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THE FRENCH NUCLEAR CHALLENGE TO THE EU GREEN ENERGY GOVERNANCE

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Abstract. This paper explores the role of nuclear power in substituting fossil fuels and contributing to the net zero. It considers to what extent the French position on nuclear energy is viable within the framework of EU green energy governance. The analysis of EU legal attempts to develop a common strategy for member countries and the case study of France reveal the controversial nature of nuclear energy. The authors argue that the EU could work towards easing off nuclear energy and could successfully overcome the pro-nuclear views of countries which currently depend on it for electricity production. The limited climate benefits of nuclear energy, when the whole life-cycle of nuclear reactors is considered, and the unease of the population with nuclear energy, even in countries that depend on it, chart a probable new course for a renewable energy mix in the EU. This phasing-out of nuclear energy is likely to be progressive so as to avoid lost investments in developing the technology and will hinge on how rapidly renewables reach their technological maturity.

Key words: nuclear energy, EU Green Deal, climate change, path reversal, France

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Introduction

Climate change awareness and attempts to mitigate its effects figure high on the global policy agenda. The Paris Agreement set states on the path to contain the increase in global temperatures and members of the European Union took on the ambitious target of carbon neutrality by 2050 [Heim et al., 2022]. The decarbonisation goal is not especially controversial; however the way to reach it has been the object of many discussions with countries opting for very different paths. Since WW2 the place of nuclear power generation has been contentious and gone through phases of acceptance and rejection. Nuclear power appears to be a promising solution to produce electricity with a minimal carbon footprint as the actual production process is carbon-neutral. However, nuclear programs are not associated with a reduction of emissions in countries that implement them, mainly because nuclear plants are used to meet new energy demands rather than to phase out fossil fuels [Sovacool et al., 2020].

Public opinion often plays a significant role in determining governmental choices regarding energy [Toganova, 2016] and the decision to go nuclear depends on historical, geographical and timing factors. While nuclear energy is not considered by most scientists to be a permanent solution, due to limitations in uranium resources, its role as a transitional solution in helping to achieve the net zero in the required timeframe has officially been recognised by the European Union. Evidence suggests that the 'race against the clock' of climate change requires the use of intermediary solutions such as hydrogen and nuclear power until renewables have reached their full capacity and become a mature technology. However, attempts to expand nuclear power are thwarted by a strong anti-nuclear movement that associates nuclear facilities with nuclear weapons and builds up on the negative perception of a small number of nuclear disasters to create a powerful backlash against policymakers attempting to launch new nuclear programs or rekindle dormant ones. The question of radioactive waste resulting from nuclear energy production and the threat of weaponization of civilian facilities are other difficulties faced by the nuclear industry.

This paper explores the role of nuclear power in substituting fossil fuels and contributing to the net zero. It investigates to what extent the French position on nuclear energy is viable in the framework of EU green energy governance. The analysis of EU legal attempts to develop a common strategy for member countries and the case study of France bring out the truly controversial nature of nuclear energy. The authors make the case that the EU could work towards easing off nuclear energy and could successfully overcome the pro-nuclear views of countries which currently depend on it for electricity production. The limited climate benefits of nuclear energy, when the whole life-cycle of nuclear reactors is considered, and the unease of the population with nu-

clear energy, even in countries that depend on it, spell out a probable new course for a renewable energy mix in the EU. This phasing-out of nuclear energy is likely to be progressive and incremental so as to avoid lost investments in developing the technology and will depend on how quickly renewables reach their technological maturity.

We will first consider the European Green Deal and the ambition to create an energy union, then the possible relationship between producing nuclear energy and climate change mitigation will be analyzed. A detailed review of the development nuclear energy in Europe will be followed by a specific case study of the French nuclear power industry. The case of France is used to gauge the prospects for the acceptance or rejection of nuclear energy in the European Union in the short, medium and long term.

The EU Green Deal and Energy Union Strategy

Recent policy measures in the EU focus on creating an energy union which would ensure a stable and clean supply of energy to all EU citizens and businesses. The Energy Union Strategy was launched in 2015 and is based on five pillars: the first is security, solidarity and trust, the second a fully integrated internal energy market, the third energy efficiency, the fourth climate action and decarbonising the economy and the fifth research, innovation and competitiveness (COM/2015/080). The EU underlines its leadership role in showing the way to the energy transition to renewables and the essential role played by research and development in ensuring renewables become competitive and reliable. The efficiency pole emphasizes the need for rational consumption and the idea of solidarity encourages countries to eradicate energy poverty among citizens from underprivileged backgrounds. The idea of a fully integrated internal energy market is highly ambitious and requires the removal of regulatory barriers in order to ensure that there is an optimal energy consumption through transnational grids.

A number of initiatives were adopted within the framework of the energy union, including the ‘Regulation on the governance of the energy union and climate action’ in 2018. It sets forth an action plan for cooperation to meet 2030 decarbonisation goals arising from the EUs Paris Agreement commitments and comprises measures to unify reporting on emissions and reduce administrative burdens. A system of national energy and climate plans, each lasting ten years, has been implemented since 2021 ((EU)2018/1999). The idea of creating a single electricity market is, however, challenged by the fact that some member countries provide subsidies to power plants (‘capacity mechanisms’) to ensure stable electricity supply (France, Spain, Greece, Portugal…), while others do not. These payments can interfere with market mechanisms as those producers who have to rely only on their earnings will suffer from the unfair competition of those who receive subsidies [Capacity Mechanisms, 2023]. The goal of the energy union is to overcome in the medium term these energy distortions and have all companies generating electricity competing in price and in sustainability over the breadth of the EU market. The green transition is also dependent on all subsidies for fossil fuel-based energy generation being cut out.

The European Green Deal of 2019 is a growth strategy of the European Commission which was approved in 2020 by the European Parliament and which makes a

pledge for climate neutrality by 2050. The initiative is wide in scope and seeks to intertwine measures related to the important aspects of EU policy including biodiversity, pollution, sustainable agriculture and industry [Bongardt & Torres, 2022]. The target of a 55% reduction of greenhouse gas emissions against the baseline of 1990 levels became compulsory to all member states under EU law with the European Climate Law in 2021. It includes mechanisms to monitor progress and take further action when intermediary targets are not met. The 'fit for 55' package of 2021 presents draft legislation designed to align member states policies on matters related to climate, transport and energy [European Council, 2023]. Its goal is to ensure state readiness to meet the carbon neutrality commitments and promote coherence in the strategies of different states. In 2022 two directives on renewable energy and efficiency increased the targets for the share of renewables in the energy mix and for the reduction in energy consumption. The 2022 REPowerEU plan was designed to help member countries overcome shortages resulting from the crisis in Ukraine and meet their targets by further developing renewables and increasing imports of LNG and designing new energy-saving measures [European Commission, 2022[. The plan has a budget of 210 billion euros for the period 2022–2027 [European Commission, 2022].

The EU's capacity to create a common energy market and overcome national barriers is highly dependent on countries adopting a similar energy mix. The question of nuclear energy, embraced by some and rejected by others, significantly complicates the creation of a single market.

Nuclear energy and climate change

Although there is widespread agreement among countries of the European Union on the need to decarbonise, the ways to attain this goal are as yet unclear. Studies have also shown that there is a significant degree of inequality between EU countries in their ability to pursue environmental policy [Telyuk et al., 2022]. While common targets have been adopted, there is no unified strategy on how to achieve them and member states retain a significant amount of leverage and lee-way in the choice of path to reduce CO2 emissions. One of the major controversies concerns the role of nuclear in the production of energy and its environmental footprint, with scientists and academics taking contradictory positions on the issue [Muellner et al., 2021]. In the early 2000s nuclear energy was considered by the EU to be a potential solution to climate change allowing for the production of carbon free energy and replacing coal-fired power plants [Sailor, 2000]. Today, nuclear energy still has its advocates, who point out not only the social and environmental benefits of this low-carbon alternative to fossil fuels but also its reliability compared to renewables infrastructure which can be damaged or not meet energy needs due to bad weather conditions [Crowley-Vigneau et al., 2022]. Nevertheless, some experts express doubts about whether nuclear power actually allows economies to decarbonise and stress the risks related to nuclear power generation.

Although the development of nuclear energy is represented as a low carbon technology as nuclear power reactors do not produce CO2 when they operate, they require uranium ore and reactor fuel which are both energy-intensive to produce. Fossil fuels

are intensively used as part of the process of building and maintaining nuclear plants [Schneider et al., 2013]. Estimations of the emissions associated with nuclear energy production are variable as they depend of the quality (grade) of the uranium extracted and the different techniques to enrich and fabricate the fuel [Saidi&Omri, 2020]. Additionally, the disposal of radioactive waste and the decommissioning of reactors weigh in on the assessment of the environmental costs of producing nuclear energy, together with the risk of accidents and their potential weaponization. Although new reactors are designed with additional safety features that according to some estimates diminish the risk of a nuclear catastrophe by ten, most upcoming nuclear generating capacity in government plans rests upon prolonging the use of existing plants, usually created in the 1960s to 1990s [Muelnner et al., 2021].

Opening new plants has become increasingly controversial in some parts of Europe, especially after several large-scale nuclear accidents: the Three Mile Island (1979), Chernobyl (1986) and the Fukushima events (2011) serve as cases in point [Oe et al., 2021]. Studies on the clear-up process after these disasters illuminating the cost and difficulties linked to decommissioning the reactors and carrying out the clean-up on land, including disposing of large quantities of contaminated water into the sea [Buesseler, 2020]. Despite their low-probability, these accidents can have a strong impact on perceptions as radiation is associated with significantly heightened cancer risks and plant operators are suspected of a lack of transparency in communicating the real level of risk to the general public.

Preliminary studies on the impact of developing large-scale nuclear programs suggest that they are not associated with a reduction of CO2 emissions [Sovacool et al., 2020] pointing to the fact that countries frequently use the electricity produced through nuclear means to meet an increase in energy demand rather than to phase out dirtier forms of energy, namely fossil fuels.

Nuclear programs pursued specifically by developed countries to replace other dirtier energy sources could, however, lead to saving CO2 emissions and mitigating climate change. Were EU countries to replace all coal, oil and gas electricity production by nuclear, in a rapid expansion prediction scenario, decarbonisation targets could be met in accordance with EU objectives according to some assessments [Muelnner et al., 2021]. This hypothetical scenario may not be possible, however, as the demand for uranium is already higher than its supply on the world market [World Nuclear Association, 2022]. Also putting a strong focus on developing nuclear energy and making the decision to open a large number of nuclear plants requires a thorough analysis of the total uranium resource stock worldwide to avoid shortages in the future.

Surveys have shown that although public opinion in Europe is divided over the further development of nuclear energy, emerging economies have embraced this solution in order to meet their growing energy needs with the support of the population. Public opinion has been identified as the most significant driver in the expansion or decline of the use of nuclear reactors to generate energy [Gupta et al., 2021]. The governments of India and China emphasize the role of nuclear plants in helping to meet their decarbonisation targets while ensuring energy security for their populations. Cheap and reliable energy has been shown to have a positive economic impact and is frequently stated as

the main reason that countries invest in civilian nuclear programs [Kim et al., 2014]. Another increasingly important factor is that nuclear endeavours provide a moderate level of energy independence. Indeed, although some primary materials to run nuclear plants need to be imported, it does not amount to the same level of reliance as the regular import of fossil fuels. Countries with large territories may find it easier to rally popular support around the incorporation of nuclear sources into the energy mix as the 'not in my backyard' syndrome is easier to overcome and the consequences of potential accidents are perceived as lower [Hu et al., 2020]. Levels of trust in the government also predetermine a population's readiness to accept nuclear energy, with public attitudes in China testifying to a greater willingness to integrate it in their energy mix than in South Korea or most European countries. Recent polls have also found an increase in support for nuclear energy expansion in India which was initially assumed to oppose it [Gupta et al., 2021].

The decision to develop civilian nuclear energy depends on a trade-off between perceived risks and tangible benefits reflected by a relatively stable, independent and affordable energy supply. The decision to go ahead with nuclear energy depends on public opinion, how easily it can be moulded, the degree of commitment to decarbonization, the energy needs of the country and the nature of the existing energy mix.

Nuclear energy in Europe

Nuclear energy was initially, after WW2, perceived as presenting significant new opportunities for Europe and the world at large. During the 1950s some of the world's first nuclear energy reactors were set in operation in the Soviet Union and Western Europe, and the 1960s witnessed an extensive expansion in nuclear energy. Yet, the industry elicited mass protests in the 1970s which resulted in stagnation and doubts about the prospects of this sector, with numerous orders for reactors being cancelled [Muller &Thurner, 2017]. The anti-nuclear movement took shape in the US and Europe with large demonstrations causing various nuclear projects to be cancelled, as was the case in West Germany over the plans to build a plant in Wyhl. The 1977 protest in Bilbao, Spain, gathered 200 thousand people and opposition increased in Europe following the Three Mile Island disaster of 1979 in the US. In 1981, 100 thousand people took to the streets to oppose the building of a power plant near Hamburg [Falk, 1982].

The problem of nuclear energy in Europe was constructed by advocacy networks and reinforced in the public psyche by building on the issue of nuclear accidents [Wang &Kim, 2018]. Framing and timing have a significant influence on determining the salience of policy issues. Objective facts on the risks associated with nuclear energy were found to have less importance than the manner in which they were framed in different countries [Crowley-Vigneau &Baykov, 2018], suggesting that 'objective conditions as such have little explanatory power, and that similar events and conditions have led to widely diverging interpretations and levels of anti-nuclear mobilization in different countries' [Koopmans &Duyvendak, 1995: 235]. The reactions to the Chernobyl disaster in Germany, France, the Netherlands and Switzerland were very different and this variation has been put down to the political opportunities of non-governmental organi-

zations and the historical strength of anti-nuclear movements rather than the credibility or strength of the evidential claims presented to the general public [Koopmans &Duyvendak, 1995]. After the Chernobyl disaster, 180 thousand people took to the streets in Rome to oppose the nuclear program of the Italian government (Falk 1982). Nuclear projects remained off the policy agenda until the 1990s when an increase in energy needs and the creation of a third-generation reactor led to reports of a 'nuclear renaissance' [Muller &Thurner, 2017: 3].

There were stark differences in policy choices across Europe, with some countries deciding to go down the nuclear route for the first time, others to reactive programs which were paused during the 1970s and 1980s and another category standing firm in the decision to rule out nuclear energy. In the 2000s, the EU started to recognise some of the benefits of nuclear energy, specifically the fact that it constituted the cheapest form of low carbon energy available on the European market at the time [European Council, 2007]. Although the EU issued no binding requirements to increase the use of nuclear energy, leaving member states the choice of their energy mix and how to reduce CO2 emissions, it still published a 'Nuclear Illustrative Program' making recommendations about the possible developments in this sector and presenting best practices [Nuclear Illustrative Program, 2006].

The debate on nuclear energy and its place in the EU decarbonisation strategy was reignited in the 2010s following the Fukushima accident. There was, however, no unified policy response to the incident, which in some countries such as Germany triggered a governmental decision to shut down old-generation nuclear reactors, while in others such as the UK, did not bring about a change in the policy course to step up nuclear power generation [Ming et al., 2016]. The difference in perception has been attributed to the timing of elections (closer or further away from the accident), the depth of the media coverage of the accident (the UK was more focused at the time on Libya where its troops were engaged on the battlefield), the level of popular trust in the development of renewables (Germany was a leader in developing the technology for solar and wind power generation) and a country's historical relationship to nuclear weapons (with the anti-nuclear power campaign feeding off any existing anti-nuclear weapon movements) [Wittneben, 2012].

In the aftermaths of the Fukushima incident the EU went silent on the issue of nuclear energy as countries were wrestling with public opinion and shutting down their programs. The 2011 EU Energy Roadmap of 2050, nonetheless, recognises that nuclear energy remains in the short term a significant and irreplaceable part of the bloc's energy mix. As the countries of the EU have different positions on nuclear energy, the Union does not stipulate the target share of nuclear energy as it does for renewables. It does, meanwhile, offer safety instructions and establishes a legal framework regulating training, licensing and liability [Nuclear Power, 2023].

Nuclear energy is mostly popular with new EU members, who inherited this industry from the Soviet Union but rapidly adjusted their plants to EU requirements. France is the Western EU country that has the most consistently developed the nuclear energy sector and is by far the most reliant on it. Finland and the UK opened plants in the 1970s, and after a slowdown in the 1990s, reinvigorated their investments in the 2000s

and opened new sites in the 2010s. Sweden decided to renovate and increase the production capacity of existing sites, rather than open new ones and risk attracting excessive public attention [Jensen-Eriksen, 2022]. Italy's endeavour to return to nuclear energy after abandoning it in the 1980s was rejected after the Fukushima incident and countries which have never invested in nuclear technology such as Greece and Portugal have no serious intentions of launching nuclear energy programs [Thurner et al., 2017]. The Fukushima had the strongest impact on Germany and Switzerland, leading to a reversal of their policy course that had been aimed at reviving the industry.

Case Study of France and nuclear energy

The case study of France reveals to what extent a country which is highly dependent on nuclear electricity production is irreversibly engaged with developing nuclear energy. It attempts to explain French policy choices by situating them in a historical and political context. In 2021, 69% of the electricity consumed in France was produced with nuclear power. This level of dependence stems from the fact that the country has, unlike others in the European Union, held firm on the path of developing nuclear energy and not experienced any significant phases of policy reversal [Brouard&Guinaudeau, 2017]. France comes second globally only to the US in the number of nuclear plants it possesses, and its nuclear energy production staggeringly tripled between 1970 and 2020.

The reasons behind this nuclear emphasis are multiple and often misinterpreted. Indeed, the lack of natural resources or a bureaucratic decision-making process are definitely amongst contributing factors but cannot account fully for the nuclear choice [Baumgartner, 1990]. The argument that the nuclear question was not put to the public and was made behind closed doors can to some extent be dismissed as flawed as nuclear policy had been repeatedly subjected to parliamentary debate and France was a functional democratic state throughout this period [Schneider, 2009]. The notion that the French scientific community, fused around the Corps des Mines graduates, was tight-knit and pro-nuclear played a significant part in policy-making is accurate. It did not prevent some experts from vocally espousing anti-nuclear views, as in the case of the Commission for Independent Research and Information on Radioactivity which appeared after the Chernobyl accident and diffused critical views on nuclear energy [Topcu, 2006]. The claim that the French population was naturally more favourable to nuclear energy has been disproved by longitudinal studies of public opinion and the anti-nuclear movement in France was quite visible in the 1970s with demonstrations around the construction site of Creys-Malville. However, 'nuclear policy was not contested in Parliament until 1997 and anti-nuclear stances were kept outside the political institutions' [Brouard&Guinaudeau, 2017: 127] suggesting there was an understanding in the political elite among all parties that there was no credible advantageous alternative to the nuclear path.

France's nuclear policy began in 1945 with the creation of the Commission for Atomic Energy, a research institute dedicated to investigating the different civilian uses of nuclear energy and its potential for electricity generation but also to create nuclear

weapons to ensure French security. Developing civilian nuclear power became one of France's 'Grand Projects' during the reconstruction period after WW2 and the French national electricity company EDF became actively involved together with the Ministry of Industry and the Atomic Energy Commission [Andrews-Speed, 2022]. Strong state involvement and a centralised approach are typical political features of French projects historically, and the consensus on nuclear power linked to the idea of energy independence led to the rapid development and rollout of nuclear power stations.

The decision to develop a civilian nuclear program was approved by the Parliament in 1952 and the first nuclear plant opened in Marcoule in 1956. In 1958, De Gaulle's return to the presidency gave the country's nuclear path an extra boost and in 1972 the ambitious Messmer project made plans for the opening of thirteen new nuclear plants every two years [Rucht, 1994]. The 1970s were characterised in France by an increase in public opposition to nuclear plants and the overly ambitious Messmer plan was not fully carried out. Protests yielded few policy results and the absence of mainstream parties addressing the nuclear problem led to a vacuum of political representation of these citizen concerns. The only tangible outcome was the cancelation of the Plogoff nuclear plant in 1982, which did not otherwise lead to a reduction in the production of nuclear energy in France [Brouard &Guinaudeau, 2017[.

The 1980s witnessed a slowing down of the nuclear development plan in France. Existing plants continued to fully function. In spite of the demonstrations and a growing opposition of public opinion, nuclear energy remained a topic which commanded the political consensus of all parties during the 1970s and 1980s. During the 1990s the question was evaded as much as possible. The right-wing party, with its Gaullists roots, and the Communist party, for historical reasons leaning towards energy independence, championed the use of nuclear energy. The left-wing Socialist party, historically affiliated to trade-unions, campaigned for greater accountability of the nuclear industry but refrained from going against its development.

The anti-nuclear movement only found representation through the new Green Party from 1997 which promised in its 2007 program to completely phase out nuclear energy by 2030. Coalitions between the Greens and the Socialist Party led to the latter adopting a forceful position in condemning nuclear energy [Lee &Gloaguen, 2015]. Hence, the true politicisation of the nuclear issue took place in the 2000s but did not immediately lead to a slow-down in the pace of the development of nuclear energy in French society. A national energy debate which began in 2003 ended in a decision to relaunch the nuclear program that was paused with the Energy Law of 2005. The increase in the political debate did, however, result in the adoption of legislation to improve governance in this sector: The 2006 'Act on Transparency and Security in the Nuclear Field' which instated checks and balances by creating a Nuclear Safety Authority responsible for independently assessing the risks relayed to the nuclear industry [Andrew-Speed, 2022]. The active phase of building of nuclear plants restarted almost immediately in 2005 and lasted until 2015 when the first French law to limit the production of nuclear power was introduced. The Fukushima accident led to a reopening of the nuclear debate with the Socialists in power. The Green Growth Law of 2015 represents the first legal limitation to the production of nuclear energy and sets targets to reduce the contribution

of both fossil fuels and nuclear sources to the country's energy mix [Dreyfus &Allemand, 2018]. The law plans for the reduction of the proportion of nuclear energy to 50% and its compensation by renewables. It does not however preclude the construction of new nuclear reactors and President Macron announced in 2021 that 14 new nuclear reactors were to be built by 2050 [Chrisafis, 2022]. The French nuclear program has yet to fully set in motion its reversal as no plans for its phase-out have thus far been adopted.

Nevertheless, the nuclear energy industry is confronted with uphill challenges in France that have prompted experts and the public to question its viability. Beyond the significant risks and problems related to nuclear accidents, radioactive waste and managing public opinion, France's nuclear power industry faces organizational and financial problems. One of the first challenges is related to the roll-out of the new European Pressurized Reactor, France's third generation reactor that it planned to widely export worldwide [Zohuri, 2020]. Although it is a best practice to first build at home new reactor models and develop projects abroad only after they have been tried and tested, Areva did not have permission to open a new nuclear power station in France due to restrictions and launched its new project instead in Olkiluoto in Finland [Andrews-Speed, 2022]. The project experienced significant organizational difficulties due to a takeover of the original vendor by AREVA and a delay of over a decade [Eash-Gates et al., 2020]. The costs associated with the project skyrocketed from the initially planned 3 billion euros to 11 billion euros [Reuters, 2022]. The new nuclear reactors are being built by the French company in the UK and China, due to early commissioning, however, few new orders have come through as EDF is subjected to bad publicity. Irregularities in quality control procedures led to the shutdown of numerous stations and to widespread concerns about a lack of transparency in the monitoring process. EDF is also looking at the financial burden of dismantling 40 to 50 of its early reactors which are reaching the end of their life-cycles [Wealer et al., 2019]. An increase in the number of low-level incidents and nuclear power outages also suggests the industry is undergoing significant challenges [World Nuclear News, 2023]. The financial stability of the French nuclear industry is further challenged by the liberalisation of the French electricity market and the appearance of competitors which led to a loss of customers for EDF [Morena & Podesta, 2022]. The financial problems of both EDF and AREVA, characterised by prominent debts, have led the government to inject funds to keep the companies afloat [Andrews-Speed, 2022].

The prospects of France's nuclear power industry are further weakened by low levels of public support. The deployment of nuclear energy in France has often been linked to favourable public opinion or at least acceptance of the necessity of nuclear power stations [Brouard&Guinaudeau, 2015]. However recent studies and polls reflect not only a decline in nuclear support across all party lines but also a general unfavourable public perception of this form of power. A study of public opinion over the years 1975 to 2015 reveals that the low mood surrounding nuclear energy is not a new phenomenon and that the French public has been against it for decades, with a report testifying to 'the absence of majority support for nuclear energy among French citizens' [Brouard&Guinaudeau, 2017: 150]. This finding reveals the limited impact of public opinion on some aspects of French policy-making.

Discussion on the future of Nuclear in French and EU energy strategy

The case-study of nuclear energy in France is representative of a new reality which starkly clashes with general understandings that the nuclear industry developed based on a rational acceptance of the risks and benefits of nuclear power. The lack of majority acceptance of nuclear power did not prevent the political class from implementing it in France and making the country a world leader in the export of nuclear technologies. However, the circumstances have been changing as the country's elite has had to face off with new political parties resolutely opposed to nuclear power and recruiting significant parts of the electorate (e.g. "France Insoumise" and the greens). Although France is firmly committed to nuclear energy, the growing public opposition may lead to a policy reversal. The financial struggles faced by the major energy players EDF and AREVA and public opposition to the bailout of these companies with public money testify to the fact that the nuclear industry is not a cheap and easy option to decarbonise the economy. Although technology traditionally gets cheaper with time, nuclear power is becoming more expensive due to increased security and safety requirements and the struggles in dealing with nuclear waste. Containment building costs doubled between 1976 and 2017 according to a study carried out by MIT [Eash-Gates et al., 2020]. The carbon footprint of a nuclear plant is significant during its construction and dismantling, and the constant need for uranium for the functioning of the reactors makes nuclear power countries dependent on foreign imports (although not to the same extent as oil and gas). The exit costs of a country with nuclear path dependence are high and France's move to renewables is likely to be slower than countries that never opened nuclear facilities (e.g. Portugal) or those that renounced earlier their nuclear ambitions (e.g. Germany).

However, there are already clear signs that France has begun backtracking on nuclear projects, and that in spite of the vocal statement of political leaders, including President Macron [see Chrisafis, 2022]. The cap adopted in 2015 on the amount of energy coming from nuclear sources has already led to a reduction in the share of French nuclear electricity, and the target to have no more than 50% of electricity from nuclear origin by 2035 remains in place in spite of the hike in global energy prices. The liberalisation of the electricity market has led to the progressive development of renewables and allowed the public to prioritise companies that are green. Consumer choice is becoming an increasingly important factor in the energy industry, with smart grids allowing for the development of energy citizenry. Another factor that may increase the push-away from nuclear energy is the widening jurisdiction of local governments over energy-related issues with the long-standing tradition of centralised government projects losing ground. The 2015 French Green Growth Law offers municipalities the opportunity to develop energy projects and makes them responsible for environmental protection. By bringing energy and environmental matters closer to the electorate and the consumer, the green agenda paves the way for the denuclearisation of the energy market. Additionally, renewables are becoming cheaper options and benefit from a wide range of national and European subsidies. The problem of where to dispose of nuclear waste

is extremely controversial: while some municipalities may accept nuclear plants close by as they foster an economic revitalization, the storage of nuclear waste is highly controversial. Projects to organize permanent storage points underground caused such outrage in France than the waste remains to this day in temporary repositories near power plants.

Although traditionally the analysis of EU energy policy reflects a split between the pro-nuclear and the anti-nuclear countries, with the former presented as spearheading a strong nuclear lobby, the reality appears far more complex, with even the European leader in nuclear power, France, slowly shying away from an expensive, unpopular and environmentally-problematic form of energy. France's desire to actively participate in the creation of a European Energy Union has led to a form of compromise, by which it has slowly undertaken to exit the nuclear path. This case suggests that countries where governance is guided by popular sentiment are likely to shift away from the nuclear option with time and that often nuclear civilian power is developed by neglecting public opinion rather than with its support. Talk of a 'nuclear renaissance' is premature and France's shift away from it may have a global and European policy impact. The parts of the world inspired by France's energy independence several decades ago may change course of action as France faces the challenge of decommissioning its first generation of nuclear plants and struggles to deal with the waste materials. In the EU, France's change of heart would deprive Eastern European pro-nuclear members of a key ally and could lead to a stronger EU stance on curbing nuclear-generated power. In the short term however, nuclear energy will preserve, alongside hydrogen and other low-carbon gases, the qualification of 'transitional energy source', particularly in view of the energy shortages currently experienced in the EU.

Conclusion

Both due to its high carbon footprint compared to renewables and its dependency on depletable resources, nuclear energy appears to be a transitional remedy rather than a permanent solution to ensure stable electricity supplies to both Europe and the world. The authors argue that the nuclear industry is experiencing major challenges, both in terms of its public acceptance and its business worthiness. The French case, frequently used to illustrate the success story of nuclear power and its capacity to provide stable and independent energy supplies, testifies to the difficulties the civilian nuclear industry is facing. The French exception in Western Europe appears to result from a democratic deficit and lack of representativeness of the ruling elite rather than acceptance from the general public of nuclear power. The business model of nuclear power is facing increased difficulties as new projects cost more than planned, and old reactors require safe dismantling. Although renewables are still an immature technology and the urgency of the climate challenge requires a rapid transition away from fossil fuels, the use of nuclear energy is unlikely to ensure the most rapid path to carbon neutrality and to help avoid the point of no return beyond which the increase in temperature globally could no longer be contained. There are indications that nuclear energy will likely be phased out in the EU in the medium term, including in France where the mechanics of policy re-

versal have begun to unfold. This happens in spite of the energy crisis experienced in 2022 in the EU: while it has forced the member-states to extend the lives of coal mines and nuclear reactors, these short-term fixes are not believed to threaten the trend of nuclear reversal.

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