France and Europe. The challenges of financing investments”. Webinar X-Sursaut on 29 April 2021 with Bernard Accoyer and Claude Fischer Herzog: https://www.youtube.com/watch?v=pG49yGBdDRk

Notes

Cover image. Nuclear power plants in Europe. [Source: Alexrk2, CC BY-SA 3.0, via Wikimedia Commons]

[1] European Commission (EC), A Clean Planet for All: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, 2018 (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN).

[2] List of decarbonised activities drawn up by the institutions which will benefit from labels and guarantees. Nuclear power was the subject of a JCR (Joint Research Centre) report commissioned by the Commission to assess compatibility with the taxonomy's criteria. Its conclusions are positive: see below.

[3] In France, it is 75% fossil fuels, 25% electricity (representing 537.7 TWh. And within electricity: 70.6% nuclear, 11.2% hydroelectric, 7.2% gas, 6.3% wind, 2.2% solar, 1.8% bioenergy, i.e., 84% "decarbonised" electricity. (Figures from RTE 2020) Accueil RTE Bilan électrique 2020 (rte-france.com) – See supplement to La Lettre des Entretiens Européens "Nuclear Special in France" from March 2021. www.entretiens-europeens.org

[4] Nuclear power is 6 gCO2/kWh on average in Europe, but in France it is even between 4 and 5; a performance achieved thanks to the flexibility of the fleet and the change in uranium enrichment technique from gaseous diffusion to centrifugation.

[5] For gas, the gap with coal is cancelled out as soon as leakage exceeds 2% of the volumes extracted and transported, which is largely exceeded with American shale gas, and will depend in the next few years on Russia's ability to cope with the thawing of the permafrost, which is a real calamity for the structural integrity of gas pipelines coming from Siberia).

[6] German environmentalists are now calling for the closure of fossil fuel power plants before nuclear power plants. See Veronika Wendland's speech at Les Entretiens Européens 2021. www.entretiens-europeens.org

[7] See Bart Groothuis "The Netherlands choose nuclear safety over gas risk" –in *La Lettre des Entretiens Européens* N°19 February 2021. www.entretiens-europeens.org

[8] Poland has announced an investment of €33 billion to build the country's first six nuclear reactors, the first of which will be operational by 2033, compared to the announced €29 billion effort in offshore wind power by 2040.

[9] Another indicator that should be taken into account is the installed wind power capacity per capita. It should be compared to the number of inhabitants to assess its importance in relation to the population.

[10] Europe's 205 GW wind farm often produces at less than 10% of its installed capacity. The 132 GW solar park only delivered 100 TWh in 2020, while the 118 GW nuclear park supplied almost 800 TWh in 2020.

[11] Nuclear Energy Agency of the OECD NEA-OECD (2012): Nuclear Energy and Renewables: System Effects in Low-Carbon Electricity Systems; AEN-OCDE; (2018) Cost-effective Decarbonisation: System Costs in Energy Systems with High Shares of Nuclear and Renewables; NEA-OECD (2019). The Full Costs of Electricity Provision.

[12] For inter-seasonal storage, it would be necessary to switch to hydrogen and possibly transform it into methane, before producing electricity at critical hours by gas turbines or large fuel cells.

[13] See the Nuclear Illustrative Programme (PINC) presented in accordance with Article 40 of the Euratom Treaty - final - after EESC opinion - (SWD (2017) 158 final). These figures are based on a 15% nuclear share of the future electricity mix.

[14] Built in series and in pairs, the future EPRs would be much cheaper than Flamanville 3 (8 billion per unit) by benefiting from the re-learning of the French nuclear industry and the subcontractor chains. See the March Supplement to *La Lettre des Entretiens Européens* "Nuclear in France". www.entretiens-europeens.org

[15] This topic will be at the heart of the Entretiens Européens 2021 "The valorisation of nuclear projects in Europe and their financing. Comparison between European countries and regions of the world (China, USA, Russia...)".

[16] Guidelines on State aid for environmental and energy protection. Commission Regulation (EU) No 651/2014 of 17 June 2014.

[17] The CfD does not add anything to the market price. It is a balanced system that guarantees a stable selling price: if the market price is lower than this price, the State provides the supplement. If the market price is higher, the operator pays the surplus.

[18] In Turkey, Rosatom offers to take on all construction risks in return for a guaranteed fixed price per KWh sold (Akkuyu).

[19] See page 9/387 of the report (Key conclusions) – https://politico.eu/wp-content/uploads/2021/03/26/JCR-report_March-2021-clean-C

[20] *The letter, dated 19 March 2021, is signed by the French President and the Prime Ministers of Hungary, Poland, Czech Republic, Romania, Slovakia and Slovenia.*

[21] See the letter from Bernard Accoyer to the President of the French Republic on 6 May 2021: www.pnc-france.org

[22] See *Supplement to La Lettre des Entretiens Européens* from April 2021 "Nuclear Waste Special": we have the solution. What we don't have is the courage to make a decision! Find also the proceedings of the 2018 Entretiens Européens in Paris "The management of spent fuel and nuclear waste. The solutions exist, they must be implemented". www.entretiens-europeens.org

[23] In Finland, the encapsulation plant is being built and the operator hopes to apply for an operating licence next year. On the Swedish side, the project is blocked for the time being, with the government delaying a decision to give the green light to the industrial phase.

[24] See the cases of the Czech Republic or Poland, which have no other choice than nuclear power to decarbonise their mix, as they do not have enough wind, sun or rivers…

[25] It reads, "Measures (of the common energy policy) must not affect the right of a Member State to determine the conditions for exploiting its energy resources, its choice between

different energy sources and the general structure of its energy supply, without prejudice to Article 192(2)(c)".

[26] Initiated by Finland, the project brings together companies in the industry (with the participation of the Safety Authority as an observer) to strengthen cooperation between licensees in Finland, the Nordic countries and Europe.

KEY WORDS:
DECARBONISATION ELECTRICITY RENEWABLES NUCLEAR ENERGY TRANSITION