Juho Räsänen

The Future of the French Nuclear Industry

Metropolia University of Applied Sciences
Bachelor of Business Administration
European Business Administration
LXA20S1
5 May 2025

Abstract

Author(s):	Juho Räsänen
Title:	The Future of the French Nuclear Industry
Number of Pages:	47 pages + 7 appendices
Date:	5 May 2025
Degree:	Bachelor of Business Administration
Degree Programme:	European Business Administration
Specialisation option:	Finance & Economics
Supervisor:	Michael Keaney, Senior Lecturer

France is one of the largest nuclear energy producers and electricity exporters in the world alongside with the United States, but the nation is facing problems related to the 53 out of 57 reactors that have passed or about to pass their originally intended 40-year life cycle with a probable loss in energy production capacity which would be a tremendous setback for a nation, that produces approximately 70% of their energy in the 18 nuclear power plants in Metropolitan France. The nuclear energy power plants, including their construction, design and operation is handled by the state-owner EDF, which has been accumulating debt on the company level and facing several issues both domestically and internationally with their generation III+ nuclear reactor design EPR as all EPR projects in France, China, Finland and the United Kingdom have faced similar issues that have led to massive delays and budget overruns. The purpose of the thesis is to answer what are the options and prospects of the French nuclear program between 2025 and 2050, based on the economic, financial and political considerations. The government of France under President Macron has rather decisively chosen to continue with nuclear energy in line with the low-carbon future goals set in the Paris Agreement and as France has very few domestically available resources, nuclear energy has long been the cornerstone if not the only viable option to produce electricity on a level that is required for trading and the national grid. However, to close an energy gap that would form as a result of decommissioning all reactors which exceed a 60-year lifecycle, France will need to expand their nuclear fleet by 27 reactors with a capacity of at least 1630 MWe by 2050 on top of the planned six EPR2 reactors or begin to strategically build more SMR reactors with an excess of 91 that would support more localised energy clusters such as businesses in addition to eight reactors with a net capacity of 1630 MWe. EDF would remain financially capable of constructing a project of this scale unless the most extreme scenarios are taken into account where the annual costs would balloon up to 62 billion under proposition one and 42 billion under proposition two.

Keywords: France, Economics, Civilian Nuclear Industry, Energy

Contents

Glossary

CAREM	Central Argentina de Elementos Modulares. A small modular nuclear reactor design used in Argentina.
CEA	Commissariat à l’énergie atomique et aux énergies alternatives. A French government-funded research organisation, which provides information about issues pertaining to energy and other technological areas.
EDF	Électricité de France. A French publicly owned electricity company.
EPR	A pressurised water nuclear reactor type produced and designed by Électricité de France and Framatome. The reactor was originally known as European Pressurised Reactor then changed to Evolutionary Power Reactor, but the abbreviated form is more commonly used.
HTGR	A high-temperature gas-cooled reactor.
ITER	International Thermonuclear Experimental Reactor. World’s largest experimental tokamak reactor as of 2025 located in Saint Paul-lez-Durance, France.
LNG	Liquefied Natural Gas.
PWR	Pressurised water reactor. The most common type of reactor in the world as of 2025 using light-water cooling technology.
SA	Société anonyme. A French designation of a company type, which is comparable to the limited company in the United Kingdom.
SMR	Small Modular Reactor.
TVO	Teollisuuden Voima. A Finnish electricity utility.

UNGG	Uranium Naturel Graphite Gaz. UNGG reactors were an early form of nuclear reactor design developed in France using gas-cooling technology instead of light-water cooling.
USNCR	United States Nuclear Regulatory Commission.
WEST	W Environment in Steady-state Tokamak. An experimental tokamak reactor operated by the CEA in Cadarache, France.

1 Introduction

France is the second largest producer of nuclear energy in the world, behind the United States of America, and it has the largest proportion of energy produced per capita alongside with the highest portion of the energy mix produced via nuclear power in the world at 65% in 2025, produced at 57 pressurised water reactors or PWRs across 18 sites across France (World Nuclear Association 2025a). France is also the largest net exporter of electricity in the world, yielding approximately six billion euros per year to the trade balance, which makes it vitally important for the French government in addition to granting a high degree of energy independence (World Nuclear Association 2025a; Orano 2022). The nuclear industry is the third largest industry overall in France, only behind the automotive and aerospace industries, with around 400 000 people working within both public and private sectors (Orano 2022).

However, the civilian nuclear fleet is facing several problems. 31 reactors have exceeded the originally planned lifeline of 40 years in 2025, which has led the government to extend the life cycle up to 60 years. Nevertheless, the older reactors have faced problems related to corrosion, in addition to requiring retrofits which have led to more expenses, energy shortages and hindrances to energy exports at a time when the French government is combating against an ever increasing public debt by cutting around 40 to 50 billion euros of expenses in 2026 (Lough & Mallet 2022; Dumoulin & Loignon 2025; World Nuclear Association 2025a). Simultaneously, only one new reactor has been built since the Chernobyl nuclear disaster in 1986, excluding the reactors that were being constructed at the time. The newly built EPR type reactor at the Flamanville nuclear power plant faced several budget overruns and delays before being completed in 2024 after nearly 17 years, casting doubts over the viability of modern nuclear reactors. Nevertheless, preparations to start building six new reactors were announced in 2022 with the first set to be completed in 2035.

At the same time, the United Nations (2015: 3) Paris Agreement signatories have committed to lower carbon emission levels that would limit the increase of the global temperatures below 2ºC and a rift has formed between many of the signatories and France, as the latter has been trying to push the categorisation of nuclear energy to be included in the green energy transition plans alongside hydrogen and other renewable energy sources (Szarka 2013: 647; IAEA 2016: 7; Abnett 2023; Abnett & Gray 2023). France sees itself tied to nuclear energy with few domestically available natural resources, while the renewable energy alternatives are argued to be too insufficient to fill the energy gap that would form without nuclear reactors (Birraux 1999; Broomby 2014).

Geopolitical changes have significantly changed the outlook for nuclear energy in France. The nuclear accident at the Fukushima nuclear power plant in 2011 had led many countries including France to reconsider their position regarding nuclear energy, with some countries starting to phase-out from nuclear energy, but the Russian invasion of Ukraine in 2022 as the world was beginning to recover from the economic downturn caused by the Covid-19 pandemic resulted in significant increases to energy prices. Countries such as Germany, which had begun to phase-out from nuclear energy in favour of other forms of energy production including energy imports from Russia, began to suffer from major energy outages. The United States government under the Biden presidency aimed to increase the LNG deliveries to the European Union by 50 billion cubic metres a year at least until 2030 in order to reduce Europe’s dependency on Russian fossil fuels and increase dependency on American energy exports (von der Leyen & Biden 2022). This strategy was continued with a different approach under the Trump presidency when the United States government set tariffs on the European Union in April 2025, accompanied with demands on the members of the European Union to increase energy imports from the United States to close the assumed 350 billion trade deficit, which has led many nations to look for other options (Hernandez et al. 2025; Hodgson 2025). All these changes have led to a situation where more countries in Europe are more likely to start to rely on France for their energy needs, adding to the urgency to address the issues concerning the nuclear fleet.

While it is generally perceived that France has a high level of energy security at least in terms of production, this becomes more arguable regarding the supply lines as France is solely reliant on foreign imports of uranium for the fuel used in the reactors, with an average imported amount of around 8157 tonnes of uranium per year between 2012 and 2022 (Maad 2023). The potential vulnerability was highlighted in 2023 as a result of the military coup in Niger, which has led to uncertainty over the supply line security of French nuclear reactors and energy production, as Niger has provided around 20% of the total amount of imported uranium since 2012 (Maad 2023; Schwikowski 2023). The three mines in Niger where the uranium is produced are operated by the majority French state-owned company Orano, but the coup itself was fuelled at least in part by anti-French sentiments, specifically aiming to destabilise French energy production. Similar concerns have been raised over a Greenpeace report which shows that France continues to rely on Russia for the transport of imported uranium from Kazakhstan and Uzbekistan, which provided 50,2% of the total imported uranium to France in 2022 (Greenpeace 2023; Maad 2023; Mouterde & Cessac 2023). Amid rising tensions between Russia and France over Ukraine and military security in Europe, this is a potential weakness specifically affecting France due to the high ratio of energy dependence on nuclear reactors.

All things considered, as the French government is seemingly keen to continue investing in nuclear technology for their energy needs, the nation will have to make many hard decisions for their current and future nuclear fleet to stay competitive, keep up with the increasing energy demands and remain self-sufficient.

1.1 Research Area

The research area is limited to the political ramifications, both historical and present, and the economic and financial aspects of the civilian nuclear industry as part of the energy mix in France. The main research area is limited to the policies, production, construction, maintenance and procurement regarding the civilian nuclear industry, but military use is also referred to where necessary, due to the interconnectedness of the military and civilian use of nuclear technology in France. The cost, financing and the economic benefits generated by the nuclear fleet are considered, but environmental impact, nuclear waste management, fuel-supply lines, logistics and economic impact on the consumer are not part of the research area unless they are directly linked to the policies or cost-benefit considerations. The central focus of this thesis is on the French civilian nuclear fleet, but data and studies regarding other nations are also used if applicable to the situation in France. This also applies to international politics which have directly influenced the policy making decision in France.

1.2 Purpose of the Thesis

The purpose of the thesis is to answer what are the future prospects and strategic options concerning nuclear energy in France based on economic, financial and political considerations. More specifically, analysis regarding the present and future nuclear fleets and the requirements for the implementation of the strategic options will be provided, which in turn will help to estimate the financial and economic feasibility of the nuclear program in France.

The issue of the French nuclear fleet is its feasibility, whether it can be supported in the long-term as the expenses are increasing and construction projects are becoming more complex. The focus of the thesis is to answer the following questions:

- Research Question One: What Options Are Available?

- Research Question Two: How Can the Options Be Achieved in Terms of Costs in Relation to the Economic Situation of EDF?

- And Research Question Three: Is the Civilian Nuclear Program in France Feasible?

An appraisal to answer these qustions will be done via an audit, where the demand and production of electricity are first determined to understand any deficits or surpluses that may occur from the decision that are made from the sociopolitical standpoint. These are analysed using the collected quantitative data, which is also compared with the qualitative data based on the literature review.

1.3 Acknowledgements

The scope of the thesis is limited in its approach as it does not address some of the environmental, socio-, micro- and macroeconomic considerations including the costs from nuclear energy compared to other forms of energy production, consumer pricing, logistics, workforce and fuel procurement.

Due to the geopolitical and socioeconomic changes since 2019, many of the studies made before this point contain estimates and projections that are less reliable. For example, this affects a study by Malischek and Trüby (2016) that calculated the estimates and modelled the phase-out timeline assuming that decision could be taken every five-year interval based on the legislative election years, with 2035 selected as the year after which a decision for phase-out could no longer be taken. However, the National Assembly has since approved the construction of six new reactors with the first set to start in 2027 and finish in 2035. The legislative snap elections in 2024 following President Macron's decision to dissolve the National Assembly since the publication of this study have likely had at least a minor impact on its current relevance.

The thesis will only consider the fission reactors that are currently in use or in development in France and therefore, fusion reactors are excluded. The International Thermonuclear Experimental Reactor or ITER is the world's largest tokamak fusion reactor under construction in Saint Paul-lez-Durance, France as an international cooperative project between 35 countries that is intended mainly for scientific use but also create a blueprint for a commercially viable fusion reactor that could theoretically generate 500 MWe of fusion power

(Seife 2023; ITER 2025a; ITER 2025b). The reactor is being constructed by the European Union, which carries 45,6% of the construction costs and the rest is divided evenly among People's Republic of China, Republic of India, Japan, Republic of Korea, the Russian Federation and the United States of America, but while the construction was started in 2006 with an estimated build time of ten years and a budget of five billion euros, the project has faced similar budget overruns and delays as EDF's EPR projects as the costs were estimated to have accumulated to over 20 billion euros by 2023 and operations will not begin before 2039 according to the revised timetable released in January 2025 (Seife 2023; Turner 2024; ITER 2025a; ITER 2025c; Stanway 2025). However, CEA's WEST Tokamak reactor located in Cadarache, France set a record on 12 February 2025 when the plasma was sustained for 1 337 seconds in the reactor, which was seen as a significant step forward in fusion technology and understanding the requirements for reactor cooling (Lea 2025; Szondy 2025). It can be argued that if the construction costs for fusion reactors can be reduced to a similar level as for fission reactors and if a comparative power output can be achieved reliably, France, among many other nations, is likely to promptly commence a large-scale construction project to replace the fission reactors with fusion power as the benefits of clean and virtually limitless power would effectively render the fission reactors obsolete (McGrath 2024; Lea 2025). While fusion reactors are a promising concept for the future, technologically they exist on a purely experimental level for energy production in 2025 and unlikely to be ready to be deployed on an industrial scale for 2050 with costs and construction times that far exceed conventional fission reactors, which is why fusion is excluded as a viable option in relation to this thesis (Seife 2023; Stanway 2025).

2 Literature Review

2.1 Historical Context of the French Nuclear Industry

Before 1973 France had only nine UNGG reactors, one HTGR, one PWR and two experimental reactors and while the development of nuclear energy technology remained relatively even with other forms of energy production, France relied heavily on imported oil for the energy production needs of the nation and the portion of nuclear energy was comparatively low in the energy mix (Reuss 2007: 40; Le Gros 2020; World Nuclear Association 2025b). The Yom Kippur war started on 25 October 1973 between Israel and a coalition of Arab states, which caused a sharp increase of 400% in global oil prices between June 1973 and January 1974, hitting countries like France hardest as their energy production relied overwhelmingly on foreign oil imports from the Middle East (Le Gros 2020; Mangeon 2024). The annual oil costs in France increased by 346% from 15 billion francs in 1972 (approximately 17,08 billion euros in 2024, inflation adjusted) to 52 billion francs in 1974 (approximately 47,66 billion euros in 2024, inflation adjusted), which also resulted in a severe overall economic downturn with the inflation reaching 14% in 1974 causing an impairment in the value of the franc, and further impacting the global buying power of the nation (Le Van-Lemesle 2004: 88; Le Gros 2020; Insee 2025).

A response to the crisis came on 6 March 1974 in the form of the Messmer plan, an ambitious project to construct six to seven new reactors per year for a total capacity of 13 000 MWe to end France’s energy production reliance on foreign imports (Le Gros 2020; Mangeon 2024). The success of the plan is generally credited to design standardisation, large number of domestic, readily-available and well-trained engineers, strict quality- and cost-control, state-controlled centralised decision-making, and scale, but it is worth noting that other countries were also building nuclear reactors in large numbers parallel to the French nuclear program between 1960-1980, which kept the construction costs more balanced with a sustained demand of supplies on the global level, but until very recently, France was virtually the only country planning on a large-scale construction project of new reactors (Reuss 2007: 68; Grubler 2010: 5177-5178, 5185; Szarka 2013: 651; Malischek & Truby 2016: 909; Le Gros 2020; IEA 2025a). The total costs of the nuclear program in France between 1970 and 2000 are estimated to have been 1 505 to 1 643 billion francs (based on the value of the franc in 1998, which converts to approximately 351,55 to 383,78 billion euros in 2024, inflation adjusted), but politically the attitudes towards the costs of the nuclear program have been criticised to have been implemented by any means and costs necessary (Grubler 2010: 5179; Mangeon 2024; Insee 2025). After the Three Mile Island incident in 1979 and especially after the Chernobyl nuclear disaster in 1986, no new reactors were commissioned in France until 2007 aside from those which had been previously approved, leaving the French energy production heavily relying on a large number of older nuclear reactors build with almost no replacements as other forms of energy production have been deemed unviable, and left underdeveloped and underinvested as a result (Birraux 1999; Broomby 2014; Malischek & Trüby 2016: 909).

2.2 Current Situation & Recent Changes

In 2022 President Emmanuel Macron revealed plans to build six new nuclear reactors based on the improved EPR reactor model titled EPR2 at an estimated total cost of 52 billion euros, with the first reactor becoming operational by 2035. Meanwhile, studies for an additional eight reactors were announced during a speech at the Belfort GE nuclear reactor turbine plant on 10 February 2022 (Lough & Mallet 2022). Simultaneously it was announced that there were plans to extend the lifeline of the older reactors of the fleet from 40 years to more than 50 years, which would affect 31 reactors in 2025 based on the date of the first grid connection, as shown on Table 1 (Lough & Mallet 2022; World Nuclear Association 2025a). These changes seemed to indicate a significant policy reversal from the President and a long-term commitment to nuclear energy, as Macron had formerly followed the goals of the previous government to reduce the portion of nuclear energy in the energy mix from 70% to 50%, albeit by first issuing a delay in 2019 to change the target year for the reduction from 2025 to 2035 and finally withdrawing from any commitments to reduce the ratio in 2023 (Lough & Mallet 2022; World Nuclear Association 2025a).

Table 1. A table listing all of the reactors of the nuclear fleet in 2025, the model, net capacity in MWe, the date of first grid connection and the years in use in 2025 and 2035. Reactors that have passed the 40-year lifeline in 2025 are highlighted in blue and the reactors that will pass the 40-year mark in 2035 are highlighted in orange (World Nuclear Association 2025b).

#	Reactor Name	Model	Net Capacity (MWe)	First Grid Connection	Years in use in 2025	Years in use in 2035
1	Belleville 1	P4 REP 1300	1310	14/10/1987	37	47
2	Belleville 2	P4 REP 1300	1310	06/07/1988	37	47
3	Blayais 1	CP1	910	12/06/1981	44	54
4	Blayais 2	CP1	910	17/07/1982	42	52
5	Blayais 3	CP1	910	17/08/1983	41	51
6	Blayais 4	CP1	910	16/05/1983	42	52
7	Bugey 2	CP0	910	10/05/1978	47	57
8	Bugey 3	CP0	910	21/09/1978	46	56
9	Bugey 4	CP0	880	08/03/1979	46	56
10	Bugey 5	CP0	880	31/07/1979	45	55
11	Cattenom 1	P4 REP 1300	1300	13/11/1986	38	48
12	Cattenom 2	P4 REP 1300	1300	17/09/1987	37	47
13	Cattenom 3	P4 REP 1300	1300	06/07/1990	35	45
14	Cattenom 4	P4 REP 1300	1300	27/05/1991	34	44
15	Chinon B 1	CP2	905	30/11/1982	42	52
16	Chinon B 2	CP2	905	29/11/1983	41	51
17	Chinon B 3	CP2	905	20/10/1986	38	48
18	Chinon B 4	CP2	905	14/11/1987	37	47
19	Chooz B 1	N4 REP 1450	1500	30/08/1996	28	38
20	Chooz B 2	N4 REP 1450	1500	10/04/1997	28	38
21	Civaux 1	N4 REP 1450	1495	24/12/1997	27	37
22	Civaux 2	N4 REP 1450	1495	24/12/1999	25	35
23	Cruas 1	CP2	915	29/04/1983	42	52
24	Cruas 2	CP2	915	06/09/1984	40	50
25	Cruas 3	CP2	915	14/05/1984	41	51
26	Cruas 4	CP2	915	27/10/1984	40	50
27	Dampierre 1	CP1	890	23/03/1980	45	55
28	Dampierre 2	CP1	890	10/12/1980	44	54
29	Dampierre 3	CP1	890	30/01/1981	44	54
30	Dampierre 4	CP1	890	18/08/1981	43	53
31	Flamanville 1	P4 REP 1300	1330	04/12/1985	39	49
32	Flamanville 2	P4 REP 1300	1330	18/07/1986	38	48
33	Flamanville 3	EPR	1630	21/12/2024	0	10
34	Golfech 1	P4 REP 1300	1310	07/06/1990	35	45
35	Golfech 2	P4 REP 1300	1310	18/06/1993	32	42
36	Gravelines 1	CP1	910	13/03/1980	45	55
37	Gravelines 2	CP1	910	26/08/1980	44	54
38	Gravelines 3	CP1	910	12/12/1980	44	54
39	Gravelines 4	CP1	910	14/06/1981	44	54
40	Gravelines 5	CP1	910	28/08/1984	40	50
41	Gravelines 6	CP1	910	01/08/1985	39	49
42	Nogent 1	P4 REP 1300	1310	21/10/1987	37	47
43	Nogent 2	P4 REP 1300	1310	14/12/1988	36	46
44	Paluel 1	P4 REP 1300	1330	22/06/1984	41	51
45	Paluel 2	P4 REP 1300	1330	14/09/1984	40	50
46	Paluel 3	P4 REP 1300	1330	30/09/1985	39	49
47	Paluel 4	P4 REP 1300	1330	11/04/1986	39	49
48	Penly 1	P4 REP 1300	1330	04/05/1990	35	45
49	Penly 2	P4 REP 1300	1330	04/02/1992	33	43
50	St. Alban 1	P4 REP 1300	1335	30/08/1985	39	49
51	St. Alban 2	P4 REP 1301	1335	03/07/1986	39	49
52	St. Laurent 1	CP2	915	21/01/1981	44	54
53	St. Laurent 2	CP2	915	01/06/1981	44	54
54	Tricastin 1	CP1	915	31/05/1980	45	55
55	Tricastin 2	CP2	915	07/08/1980	44	54
56	Tricastin 3	CP3	915	10/02/1981	44	54
57	Tricastin 4	CP4	915	12/06/1981	44	54

As of 2025, France has a total of 57 reactors in operation over 18 sites for a net capacity of 63 000 MWe after the Flamanville reactor number three was connected to the grid in 2024 and starting energy production during the first quarter of 2025, becoming the most powerful and the first new reactor since the addition of Civaux reactor two in 1999 (World Nuclear Association 2025a).

2.3 Électricité de France

Électricité de France SA or EDF (2025a) is a French electric utility formed in 1946 responsible for the construction, development and operation of all the nuclear reactors inside France, but the company is also a major international energy provider and producer with 41,5 million customers globally and an annual turnover of 118,7 billion euros as of 2024 (Forbes 2025). The state-owned company was widely credited for the success during the Messmer plan and the following buildup of the nuclear fleet as Grubler (2010: 5177-5178) argues that the relation and the direct control of EDF by the French government nullified the negative effects from principal-agent asymmetry that heavily plagued the nuclear effort in the United States, further exemplified by the efficiency deterioration during the latter parts of the nuclear construction process in the late 1970’s when Areva, which was reorganized in 2018 under two majority-state-owned companies Framatome and Orano, became more involved in the reactor design process starting with the P4 reactor resulting in growing distance between the governance asymmetry (Le Billon 2018; Wakim 2018). EDF has maintained a strong presence also outside France as an energy producer and provider with a strong emphasis especially on nuclear power, which has included EPR construction projects in the United Kingdom at Hinkley Point, in Olkiluoto, Finland and at the Taishan nuclear power plant in China.

The company has been under state ownership since its creation until 2004, when the around 15% of the ownership was made publicly available for trading, but Prime Minister Élisabeth Borne announced on 6 July 2022 that the French state has decided to fully nationalise EDF to increase the French energy security in response to the War in Ukraine that had caused problems and concerns in Europe. Many countries, Germany in particular, had been reliant on Russia for their energy needs, but this was also done as a response to the rising energy prices in Europe triggered by the war (Le Monde 2022; Rosemain & Thomas 2022; Martuscelli et al. 2024; European Council 2025). The state already had an 83.7% ownership of the company at the time of the announcement with 15,3% made available to private investors and individuals while the remaining 1% was held by the employees of the company, but the government officials argued that in addition to improved energy security, the move would allow the company to better commit to long-term projects, lower the cost of financing and remove the volatility caused by public trading of equities (Mallet 2021; Le Monde 2022; Mallet & Thomas 2022). The ownership of EDF was consolidated by the state on 31 July 2023 pending court decision, with the process finalised on 1 January 2024 following a reported 9,7-billion-euro buyout of all publicly traded shares and bonds at a considerable premium of 53% based on the closing price on 5 July 2022 (Rosemain & Thomas 2022; EDF 2023; Honney 2023). EDF is a completely state-owned utility as of 2025 and the investment structure in any of the future projects is solely reliant on the government and the company itself.

Aside from the unusual year of 2022 when EDF Group had losses of 17,940 billion, the company has been profitable with 5,1 billion in 2019, 650 million in 2020, 5,1 billion in 2021, 10 billion in 2023 and 11,4 billion in 2024, but the organisation has been struggling with debt partly resulting from the maintenance projects for the older reactors, cost overruns of the Flamanville reactor number three and the government set energy cost ceiling in 2022 as part of the measures to combat against rising inflation rates (EDF 2021: 5; EDF 2022a: 2; Hummel & Thomas 2022; EDF 2025b: 13). EDF (2022a: 4) took a one-billion-euro loan in November 2022 to address maintenance works regarding the reactor lifecycle extension beyond 40-years, which added to the debt, which reached 71,05 billion euros for non-current financial liabilities in 2022, a 25,67% increase from 2021 (World Nuclear Association 2025a). The debt was at its highest in 2022 at 64,5 billion euros and still a significant portion of 54,3 billion euros remain after 2024, while the government is trying to make cuts to public spending (EDF 2024a: 13; EDF 2025b: 11). EDF (2024a: 33) estimates that the total expenses would be close to 33 billion euros between 2022 and 2028 and during this time the company is conducting inspections and studies for both 900 and 1300 MWe reactors related to lifetime extension from 40 to 50 years as part of the Grand Carénage programme started in 2016.

The EBITDA of the company has remained rather stable over a ten-year period between 2015 and 2024 with an average value of 18,538 billion euros, except for 2022, 2023 and 2024 as shown on Figure 1.

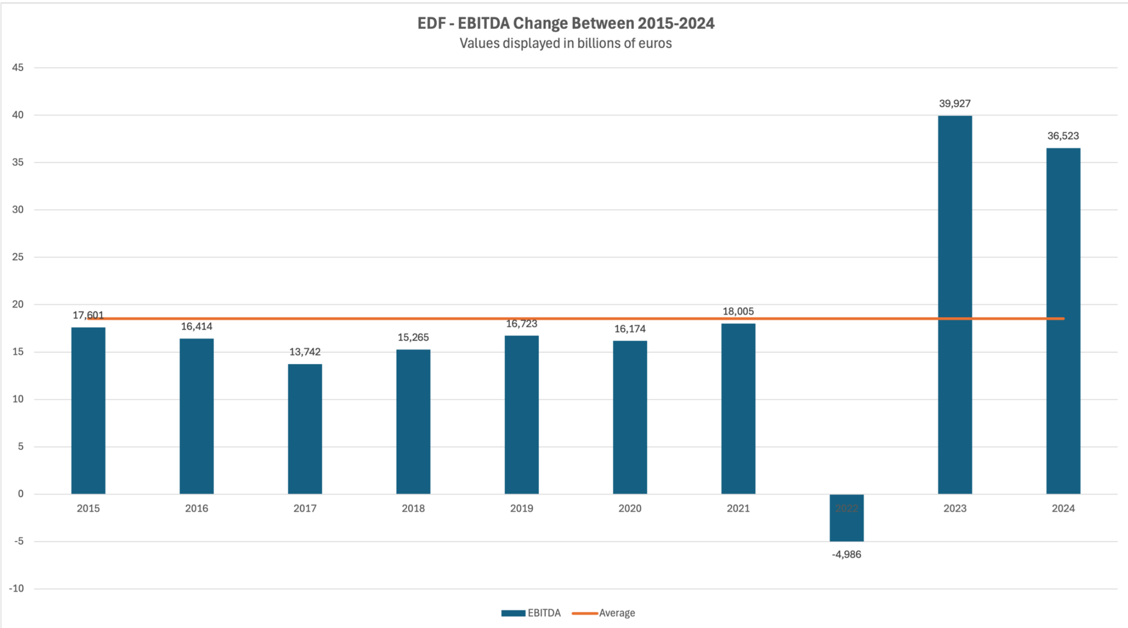

Figure 1. EDF’s EBITDA changes between 2015 and 2024 with the values displayed in billions of euros (EDF 2017: 12; EDF 2019: 12; EDF 2021: 5; EDF 2022a: 2; EDF 2025b: 47).

Before 2022, the largest change to the company’s EBITDA happened in 2017, when the value changed by minus 22% and then again in the following year by minus 13%, but otherwise the EBITDA did not change by more than 8% between 2015 and 2021 when compared to 2015. The stress corrosion and other issues in 2022 drove the EBITDA into the negative, but the EBITDA grew considerably in 2023 and remained on a comparative level in 2024 due to the overall revenue growth from the elevated consumer prices in France and increased energy exports to other countries in Europe, but also from lower operational costs (EDF 2024a: 16, 71).

2.3.1 Stress Corrosion Issues in 2021

Stress corrosion was found near the welds of the safety injection system at the Civaux reactor one in the late 2021, after which the whole fleet was inspected for similar issues and revealing corrosion problems with eleven other reactors, which prompted EDF to shut down all but 32 reactors in 2022 during a period which saw rising energy prices as a result of the War in Ukraine and as the power output capacity was drastically reduced, France was forced to import electricity from other countries in Europe while simultaneously suffering a dent to the lucrative energy export deals to the detriment of the beleaguered EDF (Mallet 2022; News Wires 2022; Pécout 2022; World Nuclear News 2022; World Nuclear Association 2025a). While the reason for the corrosion problem is unknown, it has been suggested that the changes made to the Westinghouse reactor design to create the more indigenous P4 model reactor in the 1980's have made them more susceptible to corrosion as they are the only ones affected (Bartak & Camarcat 2022; Mallet 2022; Murray 2023). EDF (2022a: 2, 56) reported losses of 22,916 billion on EBIT in 2022 compared to a positive result of 5,585 billion a year before, where the corrosion issues were a major contributor for the sudden downturn (Pécout 2022). EDF (2024a: 33) estimated that a total of 1,2 billion euros will be used to cover the work expenses between 2022 and 2025 in relation to the stress corrosion issues of which approximately 0,9 billion was used in 2023.

2.4 Market Position of Nuclear Energy

Nuclear energy makes about 10% of the world's total energy production output and according to the IEA (2025a) the total production capacity will increase by 204% from 427,6 GWe in 2025 to 874,2 GWe in 2050 with over 40 countries looking for expansion in their nuclear capacity and especially China, which would produce approximately 31,7% of the world's nuclear energy by 2050.

Many European nations are still more hesitant to start rebuilding their nuclear fleets and have instead preferred renewable energy sources in line with the goals set in the Paris agreement and European Union green energy initiatives, but France has staunchly maintained a position to continue with nuclear power as the main source of energy production.

France was in a unique position at the start of the 2000s when it was the first country to start building a new nuclear reactor after the 1986 Chernobyl nuclear accident and simultaneously the only country with a new type of reactor model in EPR that could be exported also to other countries, as no other nation was planning to expand the portion of nuclear in their energy mix. The reactor received interest in several other countries, of which Finland, China and the United Kingdom decided to procure EPR reactors directly from EDF. As such France had close to a monopoly position in the global nuclear reactor building business, beginning a revitalised interest in nuclear energy internationally and a commercialisation opportunity for EDF. However, the interest for the EPRs have vaned significantly especially after both Olkiluoto reactor three and Flamanville reactor three construction projects were riddled with delays and budget overruns that virtually have ended all aspirations for nuclear expansion internationally under the EPR design.

Before the Fukushima nuclear accident in March 2011, the interest for nuclear energy was increasing noticeably as is exemplified by the fact that starting in 2007, the United States Nuclear Regulatory Commission or USNRC had received a total of 17 licence applications for the planned expansion of 24 reactors, partially fuelled by the increased costs for natural gas and the proposed government subsidies for nuclear expansion (Davis 2012: 49). Several countries around the world, including Belgium and Germany in Europe, began a process of phasing-out nuclear energy from the energy mix as a direct response to the accident and replacing the deficit via other energy production sources, especially Germany, who started to rely more on natural gas sourced from Russia, but Germany has had to reconsider its options after the war in Ukraine began in 2022 and the suspected sabotage of the Nordstream pipeline between the two countries severed the German energy production capacity, raising questions over the energy security and political implications for relying on foreign powers. Simultaneously, the energy demand has increased and is projected to continue to increase due to technological developments especially related to high electricity consumption capacity needed for artificial intelligence and other energy intensive computational technology. For example, Microsoft has confirmed a purchase of the previously closed Three Mile Island nuclear power plant in Pennsylvania to be recommissioned by 2028 to accommodate the increasing energy demands for the company’s data centres (Filippone 2024; Wajsbrot 2024). The two PWR units of the power plant were previously owned by Exelon Generation LLC, with unit two having been shut down since the nuclear accident in 1979 and unit one being decommissioned in 2019 due to economic reasons, but in the face of the ever-growing energy needs, the low operation costs for high energy output from nuclear energy to accommodate these needs is likely to become more acceptable and economically viable solution in the future (Crownhart 2024; Filippone 2024; Wajsbrot 2024; USNRC 2025).

The main source of costs in nuclear energy is the construction of the reactors and the power plant itself, while the operational and supply costs remain relatively low. The estimate for the annual expenditures was approximately 0,16 francs per kWh in 1998, which would be 0,04 euros in 2024 with the inflation adjusted and 0,0741 euros per kWh in 2050 based on the France’s nominal interest rate of 2,4% as of 17 April 2025 (Grubler 2010: 5179; Insee 2025; Trading Economics 2025). The fundamental problem with nuclear energy in energy production is that it is not well suited for load-following and as such will run at a certain capacity when online, while it is unable to react to sudden spikes in demand or decrease the levels at when there is less demand.

2.5 The Old Fleet

2.5.1 Decommissioning Older Reactors

All power production plants have a limited life cycle regardless of the fuel source at which point they need to be decommissioned, which will include the breakdown of the plant and clean-up of the site and especially with nuclear power plants this will include decontaminating the earth for any radioactive exposure. Nuclear plants specifically have a life cycle of around 30 years for the older generation reactors and the newer ones are generally built to last for 40 to 60 years, after which point they are generally no longer deemed economically viable as was the case with the Three Mile Island Unit One in 2019 having had a life cycle of 45 years (World Nuclear Association 2022; Filippone 2024). France is in a somewhat unique situation in this regard as unlike in many other countries where the nuclear plants are operated by privatised companies, the state-owned EDF operating the plants means that while the company itself tries to remain profitable, the government can theoretically direct EDF to keep the reactors running beyond the point of profitability if that is required to maintain a certain national level of electricity production, especially when the replacing energy production facilities are not ready to cover the energy gap that would form as a result of decommissioning, and at that point they can be kept online as long as the reactors are deemed safe to operate.

Fessenheim nuclear power plant with two CP0 reactors, which was shut down on 29 June 2020 after over 42 years of service, is the best source for the cost estimation in relation to the decommissioning as 26 reactors currently in use have either the same design or the updated version of CP1 or CP2 (World Nuclear Association 2025b). The decommissioning itself was decided as a result of policies to decrease the share of nuclear energy to 50% of the energy mix under the Hollande presidency, a plan which was continued under President Macron’s first term in office and prepared in the wake of the expected completion of the Flamanville reactor three in 2022, but the economic feasibility of the plant was also questioned under the inquiry commission of the National

Assembly (Brottes & Baupin 2014; Day 2020). The decommissioning of the plant is planned in four stages starting with electromechanical dismantling and ending with site rehabilitation, estimated take a total of 15 years to complete at the cost of 350 to 500 million euros per reactor according to EDF, based on the previous experiences with the Chooz A reactor decommissioned in 1991, which would put the price of decommissioning at between 397 727 and 568 182 euros per net MWe installed (Day 2020; World Nuclear Association 2025b). This estimate is significantly lower than the estimate of 900 million to 1,3 billion euros per reactor provided by other European operators (Day 2020).

2.5.2 Maintenance & Retrofits

After the Fukushima nuclear accident in 2011 and the subsequent political implication in many European countries to phase-out nuclear power, some suggestions and estimates were also made for a phase-out in France. Considering that France is the nation with the fourth largest nuclear arsenal in the world based on the number of warheads and the renewed interest for civilian nuclear energy around the world, it is rather unlikely that any French government is willing to discontinue the civilian nuclear program completely, but the estimates from studies for phase-out made at the time can aid understanding the costs in relation to decommissioning the older reactors (ICAN 2025; IEA 2025a).

Maïzi and Assoumou (2014: 853) created three scenarios for phasing-out the old reactors where fast exit scenario would limit the lifecycle of the reactor to 40 years and production from nuclear sources would cease between 2042 and 2043, while the progressive scenario would offer a lifeline extension to 60 years for every second reactor at an estimated cost of 600 million euros per reactor or a total cost of 15,6 billion euros for 26 reactors and the third option would allow maintaining the nuclear capacity at 65 GWe for 60 years, which would increase the total cost to 31,2 billion euros for 52 reactors, but the phase-out process could reach a maximum of 78 billion euros over a period of 20 set for the decommissioning process (Malischek & Trüby 2016: 910). The costs per reactor would pertain the maintenance of the reactors and the required retrofits for the extended period past the originally intended 40 years. However, as technologies develop over time and more resources are assigned to nuclear research globally to make the old reactors more efficient and cost effective with upgrades, it is possible that the reactor life cycle can be extended even past 60 years, but 60 years is considered to be the outer lifetime limit along with the cost estimates associated to the 20 year extension in regards to this thesis based on the available information in 2025.

2.6 The New Fleet

2.6.1 EPR & EPR2

Flamanville reactor number three was the first nuclear reactor construction project to start in France in over 16 years since the Civaux reactor number two in 1991. The reactor was based on the new EPR design with a net capacity of 1630 MWe and with an initial budget of 3,3 billion euros, the construction was set to begin in 2007 with an estimated build time of 56 months (Nuclear News 2024). However, the reactor saw the first grid connection only in December 2024, twelve years behind the schedule and an estimated 13 billion euros assigned to the project as announced by EDF, but this account has been challenged by Cour des comptes, France’s national institution performing audits, which estimated that the costs would have been as high as 19,1 billion euros already in 2020, more than four years before the first grid connection (Wakim & Mouterde 2020; RFI 2024). Several reasons have been presented to explain the issues, where the quality of both the work and materials are given as the primary faults in the project, but Ruuska et al. (2011: 648) further define these to lapses in governance further exacerbated by the extended period of inactivity in the reactor construction industry, which is argued to have left a skill gap in the workforce required specifically for nuclear projects (Ursat 2020: 133; Wakim & Mouterde 2020).

Olkiluoto nuclear power plant reactor three is identical to the EPR in Flamanville, but it was developed by Areva and a German electronics company Siemens and built by EDF, which began the construction in 2005 with an original estimated budget of 3,2 billion euros and a construction time of around four years, however in a similar fashion to the reactor three in Flamanville, the project faced many delays and budget overruns with the first grid connection only in March 2022 and starting commercial production a year later in May 2023, around 13 years behind the original timetable (Le Monde & AFP 2023; Le Gros 2024). While the reasons for delays have some similarities to those at Flamanville in relation to problems with the workforce, technical issues and materials, the relationship between Teollisuuden Voima or TVO, Areva and Siemens has been strained during the project as both sides seemed to pass the responsibility to the other, while Areva and Siemens agreed to pay compensation worth 450 million euros to TVO in 2018, casting doubt over the failures of multi-firm governance in large scale projects as was similarly highlighted by Grubler (2010: 5178) over the increasing costs and longer construction times when Areva entered the project and increasing the level of principal-agent asymmetry during the 1970's (Ruuska et al. 2011: 652; Digges 2013; Honney 2022; Rogers 2022). The financial viability has been questioned several times during the process and final cost has been estimated to be around 11 billion euros, which is speculated to have left TVO with a decision to not apply for a licence for a fourth reactor at Olkiluoto (Digges 2013; Ercanbrack 2015; Yle News 2022).

Other EPR projects include two reactors at Taishan with slightly larger net capacity of 1660 MWe each, were the first EPR to come online with Unit One connected to the grid in 2018 and Unit Two in 2019 with an initially planned construction time of 46 months starting in 2009 and 2010 respectively seeing a budget overrun of around 160%, and two EPR reactors similar to those at Flamanville and Olkiluoto constructed at Hinkley Point C nuclear reactor in Somerset, England with the construction starting in 2017 (Ng 2018; IAEA 2020a; IAEA 2020b; La Rédaction 2024). The reactor design for Hinkley Point C was slightly modified based on the experiences gained from the other three projects aimed to provide a faster installation, but the construction has faced several problems both at the construction site similar to the others, but Covid-19 pandemic also slowed down the progress in addition to the political implications from the United Kingdom decision to leave the European Union in 2020 and the reactors are now projected to be completed between 2029 and 2031 with significant budget overruns that would equal to 15,5 to 17 billion pounds per reactor or 172% to 188% over the original budget (Department for Business, Energy & Industrial Strategy 2016; BBC 2022; EDF 2022b; EDF 2024b).

EPR2 design was started in 2017 after it became evident that the EPR is not economically feasible in its current state in addition for not being well-suited for a fast construction pace needed for a nuclear scaleup generally or needed as a replacement for the older reactors in France specifically, and additional studies were made based on the Folz (2019: 14, 20-21) report, which further outlined the problems related to the EPR design and EDF's overall nuclear reactor construction process including unrealistic cost estimates, organisational hindrances pertaining to engineering and insufficient studies made in regards to the reactor design. In addition to the faster construction times of 96,5 months per reactor on average, with the first one to be estimated to take 104,5 months and the sixth reactor to be completed in 89,5 months, the EPR2 design would also offer upgraded safety features and simplified containment structure, which became possible after abandoning an option from the original EPR design to operate the reactor at full power simultaneously while conducting maintenance duties (IAEA 2020; Thomas 2025). Six EPR2 reactors have been announced, which would have an equal net capacity of 1630 MWe to that of the original EPR, with an estimated construction cost of 8,61 billion euros per reactor in 2022 and increased to 11,23 billion euros under the revised cost estimate a year later, for which the government has agreed to grant a subsidised loan to EDF to partially cover the costs while eight additional reactors are being studied based on the EPR2 design, but Greenpeace has estimated that the actual budget would increase somewhere between 90 to 124 billion euros for the six reactors for a build time of 148 months per reactor, which would potentially make the project unviable for France (Thomas 2025; World Nuclear News 2025).

It should also be noted that in the early 2000's there were very few suppliers for different parts needed for nuclear reactors, but the costs for materials might decrease over time with increased demand if the world is heading for more nuclear reactor construction projects in the future as is projected, but a little is known as of 2025 on how this change would impact the costs for the EPR2 project or any possible subsequent reactor construction projects and as such they cannot be reliably considered in relation to the cost estimates presented in this thesis.

2.6.2 Small Modular Reactors

Small Modular Reactors or SMRs are small fission reactors with a net capacity between 20 to 300 MWe, which were originally developed from the naval propulsion reactors used in navy vessels such as submarines or aircraft carriers but that are still in early stages of development when it comes to civilian land-based use as only five reactors are operational as of 2025, but 88 different reactor designs are development or under construction around the world (Liou 2023; Terminet 2023; World Nuclear Association 2024). The benefits of a smaller reactor design are in its reduced requirements for infrastructure and fuel, but also in their adaptability as more conventional nuclear plants require location specific preparations and parts during the construction phase, whereas the SMRs can be scaled according to the needs even outside existing energy grids as they can be prefabricated and installed more easily on any location, which is argued to lower the construction costs (Liou 2024; Rolls Royce 2025). Generally SMRs are claimed to be better suited for load-following than large nuclear reactors as the smaller energy outputs have allowed technological developments to be made in regards to heat abstraction and cooling, which is often coupled with advanced thermal energy storage systems for reactor down times, but the SMRs are also deemed to be safer due to the passive safety features of the reactor and less prone for harmful releases of radioactive materials (World Nuclear Association 2024).

EDF has been creating their own SMR design since 2023 through their subsidiary Nuward, which is dedicated to the SMR design and development process in France. The proposed reactor would have a net capacity between 300 and 400 MWe, which is aimed for fast paced construction projects and simplicity through standardisation to be used as a more of local district-based energy supply rather than as a part of the larger national energy grid (Nuward 2025). This type of approach in relation to the energy grid and energy production might become more common in the future especially for larger private companies with great energy needs, such as Microsoft, as this could potentially allow energy production dedicated just for the company outside the national grid. The Prime Minister of the United Kingdom, Keir Starmer, has been trying to further goals for low-cost nuclear energy production in the United Kingdom where Rolls-Royce (2025) is developing their own design for a small capacity nuclear reactor scaled to be used for 60 years with a net capacity of 470 MWe, but the company also has ambitious economic goals by targeting 250 billion pounds in exports internationally, yielding 52 billion pounds in economic benefits and creating 40 000 jobs within the United Kingdom (Ambrose 2025).

However, the costs benefits related to SMRs have been questioned partly because this has not been verified based on the very few completed projects construction costs ranging from between a thousand and six thousand US dollars per kW based on estimates for the CAREM SMR built in Argentina and HTGR SMR built in China, but in the case of the latter the costs had escalated drastically to 21 900 US dollars per kW whereas it is estimated that a plant operating several SMRs could have comparable production and capital costs to a large nuclear facility (Green 2020; World Nuclear Association 2024; IEA 2025b). These estimates would put the 300 MWe reactor developed by EDF to a range of 263 million, 1,58 billion and 5,77 billion euros where one US dollar equals to 0,879 euros based on the closing exchange rate on 30 April 2025, while the construction costs for the 400 MWe reactor would be 351 million, 2,1 billion and 7,7 billion euros for one thousand, six thousand and 21 900 US dollars per kW respectively (European Central Bank 2025). This is noteworthy as the estimate of 11,23 billion euros for the EPR2 reactor is approximately 6889 euros per kW.

2.7 Learning-By-Doing in Cost Reduction

One proposed way to offset the high construction costs of nuclear power plants is learning-by-doing, which could theoretically decrease the costs from 20% to 30% after a sufficient amount of information has been gathered based on a few completed projects in a progressive manner as more projects are finished (Fertel cited in Davis 2012: 61). The learning process with nuclear reactors would include developing knowledge between the design and the performance of the reactor after becoming operational, which can be used to create improvements for all the reactors that follow as suggested by Lester and McCabe (1993: 421-422), given that the design remains sufficiently similar between different iterations. The second way learning-by-doing can yield benefits is through improved methodology in construction, operation and maintenance of the reactor, which would not need additional changes to the reactor design itself but rather through finding deficiencies or obstacles during the construction or early stages of use that can be corrected going forward, while similarly the workforce during all stages of the reactor’s lifecycle will develop in competency, which translates to fewer errors and time savings. However, the benefits in cost reduction are not infinite and the these will become less impactful over time as deficiencies are minimised from reactor to the next in addition that there will always be a base construction cost for resources and workforce that cannot be reduced beyond certain point (Lester & McCabe 1993: 422; Maïzi & Assoumou 2014: 854).

In a contradiction to this prospect, a paper by Grubler (2010: 5185) shows that the French reactor construction project between the 1970’s and 1990’s and similarly that of the United States saw constantly increasing construction costs for each new reactor with a distinction that in the United States the costs varied significantly from project to project as the overall trend was rising upwards, while in France, the average costs reduced marginally after the first completed reactor and began to increase in an almost linear fashion from 1980 onwards. The reason for the increase of the average costs in France were associated with combination of longer construction times, changes in the standardisation to the Westinghouse reactor design followed by domestically designed P4 reactor, which nullified any knowledge that may have been gained of the process from the previously constructed reactors, and the overall improvements of the design over time (Lester & McCabe 1993: 419; Grubler 2010: 5182-5183). These cost escalations would account to a multiplier of 2,4 based on the data between the base cost of the reactor and the most expensive reactor built between 1974 and 1990, but this increases further to 3,5 when the reactors built after 1990 are considered, largely due to the prolonged construction times and cost escalation from Civaux reactor two (Grubler 2010: 5182). However, France did not have similar cost volatility as the United States because of higher degree of overall standardisation as all the reactors were constructed by EDF under a direct government control, which also allowed workforce, technology and information sharing for a more unified planning and development going forward in addition to shorter construction times (Grubler 2010: 5177-5178; Davis 2012: 62).

3 Analytical Framework & Methodology

The data and information are based on the publicly available sources and peer-reviewed studies, and the use of official sources such as those from EDF are used where applicable with non-profit organisations such as World Nuclear Association that receive data directly from member nations used to fill information gaps not available via other means. The most recent developments rely heavily on articles from sources that are listed as newspapers of record or other news sources that are generally accepted to provide reliable information such as Reuters, Le Monde, The Guardian and BBC. However, some matters related to the future require assumptions to be made based on the most accurate information available as is the case with the energy demand growth and France’s position as an energy exporter after 2025.

A set of conditions is made to limit the number of different outcomes. The French government is speaking of nuclear renaissance and a lot has been made about the planned reactors alongside with the lifetime extension for older reactors based on the literature review, but the current construction plans appear to be insufficient to meet the energy demands in the future and a more extensive reactor buildup might be required than what has been publicly presented. Therefore, demand and production has to be assessed, which will form the basis for the results through defining an energy gap that would be created when the older reactors are decommissioned after 60-year lifecycle is completed, keeping in mind that the government has announced a lifetime extension of reactors only past 50 years without a clearly defined maximum limit (Lough & Mallet 2022). However, it is unlikely that any of the older reactors are immediately decommissioned as soon as reaching the 60-year mark and in a more likely scenario the decommissioning is done more flexibly over a longer period of time or some of the reactors might be decommissioned sooner. This does not exclude the fact that some of the reactors might be retrofitted, which is discussed separately. Once the energy gap is defined according to the collected data and estimates, the options based on either EPR2-based large reactor and SMR-based solutions are defined that use information from the literature review phase, which further feed into the cost estimates, where especially under the cost estimates for the EPR2 construction costs some limitations had to made in the number of scenarios as the options are too vast in regards to this thesis.

It is worth noting that as the reactor design is changed from EPR to the proposed EPR2 model, a similar upward trend in construction costs may be perceived as when changes were made to the Westinghouse design in the 1980’s followed by the possible improvement requirements from reactor to reactor, which would negate many of the benefits from learning-by-doing. Additionally, as was noted by Grubler (2010: 5182-5184), the projection for learning-by-doing becomes of limited use when the reactor design will change, and the theory is generally only applied on historical data when the costs associated with the construction are known. The information is limited regarding the planned EPR2 reactor and as none have been completed as of 2025, the costs compared to any of the EPR reactors cannot be reliably measured, but scenarios can be created based on the theoretical model for both cost reductions and cost overruns based on the historical data.

EDF’s average EBITDA value of 18,538 billion euros will be used to estimate the effects on EDF compared to the costs accumulated from the nuclear project between 2025 and 2050, but it should be noted that the results from 2023 and 2024 have skewed the results significantly as the EBITDA from any other years do not exceed the average and the exceptional negative results from 2022 also further skew the average. However, as it cannot be known whether the EBITDA will remain in the elevated level as in 2023 and 2024 for the years to come, especially after the construction of the EPR2 reactors will begin in 2027 and as it is likely that EDF will face more unplanned maintenance projects related to the old reactors in the future, the skewed average models the likely target EBITDA in order to remain profitable by taking these matters into account.

4 Results

4.1 Demand & Production

Regardless of what the decision will be in the future regarding nuclear energy’s portion in the energy mix, the French government will have to decide the fate of the older reactors as the lifeline cannot be extended indefinitely. 52 reactors of the current fleet will have passed the 40-year mark by the time the first of the six new planned reactors would be connected to the grid in 2035. Of these, 31 reactors will have passed the 50-year lifeline, leaving only five reactors outside the reactor lifetime extension. Out of the total net capacity of 73640 MWe of the nuclear fleet in 2025, the 31 reactors account for 53,76% or 39590 MWe, the 21 reactors that will pass the 40-year lifeline by 2035 account for 35,89% or 26430 MWe, leaving only 10,35% or 7620 MWe for the remaining five reactors. Given that the six planned reactors are likely to be similar to the EPR reactor number three built at the Flamanville nuclear power plant in terms of net capacity at 1630 MWe, the combined capacity of 9720 MWe would offer a replacement for 14,72% of the capacity of the reactors exceeding the 40-year mark in 2035. This is assuming that the French government is not explicitly aiming to increase the total energy production capacity of the nuclear fleet by adding new reactors but rather acting as a replacement for the older reactors that will inevitably need to be decommissioned in a way that would not cause significant disruptions to the domestic energy grid nor to the capacity to serve as an energy exporter.

The overall energy demand has been decreasing by 0,47% per year on average between 2000 and 2022, based on the electricity consumption per capita in France, but a study by the National Academy of Technologies of France (2021: 5) argues that the electricity demand will reach 729 TWh by 2050 (IEA 2025c). The increase is calculated as a linear progress of 7481 GWh added each year from 527 001 GWh in 2023 to 729 000 GWh in 2050. The average is calculated as the average value from total energy production between 2000 and 2022 and it acts as a baseline for a theoretical situation where the production needs would remain unchanged (see appendices 2 and 3; IEA 2025c). The results of these estimates are shown on Figure 2.

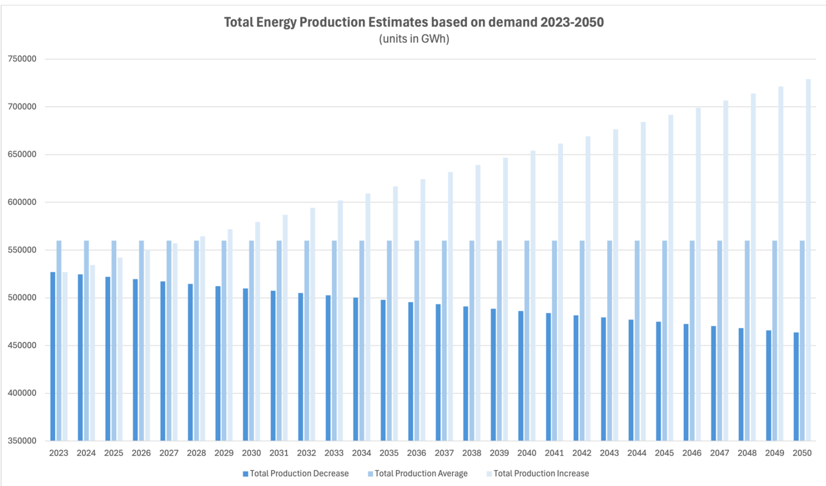

Figure 2. Total energy production estimates based on demand between 2023-2050 (National Academy of Technologies of France 2021: 5; IEA 2025c; See Appendix 1).

The average sets the overall demand at 559 873 GWh, but the increasing model estimate would reach to the aforementioned 729 000 GWh by 2050, while the decreasing model estimate would drop to 463 802 GWh for the same year.

Figure 3 shows the portion, which would be required to be produced via nuclear energy, is calculated by using the total energy production estimates and multiplying the values by 50%, 65% or 70%. The values were selected as 50% was the target for the nuclear power in the energy mix up until 2023 to which government might later return, while 65% represents the portion of nuclear energy based on the data from 2023 and 70% is the officially set target for nuclear energy.

Figure 3. Nuclear production estimates between 2023-2050 (IEA 2025c; World Nuclear Association 2025a; World Nuclear Association 2025b; See Appendices 2 & 3).

The increasing model estimates show that the demand would surpass the averages by 2028, reaching a maximum demand at 510 000 GWh with 70% of the total production produced via nuclear energy and the lowest estimate at 364 500 GWh with 50% of the total. The decreasing model estimates would set these to 324 661 GWh and 231 901 GWh for 70% and 50% of the total respectively. The increasing model at 70% would surpass the overall total demand based on the decreasing model by 2044, while the increasing model at 65% would surpass that same threshold by 2049.

Data regarding the nuclear fleet production factor is used to understand the production capacity of the current fleet, where the average capacity factor is taken from each nuclear plant and this results in a total average of 60,89% which produced a total of 294 731 GWh in 2022 and therefore, the total estimated production capacity of the nuclear fleet is calculated to be 482 303 GWh per year at 100% capacity factor (Eurostat 2024; World Nuclear Association 2025a). However, as the data from 2022 was unusual regarding the avarage capacity factor because the reduced number of reactors due to the shutdows during the maintenance and repairs addressing the problems related to corrosion and the construction of the Flamanville reactor three reducing the Flamanville power plant average capacity factor further down to 31%, the calculated 69,88% average capacity factor based on the total output of 338 202 GWh per year in 2023 was used instead as this better reflects the capacity for the nuclear power plants on an ordinary year. The 78% high-capacity factor was decided based on the highest value from the 2022 data which was from the Bugey nuclear power plant. Each reactor was given a percentage value based on the net MWe capacity, which was used to calculate the theoretical contribution to GWh production in 2023 where 1 MWe equals to 5,3682 GWh, 5,9923 GWh or 7,6825 GWh annually based on the capacity factors of 69,88%, 78% and 100% respectively, regardless of whether they were online (see appendix 4). Flamanville reactor was connected to the grid on 21 December 2024 and as such did not contribute to the energy production neither in 2022 nor 2023, but the reactor was included in the theoretical calculation as it was calculated as part of the total capacity factor already in 2022. The six planned

EPR2 reactors were assigned the same net capacity of 1630 MWe as for the Flamanville reactor three.

The nuclear energy production estimate was created using the combined GWh values from all the reactors based on the capacity factors of 69,88%, 78% and 100% with the calculated GWh production capacity assigned to each reactor individually, for which the results are shown on Figure 4. The old fleet is assumed to be decommissioned on the year where they would pass the 60-year lifeline and subtracted from the annual production contribution for that year, while the six EPR2 reactors are assumed to be completed every three years starting from 2035, which will in turn add to the annual production (see appendices 4 and 5). The capacity factor of 100% is purely theoretical as it is very unlikely due to many factors including overall safety, cost and avoiding unnecessary stress loading of the reactor (World Nuclear Association 2025c).

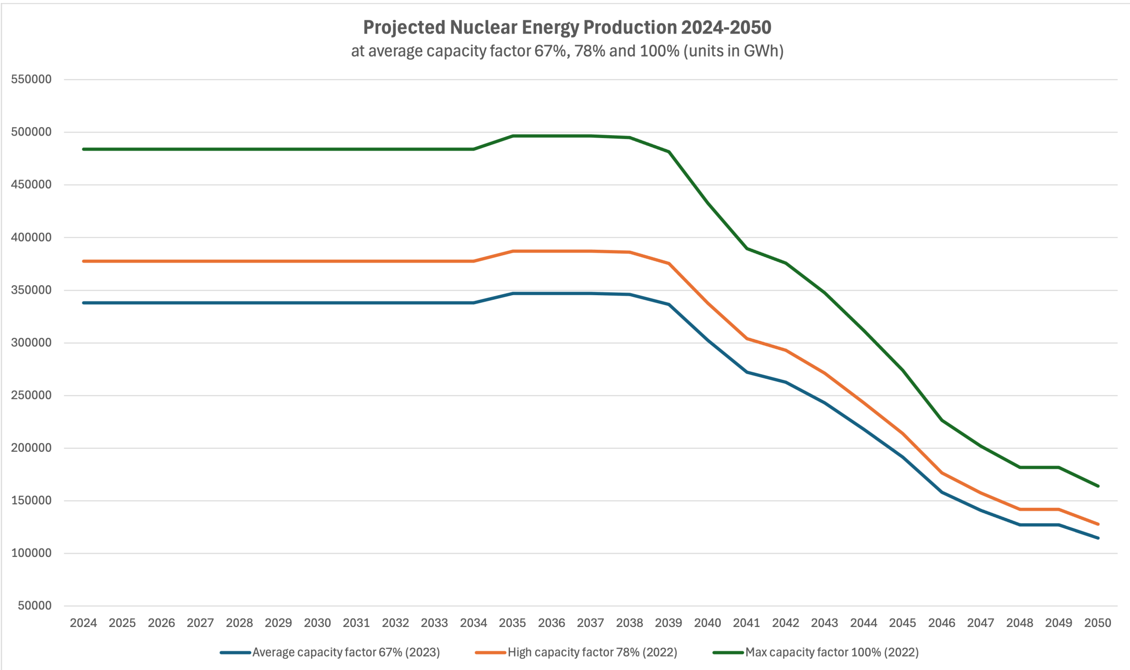

Figure 4. Projected nuclear energy production based on capacity between 2024 and 2050 (National Academy of Technologies of France 2021: 5; World Nuclear Association 2025a; World Nuclear Association 2025b; IEA 2025c; See Appendices 4 & 5).

The capacity would remain unchanged until 2035 when first of the planned reactors is added to the grid reaching a peak production capacity of 496 523 GWh at 100% surpassing the increasing model at 70% of the energy mix by 15%, but starting from 2039 the production capacity will start to fall drastically as in 2038 the addition of a new reactor keeps the production still at an acceptable level. The normal capacity of 69,88% would reach a maximum production of 346 952 GWh in 2035, which passes the threshold for the projected energy demand in 2035 for the decreasing model at 65%, but none of the models for 70%, average nor increasing model for 65%. The largest number of reactors would be decommissioned in 2041 with eight for the largest single year GWh decrease with 55 775 GWh at 100% capacity use. The largest year-to-year fall would occur in 2046 with 17,38% decrease compared to the previous year as five of the higher capacity P4 reactors are shut down.

Figure 5 presents the changes of surplus and deficit of the nuclear energy production compared to the nuclear energy demand year-by-year first under the most optimal conditions with the production capacity of 100% and 50% nuclear in the energy mix based on the decreasing model, second, under the worst conditions where the capacity is running at 69,88% and the demand is based on the 70% nuclear of the energy mix on the increasing demand model, and third, the average of the two. The average based on the two extremes is the more likely candidate to give a realistic estimate on the energy gap deciding the need for nuclear energy in the future.

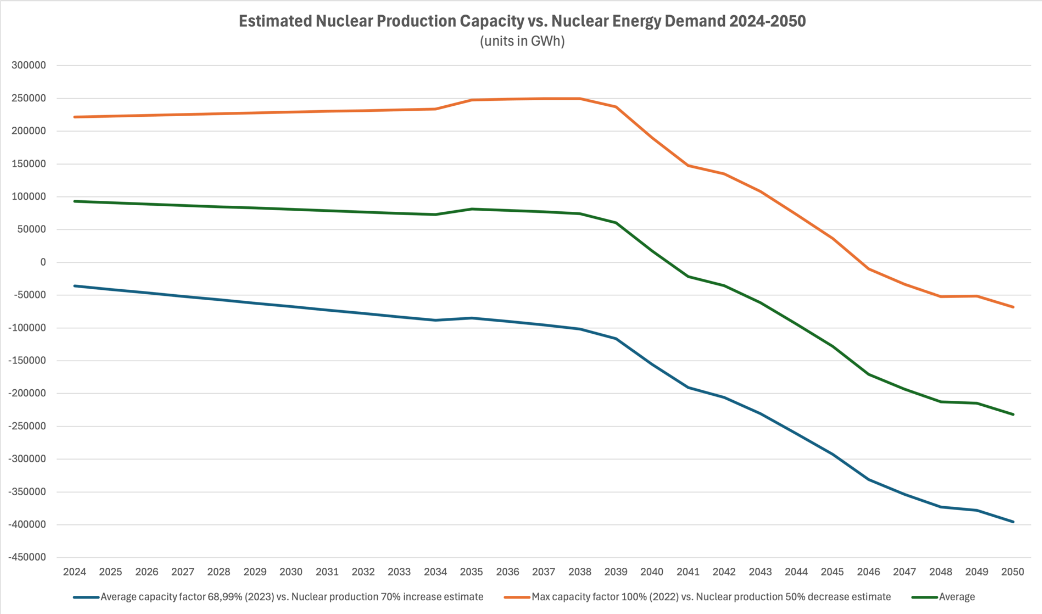

Figure 5. Estimated nuclear production capacity compared to the estimated nuclear energy demand between 2024 and 2050 (National Academy of Technologies of France 2021: 5; World Nuclear Association 2025a; World Nuclear Association 2025b; IEA 2025c; See Appendices 4 & 5).

The first year when there would be a deficit under the optimal scenario is in 2046, reaching the lowest value in 2050 with negative 67 955 GWh, but nevertheless running an annual average surplus of 201 323 GWh between 2024 and 2045. The suboptimal scenario will never have a surplus and it will reach a low of negative 395 741 GWh by 2050, which is approximately 82% of the full production capacity in 2023. The average estimate would produce a surplus of 76 543 GWh until 2040 and running a deficit from 2041 onwards, declining to negative 231 848 GWh by 2050. Based on these results the government should aim to fill an energy production gap from 220 255 GWh to 243 440 GWh with new nuclear reactors or alternative energy sources by 2050 given a 5% margin of error.

This result indicates that either there will be a significant drop in energy production starting from 2041, which would be detrimental for the national grid and France's energy exports, potentially increasing reliance on foreign energy imports and seeing a return to conditions before the Messmer plan was implemented, or that the French government is planning to keep the older reactors operating even longer than 60 years until a sufficient replacement can be secured either via nuclear energy or other energy sources. In relation to this thesis, a scenario is assumed where an energy gap is formed in line with the estimated average of 220 255 GWh to 243 440 GWH per year and the deficit is required to be supplemented only via nuclear energy to assess whether that is financially possible for EDF.

4.2 Research Question One: What Are the Options?

The two main ways to fill the nuclear energy gap is by adding more large capacity reactors like EPR2 or SMRs, which would be likely used in a more targeted way to produce electricity for local districts and industries rather than used as part of the overall national grid as previously discussed on page 22. The government has launched a study for further eight reactors that are to be based on the EPR2 design and as such the net capacity of 1630 MWe for the current EPR2 is used alongside with the more powerful variant of 1660 MWe based on the EPR reactors operated at the Taishan power plant is also used as a reference point in case the capacity of the current EPR2 design is increased in the future (Lough & Mallet 2022). The capacity factors of 68,66%, 78% and full capacity of 100% are used to calculate the annual GWh outputs based on the values of 5,3682 GWh, 5,9923 GWh or 7,6825 per installed net MWe respectively for each of the eight reactors with both MWe capacity options. The values are then combined for six different results across the eight reactors and compared to the total energy gap deficit range at the the end of 2050 as shown on Table 2.

Table 2. An outline of the results for the eight proposed high-capacity reactors based on two different capacities of 1630 MWe and 1660 MWe and their individual estimated annual GWh at 68,66%, 78% and 100% compared to the

established energy gap (Lough & Mallet 2022, World Nuclear Association 2025a; World Nuclear Association 2025b; IEA 2025c).

	MWe Option 1	Average capacity factor 69,88% (GWh)	High capacity factor 78% (GWh)	Max capacity factor 100% (GWh)	MWe Option 2	Average capacity factor 69,88% (GWh)	High capacity factor 78% (GWh)	Max capacity factor 100% (GWh)
EPR2 Study Reactor 1	1630	8750	9768	12523	1660	8911	9947	12753
EPR2 Study Reactor 2	1630	8750	9768	12523	1660	8911	9947	12753
EPR2 Study Reactor 3	1630	8750	9768	12523	1660	8911	9947	12753
EPR2 Study Reactor 4	1630	8750	9768	12523	1660	8911	9947	12753
EPR2 Study Reactor 5	1630	8750	9768	12523	1660	8911	9947	12753
EPR2 Study Reactor 6	1630	8750	9768	12523	1660	8911	9947	12753
EPR2 Study Reactor 7	1630	8750	9768	12523	1660	8911	9947	12753
EPR2 Study Reactor 8	1630	8750	9768	12523	1660	8911	9947	12753
Total EPR2 Study Reactors	13040	70002	78141	100180	13280	71291	79579	102024
Deficit 220 255 GWh		-150253	-142114	-120075		-148964	-140676	-118231
Deficit 243 440 GWh		-173438	-165299	-143260		-172149	-163861	-141416

EPR2 reactors are more likely to run on 69,88% annual capacity factor and the deficit would be narrowed down to a range of negative 150 253 GWh and negative 173 438 GWh in 2050 for the eight reactors with the 1630 MWe capacity and negative 148 964 GWh and negative 148 964 GWh for the ones with a capacity of 1660 MWe. Even the highest estimate with the max capacity factor of 100% and a net capacity of 1660 MWe option would alleviate the energy gap burden by only 41,9% to 46,3%, which indicates that either the number of reactors needs to be increased to between 25 and 27 if installed with 1630 MWe or 24 to 27 reactors if with a capacity of 1660 MWe, or a significant portion of the remaining gap needs to be compensated by either extending the life of the older reactors if possible, compensate the gap with non-nuclear energy sources including foreign imports, fill the gaps with SMRs or use a combination of all the available options. Aiming to fill the gap by 2050 just by using EPR2 is also likely to be extremely challenging both in terms of costs and logistics as the first would need to be in commercial use by 2041 to avoid going into energy deficit, while at least two additional and confirmed EPR2s are already in construction simultaneously. Based on the EDF's built time estimate of 96,5 months for the six confirmed EPR2 reactors, the construction for the last one of the study reactors should be started between 2042 and 2043 in order to be ready for 2050, which would give a total timeframe of approximately 18 years to complete 25 reactors that almost emulates the construction pace of the Messmer plan (Le Gros 2020; Mangeon 2024; Thomas 2025).

A group of three SMRs with a net capacity of 300 MWe could be used to replace the older CP0, CP1 and CP2 model reactors which have a net capacity of approximately 900 MWe per reactor, but a strategic placement and the load-following capabilities of the SMRs can also grant higher energy efficiency, where any excess from the large reactors can be then used for powering the national grid and foreign imports creating a welcome influx of capital for further investments. While the SMRs are generally run at a higher annual average capacity than the large reactors, a similar estimation for the annual GWh output can be made for the SMR as for the study EPR2s as shown on Table 3 (World Nuclear Association 2024).

Table 3. A comparison of an SMR with a net capacity of 300 MWe and 400 MWe, where annual GWh output is based on the values of 5,368 GWh, 5,9923 GWh and 7,6825 GWh per each installed net MWe (World Nuclear Association 2024; World Nuclear Association 2025a; World Nuclear Association 2025b; IEA 2025c; Nuward 2025).

	MWe Option 1	Average capacity factor 69,88% (GWh)	High capacity factor 78% (GWh)	Max capacity factor 100% (GWh)	Mwe Option 2	Average capacity factor 69,88% (GWh)	High capacity factor 78% (GWh)	Max capacity factor 100% (GWh)
SMR	300	1610	1798	2305	400	2147	2397	3073

Based on the average capacity factor of 78% for the 300 MWe, the reactor would produce approximately 1798 GWh per year while the 400 MWe yields 2397 GWh, which would require either 82 to 96 reactors for 300 MWe SMRs or 62 to 72 SMR reactors with a capacity of 400 MWe to fill the energy gap of 148 964 GWh to 173 438 GWh left after the eight study EPR2s have started production. The number of reactors would add more to the logistical pressures in terms of workforce capacity, timing, displacement of workforce to several sites simultaneously and likely also the operation and management of the reactors would incur additional costs.

4.3 Research Question Two: How the Options Can Be Achieved in Terms of Costs in Relation to the Economic Situation of EDF?

4.3.1 Maintenance & Retrofit Costs Related to the Old Fleet

The estimates concerning the 53 reactors undergoing or preparing for the 50-year lifetime extention retrofits are based on two major cost considerations of maintenance and decommissioning for which the resulting cost estimates are shown on Figure 6. The retrofit and maintenance cost estimates are based on the 600 million euros per reactor estimate by Maïzi and Assoumou (2014: 853), which are deemed to have started in 2016 with four years assigned for each reactor where the third year is decided as the year when the reactor would exceed the 40-year lifecycle. Decommissioning costs are based on the average value of 482 954,5 euros per net MWe installed from the EDF's estimate range of 397 727 and 568 182 euros for decommissioning projects (Day 2020; World Nuclear Association 2025b). The average value is calculated as per the installed net capacity for each reactor separately granting the total cost of the decommissioning, which is divided evenly for each of the 15 years estimated for the decommissioning process and set to start from the year when the reactor would exceed 60 years since the first grid connection (See Appendix 6).

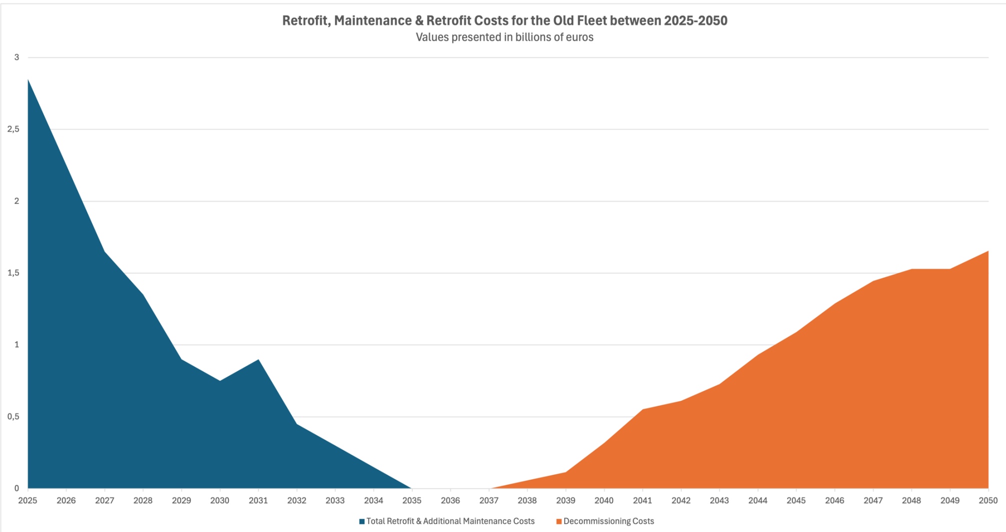

Figure 6. A cost change between the retrofit and decommissioning costs between 2025 and 205à where the values are shown in billions of euros (Day

2020; Maïzi & Assoumou 2014: 853; World Nuclear Association 2025a; World Nuclear Association 2025b; See Appendix 6).

The retrofitting and maintenance process is deemed to be part of the Grand Carénage programme, and they are already included in the total expenses of 33 billion euros accrued between 2022 and 2028 (EDF 2024a: 33). However, EDF is undergoing retrofit projects in 2025 to extend the lifetime of the project just to 50 years and further studies are being prepared to extend the operating time beyond that limit, which is likely to increase costs around the time when the first EPR2 will begin construction. The decommissioning project would be assumed to start in 2038 with Bugey reactors one and two, but it should be noted that the decommissioning process will extend beyond the year 2050 as the Goltech reactor two is the last to begin the process only in 2053. The decommissioning would add about 11,85 billion euros between 2025 and 2050 into the expenses where the year 2050 would be the most expensive at 1,65 billion euros, but simultaneously the revenue streams would decrease significantly the more reactors are taken offline.

4.3.2 EPR2 Construction Cost Estimates

The EPR2 construction cost estimates are divided between nine different scenarious that have been proposed on how the costs might change during a large-scale construction project with several identical projects for which the overall costs from each of the scenarios are shown on Table 4.

Table 4. Outline of the projected costs accrued related to the construction of the six EPR2 between 2027 and 2050 under nine scenarios with values shown in billions of euros (Grubler (2010: 5182; Fertel cited in Davis 2012: 61; IAEA 2020; Wakim & Moutarde 2020; RFI 2024; Nuclear News 2024; Thomas 2025; World Nuclear Association 2025a; World Nuclear News 2025; See Appendix 7).

EPR2	CT	Reactor 1	Reactor 2	Reactor 3	Reactor 4	Reactor 5	Reactor 6	Total
EDF Estimate in 2023	8	11,23 €	11,23 €	11,23 €	11,23 €	11,23 €	11,23 €	67,38 €
Cost Reduction 20%	8	11,23 €	10,48 €	9,73 €	8,98 €	8,98 €	8,98 €	58,40 €
Cost Reduction 30%	8	11,23 €	10,11 €	8,98 €	7,86 €	7,86 €	7,86 €	53,90 €
Cost Escalation, 2,4	11	11,23 €	16,62 €	22,01 €	27,40 €	32,79 €	38,18 €	148,24 €
Cost Escalation, 3,5	12	11,23 €	19,09 €	26,95 €	34,81 €	42,67 €	50,54 €	185,30 €
Flamanville 3, EDF estimate	17	13,00 €	13,00 €	13,00 €	13,00 €	13,00 €	13,00 €	78,00 €
Flamanville 3, CDC estimate	17	19,10 €	19,10 €	19,10 €	19,10 €	19,10 €	19,10 €	114,60 €
Greenpeace Low Estimate	12	15,00 €	15,00 €	15,00 €	15,00 €	15,00 €	15,00 €	90,00 €
Greenpeace High Estimate	12	20,67 €	20,67 €	20,67 €	20,67 €	20,67 €	20,67 €	124,00 €

EDF's estimate of 11,23 billion euros from 2023 with a construction time of 96,5 on average, rounded to eight years, is used as the baseline scenario where the project will finish with six reactors ready before for 2050 and the construction costs will not change from reactor to the next (Thomas 2025). The two cost reduction scenarios are based on the proposed learning-by-doing model where after the first completed reactor the overall cost of the reactor will progressively decrease to the next until after two more completed reactors the cost will halt either at 20% or 30% from the original based on the EDF 2023 estimate of 11,23 billion euros and with the same construction time (Fertel cited in Davis 2012: 61; Thomas 2025). 20% and the 30% cost reduction scenario will be referred to as 20cr and 30cr scenarios from hereon after.

A cost escalation via negative learning-by-doing model as proposed by Grubler (2010: 5182) is where the factor is calculated to be either 2,4 or 3,5 between the most cost-effective and the most expensive reactor, where the change happens progressively upwards in a linear fashion until in this case the sixth reactor would have been built according to the factor of the scenario. It should be acknowledged that rather paradoxically, the first reactor is deemed to have been built under the original budget of 11,23 billion euros and on time to provide a baseline for the scenario to start working. The costs will escalate from the second reactor onwards under both scenarios and the built time is increased from eight years to eleven years for the scenario with a 2,4 factor and to twelve years for the 3,5-scenario based on the extended built times for the Chooz reactor one and two respectively. The two scenarios will be referred to as 2,4ce for the cost escalation scenario with a 2,4 factor and as 3,5ce for the 3,5 factor.

The two Flamanville scenarios are identical except for the total cost estimate of which one is provided by the EDF for 13 billion euros and the other with a 19,1 billion euro estimate from the Cour des comptes based on the costs and a 17-year build time of the Flamanville reactor three project (Wakim & Mouterde 2020; RFI 2024). While the costs remain the same from reactor to reactor for both, these two scenarios have time based changes where the first eight years are identical to the costs of the baseline scenario, but the following years from the ninth year onward will incur annual costs of either 200 million under EDF estimate or 879 million euros under the Cour des comptes estimate until the project is completed nine years later (See appendix 7). The annual overrun costs are calculated by subtracting the overall cost of the baseline scenario from the Flamanville scenario and dividing the remaining amount by the number of extra years beyond the eight year. The Flamanville scenarios will be referred to as FLMVa and FLMVb for the EDF estimates and Cour des comptes estimates respectively.

The two Greenpeace estimates are based on the report which claims that the total construction costs from the six EPR2 reactors would be between 90 to 124 billion euros or 15 or 20,67 billion euros per reactor compared against a construction time of 148 months per reactor, which has been rounded to twelve years (Thomas 2025). The two Greenpeace scenarios will be referred to as GPa and GPb for the 90-billion-euro and 124-billion-euro estimates respectively. The year-to-year cost changes for each of the nine scenarios are shown on Figure 7, where the construction start year is set to three years, where the first would begin construction in 2027 and the last one is finished by 2050 under the baseline scenario.

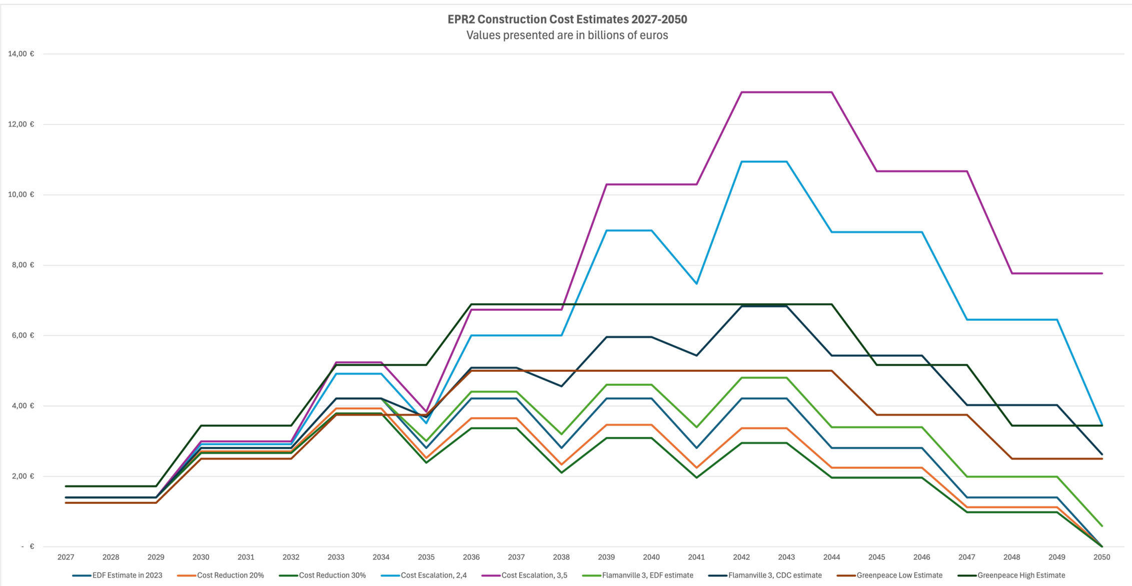

Figure 7. A graph outlining the projected combined construction costs from all six EPR2 reactors between 2027-2050 year by year with values shown in

billions of euros (Grubler 2010: 5182; Fertel cited in Davis 2012: 61; IAEA 2020; Wakim & Moutarde 2020; RFI 2024; Nuclear News 2024; Thomas 2025; World Nuclear Association 2025a; World Nuclear News 2025; See Appendix 7

The costs would peak at 4,21 billion euros per year under the baseline scenario for the ongoing EPR2 projects. This cost ceiling is maintained for two years within every three-year period between 2033 and 2043, where every third year would offer a sensible respite for the company's financial situation as more and more reactors are added into production. The peak years would account to 22,7% of the EDF's average EBITDA and only 11,5% when compared to the EBITDA of 36,523 billion euros in 2024.

The costs for the 20cr scenario would reach the peak expenses between 2033 and 2034 at 3,93 billion euros per year when three reactors are constructed simultaneously, compared to 3,75 billion euros under the 30cr scenario for the same time period. The costs are reduced to 3,37 billion euros and 2,95 billion euros for 2042 and 2043 under the 20cr and 30cr scenarios respectively for when three reactors are being constructed simultaneously. The costs follow the same pattern as the baseline scenario, where every third year between 2033 and 2043 would see lower total expenses.

The cost-escalation scenarios are the most worrying ones as there is some historical evidence in relation to long and large scale construction projects where the costs will triple over time, albeit over longer periods of time than the 25 years inspected here. The highest peak between 2042 and 2044 already reaches 12,91 billion euros under the 3,5ce scenario, that would not still exceed the EDF's average EBITDA of 18,538 billion, but it would effectively hinder the investments to the extent that further nuclear expansion would become close to impossible at a cost of more debt and this can further weigh on the French government as the lender. However, every other scenario leaves at least a gap of 11,6 billion euros to the EBITDA and if EDF can maintain the revenue streams and EBITDA on a healthy level as they have done in 2023 and 2024, even enduring large scale setbacks from the EPR2 would not necessarily cause nothing but minor short-term negative financial harm, that would not restrict the company to continue forward with more reactor projects.

The FLMVa and FLMVb scenarios have significant cost escalations over time as the construction times increase considerably even though the first costs remain mostly in level with the baseline scenario for the first three reactors under construction but as the production times are prolonged these peak between 2042 and 2043 at 4,80 billion euros per year under FLMVa and 6,83 billion euros under FLMVb scenario. These would account to 25,9% and 13,1% of the EBITDA average and EBITDA 2024 respectively under the FLMVa scenario, whereas the ratio would increase to 36,8% and 18,7% under the FLMVb scenario. Because the costs will continue to be accrued from reactor to reactor, there is much less respite during every third year when compared to the baseline scenario. However, neither of these scenarios would be financially disasterous for EDF, but the 17 year build time per reactor would significantly aggravate the energy gap problem.

The GPa and GPb scenarios are slightly different from others as both of them will peak in 2036 and the costs remain unchanged from year to year until 2044. The costs during this time would be five billion euros a year under GPa scenario and 6,89 billion euros under GPb. As the GPb scenario is on a constantly similar level as FLMVb between 2042 and 2043 during its peak, the situation is not financially devastating, but the two Greenpeace scenarios are the most financially taxing propositions aside from 2,4ce and 3,5ce, as they combine the delays similar to the Flamanville scenarios but without the decrease in expenses for every third year..

It should be noted, that none of the scenarios which include delays in construction times consider the costs that would result from the energy demand gap that forms as a result when the reactor is not contributing to the production as planned as they are presented here simply based on the construction costs without any externatilities. Most likely these gaps are filled with imports from neighbouring European countries similar to the situation in 2022, when France had to significantly increase imports due to the corrosion issues found in the P4 reactors with devastating results for EDF (Pécout 2022; EDF 2022a: 56; EDF 2024a: 71).

4.3.3 Study EPR2 & SMR Cost Estimates

Two propositions are considered regarding the Study EPR2 and SMR cost estimates. The first will assume that a the energy gap is supplemented only with 27 EPR2 reactors with a 1630 MWe net capacity generating a total of 236 258 GWh per year operated at the average capacity of 69,88% to exceed the average gap of 231 848 GWh per year. The second proposition assumes that only eight additional EPR2 reactors with a net capacity of 1630 MWe are built for a total of 70 002 GWh per year with the average capacity of 69,88% and the remaining annual gap of 161 846 GWh is supplemented with 91 SMRs with a net capacity of 300 MWe and operated at 78%, which would produce a combined 163 592 GWh for a total output of between the two reactor types being 233 594 GWh. The initial price for the EPR2 reactors is assumed to be 11,23 billion euros per reactor and the initial cost of the 300 MWe SMR reactor is 1,58 billion euros per reactor based on the value of 5274 euros per kW of the HTGR SMR in China (Green 2020; Thomas 2025). The total costs are shown on Table 5, where the costs are based on the baseline, 30cr and 3,5ce scenarios, but it should be noted that as the 3,5 factor scenario is scaled between the first and the last built reactor, the cost for the sixth reactor will be cheaper for the sixth reactor presented on page 37 under the second proposition and the eight reactor will have a lower cost under the first proposition than under the second.

Table 5. An estimate of the overall costs for Proposition One and Two under three different scenarios (Grubler 2010: 5182; Fertel cited in Davis 2012: 61; Green 2020; Thomas 2025).

Reactors	Type	EDF Estimate in 2023	Cost Reduction 20%	Cost Escalation, 3,5
Proposition One				
27	EPR2 1630 MWe	303,21 €	218,99 €	833,83 €
Proposition Two				
8	EPR2 1630 MWe	89,84 €	69,63 €	247,06 €
91	SMR 300 MWe	143,78 €	101,59 €	395,40 €
Total		233,62 €	171,22 €	642,46 €

Proposition one would be the more expensive one of the two as under the baseline scenario the cost would be 1,283 million euros per GWh compared to 1 million euros under proposition two. Both propositions would exceed the total cost of the nuclear program between 1970 and 2000 under the 3,5ce scenario with the first proposition being 217% more costly by comparing to the highest estimate from 2000 of 383,78 billion euros (Grubler 2010: 5179). Neither of the proposition are not yet announced but estimating from the construction times the first EPR2 reactor should begin construction by 2033 under either proposition to address the energy deficit, but the scale of the project would indicate that neither proposition can be finished by 2050 from the logistical standpoint and the rebuilding of the nuclear fleet is planned beyond 2050.

However, assuming that the construction of SMRs would begin in 2030 for proposition two with a target to finish by 2050, the annual costs would be 6,85, 4,84 and 18,83 billion euros under the baseline, 30cr and 3,5ce scenarious respectively, while the annual costs from the EPR2 reactors would be 4,99, 3,87 and 13,73 billion euros under the same scenarios starting from 2033, when the combined costs would reach 11,84, 8,71 and 32,55 billion euros per year. Under the first proposition where the construction would start in 2033 and finish in 2050, the annual costs would be 16,85 billion euros under the baseline scenario, 12,17 billion euros for the 30cr scenario and a 46,32 billion euros under the 3,5ce scenario. It should be noted that the costs are calculated here assuming that all the construction projects would start simultaneously when in reality the projects would begin in different intervals, which could change the annual costs very drastically in addition to the fact that it is very unlikely that EDF is aiming to complete a project of this scale by 2050.

4.3.4 Total Costs & Comparisons

For the final part of the cost evaluation the expenses from the retrofit and decommissioning and the costs from the six confirmed EPR2 construction are combined with the proposition one and proposition two used to fill the energy gap. Both propositions use the baseline scenario in addition with the two extreme scenarios of 30cr and 3,5ce. The results for the proposition one is shown on Figure 8.

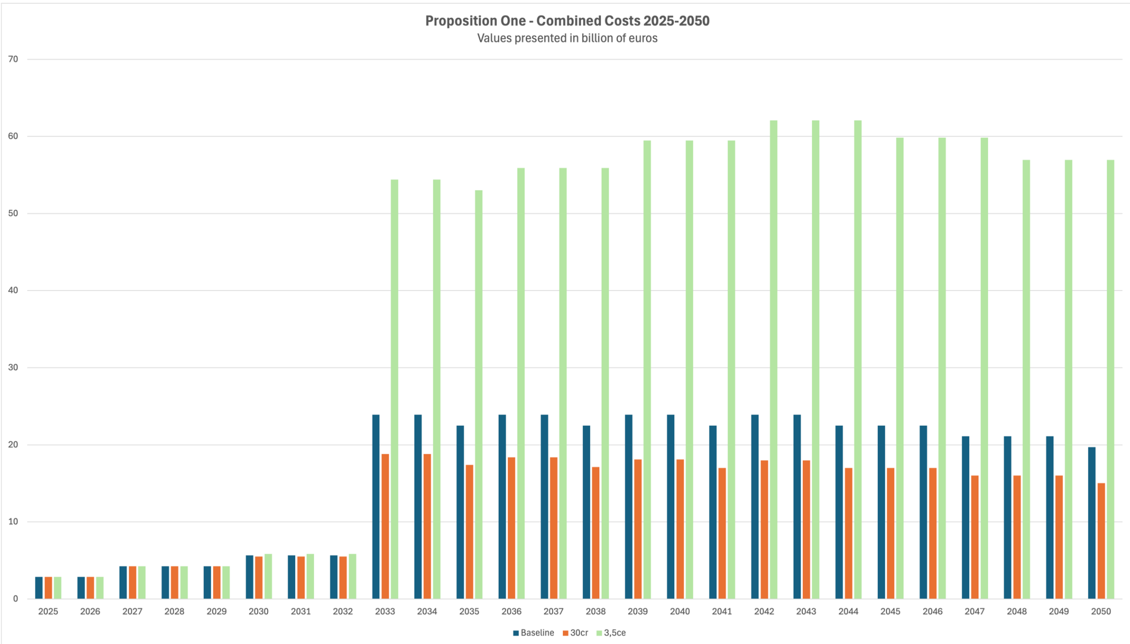

Figure 8. Total projected annual costs between 2025 and 2050 under proposition one (Grubler 2010: 5182; Fertel cited in Davis 2012: 61; Green 2020; IAEA 2020; Wakim & Moutarde 2020; RFI 2024; Nuclear News 2024; Thomas 2025; World Nuclear Association 2025a; World Nuclear News 2025).

The total costs under the proposition one increase progressively starting from 2025 until 2033, when the costs skyrocket to 24 billion euros under the baseline scenario and most notably up to 54 billion euros under the 3,5ce scenario. The latter scenario reaches its highest point of 62 billion euros between 2042 and 2044, which would exceed the EDF's average EBITDA by a factor of 3,34% and as such it is not viable. However, such a sudden cost escalation remains unlikely and is considered here as a worst case scenario, while the peak baseline value of 24 billion would exceed the average EBITDA by a factor of 1,29, it would still remain under the EBITDA in 2024 at 65,71% of the total 36,523 billion euros, which indicates, that even by adding an extra project of this magnitude both financially and logistically, it would be still at least financially viable for EDF. Proposition two is more lenient on the cost, but the costs would escalate much earlier in 2030 due to the addition of the SMRs as shown on Figure 9.

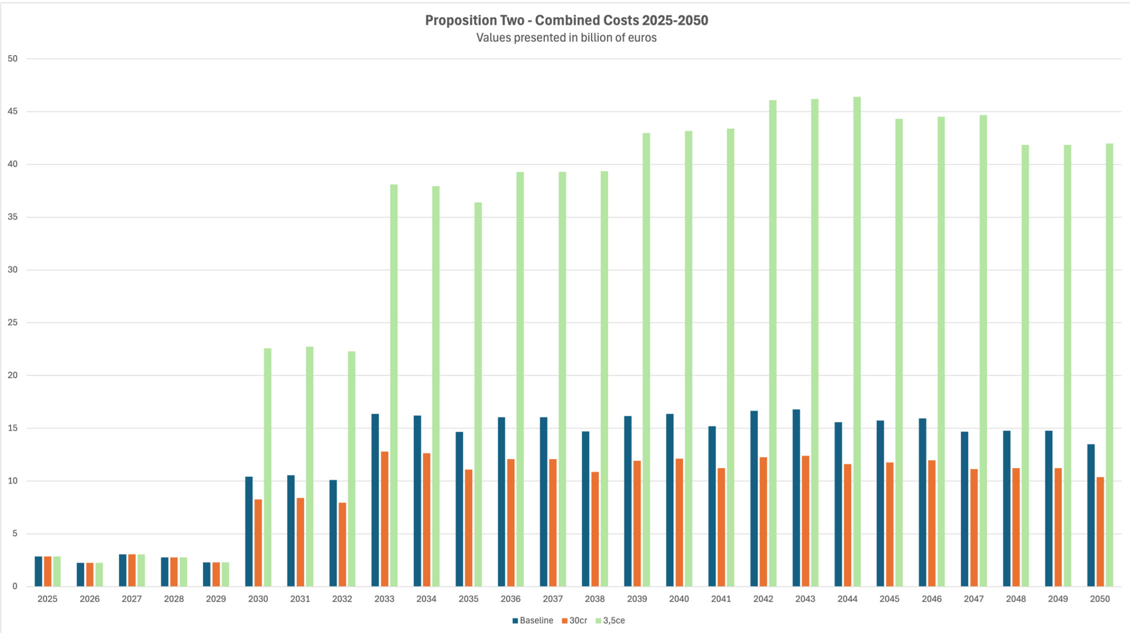

Figure 9. Total projected annual costs between 2025 and 2050 under proposition one (Grubler 2010: 5182; Fertel cited in Davis 2012: 61; Green 2020; IAEA 2020; Wakim & Moutarde 2020; RFI 2024; Nuclear News 2024; Thomas 2025; World Nuclear Association 2025a; World Nuclear News 2025).

While the circumstances of how either proposition would be done in terms of workforce, procurement of materials, scheduling and whether some technological breakthroughs have been made especially in relation to the SMRs, it is noteworthy that even the under the most extreme circumstances under proposition two when the expenses exceed 42 billion, this would not be completely impossible as this surpasses EDF’s EBITDA in 2024 only by a factor of 1,14. The baseline scenario shows that the costs would only be roughly 16 billion euros at their peak, which would be 86,3% of the average EBITDA.

This should be also considered in relation to the historical argumentation in politics, that the nuclear project will proceed in France regardless of the costs and with the government serving as a backer for EDF, the company has a lot more room for budget overruns whereas private companies would be more hesitant to continue in a similar fashion, but also that the benefits from the completed reactors extend far beyond the scope of 25 years, where the reactors would continue to serve for at least 60 years after the first grid connection with EDF having a near monopoly position in domestic energy production in addition to having a major position in European energy trade (Mangeon 2024).

4.4 Research Question Three: Is the Civilian Nuclear Program Feasible?

From the economic standpoint, the French civilian nuclear program is still feasible and viable, especially considering that while the scope of this thesis was limited to 25 year timeframe, a nuclear buildup would continue beyond this point and new reactors would be continued to be built beyond this point, where the timing of decommissioning and building of more generally powerful reactors as replacement is a longer process and therefore no energy gap might not form at any point.

5 Conclusion

France has many options regarding the nuclear fleet and a large and well-trained workforce that can drive the innovation forwards and after the government's consolidation and backing of EDF and added national interest for nuclear energy, even if the program would exceed costs of 21,31 billion a year, that is still likely to be pushed forward as long as it is politically viable and logistically doable. Regardless, as the trust for EDF is getting lower regarding the product in EPR and EPR2, the problem is not necessarily economical, but political, where more cost overruns and delays are likely to lead to less demand from outside France and at the same time when competition is once again increasing as is evident from the great number of SMR reactor currently under development, France might be the only country willing to buy their own product, which could lead to a similar situation as what the coal industry went through in the United Kingdom during the 1970’s and 1980’s. However, a more thorough appraisal of the company’s finances other than a simple comparison with the EBITDA.

However, it should be noted that only construction and direct reactor expenses related data has been considered for this theses, larger socioeconomic impact should be researched to understand the implications for trade that the energy deficit would cause or whether further reactor sales outside France could yield similar benefits that Rolls-Royce has been predicting with their nuclear program in the United Kingdom.

References

Abnett, K. 2023. *France leads push for EU to boost nuclear-produced hydrogen.* Reuters, [online] Available at: <https://www.reuters.com/business/energy/france-leads-push-eu-boost-nuclear-produced-hydrogen-2023-02-03/> [Accessed 1 February 2025].

Abnett, K. and Gray, A. 2023. *EU climate diplomacy deal on hold as nuclear dispute deepens.* Reuters, [online] Available at: <https://www.reuters.com/world/europe/eu-climate-diplomacy-deal-hold-nuclear-dispute-deepens-2023-02-20/> [Accessed 1 February 2025].

Ambrose, J. 2025. *What are small modular reactor and why does UK want to build them?* The Guardian, [online] Available at: <https://www.theguardian.com/environment/2025/feb/06/what-are-small-modular-reactors-and-why-does-uk-want-to-build-them> [Accessed 6 February 2025].

Bartak, J. and Camarcat, N. 2022. *Stress Corrosion Cracking on French NPPs – an overview.* Nuc Advisor, [online] Available at: <https://www.nucadvisor.com/post/stress-corrosion-cracking-on-french-npps-an-overview> [Accessed 8 February 2025].

BBC, 2022. *Hinkley Point C delayed by a year as cost goes up by £3bn*. BBC, [online]. Available at: <https://www.bbc.com/news/uk-england-somerset-61519609> [Accessed 8 January 2025].

Le Billon, V. 2018. *Areva se renomme Orano pour se relancer (Areva to be renamed as Orano for reorganisation)*. Les Echos, [online]. Available at: <https://www.lesechos.fr/2018/01/areva-se-renomme-orano-pour-se-relancer-982481> [Accessed 4 April 2025].

Birraux, C. 1999. *2ème séance du jeudi 18 février 1999 (Second session of Thursday 18 February 1999)*. Assemblée Nationale, [online]. Available at: <https://www.assemblee-nationale.fr/11/cra/1998-1999/99021815.asp> [Accessed 1 February 2025].

Broomby, R. 2014. *France struggles to cut down on nuclear power.* BBC, [online] (Last updated on 14 April 2025). Available at: <https://www.bbc.com/news/magazine-25674581> [Accessed 1 February 2025].

Brottes, F. and Baupin, D. 2014. *Rapport fait au nom de la commission d'enquête relative aux coûts passés, présents et futurs de la filière nucléaire, à la durée d'exploitation des réacteurs et à divers aspects économiques et financiers de la production et de la commercialisation de l'électricité nucléaire, dans le périmètre du mix électrique français et européen, ainsi qu'aux conséquences de la fermeture et du démantèlement de réacteurs nucléaires, notamment de la centrale de Fessenheim, Nº 2007 (Report made on behalf of the inquiry commission in relation to past, present and future costs of the nuclear industry, on the operation time of the reactors and various economic aspects and production financing and commercialisation of nuclear energy in the scope of the French and European energy mix as well as the consequences of closure and dismantling of nuclear reactors, especially the Fessenheim nuclear power plant, Nº 2007).* Assemblée Nationale, [online] Available at: <https://www.consilium.europa.eu/fr/policies/energy-prices-and-security-of-supply/> [Accessed 7 December 2024].

Crownhart, C. 2024. *Why Microsoft made a deal to help restart Three Mile Island.* MIT Technology Review, [online]. Available at: <https://www.technologyreview.com/2024/09/26/1104516/three-mile-island-microsoft/> [Accessed 12 April 2025].

Davis, L. 2012. Prospects for Nuclear Power. *Journal of Economic Perspectives*, 26(1): 49-66.

Day, P. 2020. *EDF updates Fessenheim plans after regulator warning.* Reuters Events, [online]. Available at: <https://www.reutersevents.com/nuclear/edf-updates-fessenheim-plans-after-regulator-warning> [Accessed 21 April 2025].

Department for Business, Energy & Industrial Strategy, 2016. *Government confirms Hinkley Point C project following new agreement in principle with EDF.* Gov.UK, [online]. Available at: <https://www.gov.uk/government/news/government-confirms-hinkley-point-c-project-following-new-agreement-in-principle-with-edf> [Accessed 8 January 2025].

Digges, C. 2013. *Olkiluoto 3's new-generation reactor hits more delays, casting an ill light on its viability.* Bellona, [online]. Available at: <https://bellona.org/news/nuclear-issues/2013-02-olkiluoto-3s-new-generation-reactor-hits-more-delays-casting-an-ill-light-on-its-viability> [Accessed 8 January 2025].

Dumoulin, S. and Loignon, S. 2025. *Déficit : le gouvernement alerte les Français sur l'effort massif à venir (Deficit: the government alerts the citizens about a massive effort to come).* Les Echos, [online] (Last updated on 14 April 2025). Available at: <https://www.lesechos.fr/economie-france/budget-fiscalite/deficit-le-gouvernement-alerte-les-francais-sur-leffort-massif-a-venir-2159774> [Accessed 15 April 2025].

EDF, 2017. *Résultats annuels 2016 (Annual results 2016).* EDF, [online] Available at: <https://www.edf.fr/sites/groupe/files/contrib/groupe-edf/espaces-dedies/espace-finance-fr/informations-financieres/informations-reglementees/resultats-annuels/2016/pdf/resultats-annuels-2016-rapport-activite-20170214-2.pdf> [Accessed 4 April 2025].

EDF, 2019. *Rapport d'activité 2018 (Operational Report 2018).* EDF, [online] Available at: <https://www.edf.fr/sites/groupe/files/contrib/groupe-edf/espaces-dedies/espace-finance-fr/informations-financieres/informations-

reglementees/resultats-annuels/2018/pdf/resultats-annuels-2018-rapport-activite-20190215.pdf> [Accessed 4 April 2025].

EDF, 2021. *Résultats annuels 2020 (Annual results 2020).* EDF, [online] Available at: <https://www.edf.fr/sites/groupe/files/contrib/groupe-edf/espaces-dedies/espace-finance-fr/informations-financieres/informations-reglementees/resultats-annuels/2020/pdf/resultats-annuels-2020-presentation-20210304.pdf> [Accessed 4 April 2025].

EDF, 2022a. *Comptes consolidés au 31 décembre 2022 (Consolidated accounts on 31 December).* EDF, [online] Available at: <https://www.edf.fr/sites/groupe/files/2023-02/resultats-annuels-2022-comptes-consolides-2023-02-17.pdf> [Accessed 8 February 2025].

EDF, 2022b. *Hinkley Point C Update.* EDF, [online] Available at: <https://www.edf.fr/en/the-edf-group/dedicated-sections/journalists/all-press-releases/hinkley-point-c-update-0> [Accessed 8 January 2025].

EDF, 2023. *Structure du capital (Structure of capital).* EDF, [online] Available at: <https://www.edf.fr/groupe-edf/espaces-dedies/investisseurs/structure-du-capital> [Accessed 25 January 2025].

EDF, 2024a. *Résultats annuels 2023 (Annual results 2023).* EDF, [online] Available at: <https://www.edf.fr/sites/groupe/files/2024-04/resultats-annuels-edf-2023-presentation-2024-04-02.pdf> [Accessed 4 April 2025].

EDF, 2024b. *Hinkley Point C Update.* EDF, [online] Available at: <https://www.edf.fr/en/the-edf-group/dedicated-sections/journalists/all-press-releases/hinkley-point-c-update-1> [Accessed 8 January 2025].

EDF, 2025a. *EDF en bref (EDF at a glance).* EDF, [online] Available at: <https://www.edf.fr/groupe-edf/edf-en-bref> [Accessed 4 April 2025].

EDF, 2025b. *Résultats annuels 2024 (Annual results 2024).* EDF, [online] Available at: <https://www.edf.fr/sites/groupe/files/2025-03/resultats-annuels-edf-2024-presentation-2025-03-07.pdf> [Accessed 4 April 2025].

Ercanbrack, A. 2015. *Filand's TVO scraps plans for fourth nuclear reactor.* Reuters [online] Available at: <https://www.reuters.com/article/business/energy/finlands-tvo-scraps-plans-for-fourth-nuclear-reactor-idUSL8N0ZA134/> [Accessed 8 January 2025].

European Central Bank, 2025. *US dollar (USD).* European Central Bank, [online] Available at: <https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html> [Accessed 30 April 2025].

European Council, 2025. *Prix de l'énergie et sécurité de l'approvisionnement (Energy prices and security of supply).* European Council, [online] Available at: <https://www.consilium.europa.eu/fr/policies/energy-prices-and-security-of-supply/> [Accessed 25 January 2025].

Eurostat, 2024. *Drop in nuclear power production in 2022.* Eurostat [online] Available at: <https://ec.europa.eu/eurostat/fr/web/products-eurostat-news/w/ddn-20240112-1> [Accessed 5 April 2025].

Filippone, D. 2024. *Pour ses datacenters, Microsoft reactive la centrale de Three Mile Island (Microsoft reactivates the Three Mile Island power plant for its datacentres).* Le Monde Informatique, [online]. Available at: <https://www.lemondeinformatique.fr/actualites/lire-pour-ses-datacenters-microsoft-reactive-la-centrale-de-three-mile-island-94776.html> [Accessed 12 April 2025].

Folz, J-M. 2019. *Rapport au Président Directeur Général d'EDF (Report to the President and Chief Executive Officer of EDF).* Vie Publique, [online] Available at: <https://www.vie-publique.fr/files/rapport/pdf/271429.pdf> [Accessed 19 April 2025].

Forbes, 2025. *EDF.* Forbes, [online] Available at: <https://www.forbes.com/companies/edf/> [Accessed 4 April 2025].

Green, J. 2020. *Small modular reactor rhetoric hits hurdle.* Renew Economy, [online] Available at: <https://reneweconomy.com.au/small-modular-reactor-rhetoric-hits-a-hurdle-62196/> [Accessed 19 April 2025].

Greenpeace, 2023. *La Russie, plaque tournante de l'uranium (Russia, the uranium hub).* Greenpeace, [online] Available at: <https://cdn.greenpeace.fr/site/uploads/2023/05/Greenpeace-Rapport-La-Russie-plaque-tournante-du-commerce-duranium-mars-2023-1-1.pdf?_ga=2.25038266.1654865824.1683099429-761220566.1612868947> [Accessed 19 January 2025].

Le Gros, G. 2020. *La naissance du parc nucléaire français : le plan Messmer (The birth of the French nuclear fleet: The Messmer plan).* RGN, [online] (Last updated 5 February 2024). Available at: <https://www.sfen.org/rgn/naissance-parc-nucleaire-francais-plan-messmer/> [Accessed 19 January 2025].

Le Gros, G. 2024. *TVO souligne les performances de l'EPR d'Olkiluoto en Finlande (TVO underlines the performance of the EPR in Olkiluoto, Finland).* RGN, [online] (Last updated 16 January 2024). Available at: <https://www.sfen.org/rgn/tvo-souligne-les-performances-de-lepr-dolkiluoto-en-finlande/> [Accessed 3 December 2024].

Grubler, A. 2010. The costs of the French nuclear scale-up: A case of negative learning by doing. *Energy Policy*, 38 (2010): 5174-5188. DOI: https://doi.org/10.1016/j.enpol.2010.05.003

Hernandez, A., Alkousaa, R. and Rashad, M. 2025. *Back to Russian gas? Trump-wary EU has energy security dilemma.* Reuters, [online] (Last updated 15 April 2025). Available at: <https://www.reuters.com/business/energy/back-russian-gas-trump-wary-eu-has-energy-security-dilemma-2025-04-14/> [Accessed 19 April 2025].

Hodgson, R. 2025. *Can the EU really ramp up imports of US energy as Trump demands? - Analysis.* Euronews, [online] (Last updated 11 April 2025). Available at: <https://www.euronews.com/my-europe/2025/04/11/can-the-eu-really-ramp-up-imports-of-us-energy-as-trump-demands-analysis> [Accessed 19 April 2025].

Honney, T. 2022. *Further delays for Olkiluoto 3.* Neimagazine, [online] Available at: <https://www.neimagazine.com/news/further-delay-for-olkiluoto-3-10433350/?cf-view/> [Accessed 8 January 2025].

Honney, T. 2023. *French government wins court approval for EDF nationalisation.* Neimagazine, [online] Available at: <https://www.neimagazine.com/news/french-government-wins-court-approval-for-edf-nationalisation-10830185/> [Accessed 25 January 2025].

Hummel, T. and Thomas, L. 2022. *France caps energy price increase at 15% next year to shield consumers.* Reuters, [online]. Available at: <https://www.reuters.com/business/energy/france-set-new-energy-price-cap-shield-consumers-2022-09-14/> [Accessed 25 January 2025].

IAEA. 2016. *Nuclear Power and the Paris Agreement.* IAEA, [online] Available at: <https://www.iaea.org/sites/default/files/16/11/np-parisagreement.pdf> [Accessed 1 February 2025].

IAEA. 2020a. *Taishan-1.* IAEA, [online] Available at: <https://pris.iaea.org/pris/CountryStatistics/ReactorDetails.aspx?current=918> [Accessed 8 February 2025].

IAEA. 2020b. *Taishan-2.* IAEA, [online] Available at: <https://pris.iaea.org/pris/CountryStatistics/ReactorDetails.aspx?current=919> [Accessed 8 February 2025].

IAEA. 2020c. *The EPR 2 for a low-carbon electricity.* IAEA, [online] Available at: <https://inis.iaea.org/records/3nq02-eaq14> [Accessed 21 April 2025].

ICAN, 2025. *Which countries have nuclear weapons?* ICAN, [online] Available at: <https://www.icanw.org/nuclear_arsenals> [Accessed 5 April 2025].

IEA, 2025a. *Nuclear Power.* IEA, [online] Available at: <https://www.iea.org/energy-system/electricity/nuclear-power> [Accessed 5 April 2025].

IEA, 2025b. *Small modular reactor construction costs in major markets, 2040.* IEA, [online] Available at: <https://www.iea.org/data-and-statistics/charts/small-modular-reactor-construction-costs-in-major-markets-2040> [Accessed 20 April 2025].

IEA, 2025c. *France - Electricity.* IEA, [online] Available at: <https://www.iea.org/countries/france/electricity> [Accessed 5 April 2025].

Insee, 2025. *Convertisseur franc-euro (Franc-Euro converter).* Insee, [online] Available at: <https://www.insee.fr/fr/information/2417794> [Accessed 19 January 2025].

ITER, 2025a. *En Bref (At a glance).* ITER, [online] Available at: <https://www.iter.org/fr/en-quelques-mots> [Accessed 2 April 2025].

ITER, 2025b. *ITER en France (ITER in France).* ITER, [online] Available at: <https://www.iter.org/fr/en-bref/iter-en-france> [Accessed 2 April 2025].

ITER, 2025c. *Les pays membres (The member states).* ITER, [online] Available at: <https://www.iter.org/fr/en-bref/pays-membres> [Accessed 2 April 2025].

Lea, R. 2025. *French WEST reactor breaks record in nuclear fusion.* Advanced Science News, [online] Available at: <https://www.advancedsciencenews.com/french-west-reactor-breaks-record-in-nuclear-fusion/> [Accessed 2 April 2025].

Lester, R. and McCabe, M. 1993. The effect of industrial structure on learning by doing in nuclear power plant operation. *RAND Journal of Economics*, 24 (3): 418-438.

von der Leyen, U. and Biden, J. 2022. *Statement by President von der Leyen with US President Biden.* European Commission, [online] Available at: <https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_22_2043> [Accessed 28 April 2025].

Liou, J. 2023. *What are Small Modular Reactors (SMRs)?* IAEA, [online] Available at: <https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs> [Accessed 20 April 2025].

Lough, R. and Mallet, B. 2022. *Macron bets on nuclear in carbon-neutrality push, announces new reactors.* Reuters, [online] Available at: <https://www.reuters.com/business/energy/macron-bets-nuclear-carbon-neutrality-push-announces-new-reactors-2022-02-10/> [Accessed 25 January 2025].

Maad, A. 2023. *À quelle point la France est-elle dépendante de l'uranium nigérien? (To which degree France is dependant on Nigerien uranium).* Le Monde, [online] Available at: <https://www.lemonde.fr/les-decodeurs/article/2023/08/03/a-quel-point-la-france-est-elle-dependante-de-l-uranium-nigerien_6184374_4355770.html> [Accessed 19 January 2025].

Maïzi, N. and Assoumou, E., 2014. Future prospects for nuclear power in France. *Applied Energy*, 137: 849-859.

Malischek, R. and Trüby, J. 2016. The future of nuclear power in France: an analysis of the costs of phasing-out. *Energy*, 116: 908-921.

Mallet, B. 2021. *France values EDF minorities buyout at nearly $12 billion - sources.* Reuters, [online] Available at: <https://www.reuters.com/article/us-edf-restructuring-idUSKBN2BT2NM/> [Accessed 25 January 2025].

Mallet, B. 2022. *Fixing EDF's reactors corrosion mystery to take several years, French regulator warns.* Reuters, [online] Available at: <https://www.reuters.com/markets/commodities/fixing-edfs-reactors-corrosion-mystery-take-several-years-french-regulator-warns-2022-05-17/> [Accessed 8 February 2025].

Mallet, B. and Thomas, L. 2022. *France starts process to fully nationalise power group EDF.* Reuters, [online] Available at: <https://www.reuters.com/business/energy/france-keeps-edf-buyout-offer-12-euros-per-share-filing-2022-10-04/> [Accessed 25 January 2025].

Mangeon, M. 2024. *Le plan Messmer : retour aux sources du parc électronucléaire français (The Messmer plan: Return to the origins of the French electronuclear fleet).* RGN, [online] (Last updated 5 February 2024). Available at: <https://www.sfen.org/rgn/le-plan-messmer-retour-aux-sources-du-parc-electronucleaire-francais/> [Accessed 19 January 2025].

Martuscelli, C., Jack, V. and Mackenzie, L. 2024. *Europe's new normal: High energy bills, fading industry and one chance to fix it.* Politico, [online] Available at: <https://www.politico.eu/article/europe-energy-bills-germany-brussels-pipeline-prices/> [Accessed 25 January 2025].

McGrath, J. 2024. *An 'artificial sun' achieved a record-breaking fusion experiment, bringing us closer to clean, limitless energy.* Business Insider, [online] Available at: <https://www.businessinsider.com/west-tungsten-tokamak-fusion-record-plasma-2024-5/> [Accessed 2 April 2025].

Le Monde, 2022. *Elisabeth Borne annonce que le gouvernement souhaite renationaliser complètement EDF (Elisabeth Borne announces that the government wishes to fully renationalise EDF).* Le Monde, [online]. Available at: <https://www.lemonde.fr/politique/article/2022/07/06/elisabeth-borne-annonce-que-le-gouvernement-souhaite-renationaliser-completement-edf_6133659_823448.html> [Accessed 25 January 2025].

Le Monde and AFP, 2023. *En Finlande, l'EPR Olkiluoto 3 finalement mis en service, après Treize ans de retard (In Finland, EPR Olkiluoto 3 finally put to service, after thirteen years of delay).* Le Monde, [online] (Last updated 17 April 2023). Available at: <https://www.lemonde.fr/planete/article/2023/04/16/en-finlande-l-epr-olkiluoto-3-desormais-mis-en-service-apres-treize-ans-de-retard_6169744_3244.html> [Accessed 3 December 2024].

Mouterde, P. and Cessac, M. 2023. *Les liens persistants de la filière nucléaire française avec le géant russe Rosatom (The French nuclear industry maintains links with the Russian giant Rosatom).* Le Monde*,* [online] Available at: <https://www.lemonde.fr/economie/article/2023/03/11/les-liens-persistants-de-la-filiere-nucleaire-francaise-avec-le-geant-russe-rosatom_6165046_3234.html> [Accessed 19 January 2025].

Murray, J. 2023. *Les arrêts nucléaires français de 2022: Leçons pour l'énergie nucléaire en Europe (The French nuclear stoppages in 2022 : Lessons for nuclear energy in Europe).* Clean Air Task Force, [online] Available at: <https://www.catf.us/fr/2023/07/2022-french-nuclear-outages-lessons-nuclear-energy-europe/> [Accessed 8 February 2025].

National Academy of Technologies of France, 2021. *French electricity demand outlook to 2050.* Academie Technologies, [online] Available at: <https://www.academie-technologies.fr/wp-content/uploads/2021/03/Position-Paper-on-the-Energy-Transition-in-France.pdf> [Accessed 5 April 2025].

News Wires, 2022. *France prolongs shutdown of nuclear reactors over corrosion amid rising energy prices.* France 24, [online] Available at: <https://www.france24.com/en/france/20220825-france-prolongs-shutdown-of-nuclear-reactors-over-corrosion-amid-rising-energy-prices> [Accessed 8 February 2025].

Ng, E. 2018. *CGN Power's latest project delay deals another blow to China's nuclear energy ambition.* South China Morning Post, [online] Available at: <https://www.scmp.com/business/companies/article/2126529/cgn-powers-

latest-project-delay-deals-another-blow-chinas-nuclear> [Accessed 8 January 2025].

Nuclear News, 2025. *France's Nuclear Energy Policy.* Nuclear News, [online] Available at: <https://nuclear-news.net/2024/12/26/frances-nuclear-energy-policy-a-chronicle-of-failure-flamanville-3/> [Accessed 1 January 2025].

Nuward 2025. *Notre SMR (Our SMR).* Nuward, [online] Available at: <https://www.nuward.com/fr/notre-smr> [Accessed 20 April 2025].

Orano, 2022. *All about the nuclear industry in France.* Orano, [online] Available at: <https://www.orano.group/en/unpacking-nuclear/nuclear-energy-france-s-3rd-largest-industrial-sector> [Accessed 18 January 2025].

Pécout, A. 2022. *EDF de plus en plus inquiet pour son parc nucléaire en raison de problèmes de corrosion (EDF is more and more worried for the nuclear fleet due to corrosion problems).* Le Monde, [online] Available at: <https://www.lemonde.fr/economie/article/2022/04/21/edf-de-plus-en-plus-inquiet-pour-son-parc-nucleaire-en-raison-de-problemes-de-corrosion_6123074_3234.html> [Accessed 8 February 2025].

La Rédaction, 2024. *Taishan 2, le réacteur nucléaire des records (Taishan 2, the record-breaking nuclear reactor).* Transitions Energies, [online] Available at: <https://www.transitionsenergies.com/taishan-2-reacteur-nucleaire-des-records/> [Accessed 8 January 2025].

Reuss, P. 2007. *L'épopée de l'énergie nucléaire: une histoire scientifique et industrielle (The nuclear energy saga: a scientific and industrial history).* Les Ulis: EDP Sciences.

RFI, 2024. *France's most powerful nuclear reactor joins grid after €13bn holdup.* RFI, [online] Available at: <https://www.rfi.fr/en/france/20241220-france-s-most-powerful-nuclear-reactor-joins-grid-after-%E2%82%AC13bn-holdup-flamanville> [Accessed 1 January 2025].

Rogers, D. 2022. *Finland’s Olkiluoto 3 goes online after 12-year construction delay.* GCR, [online] Available at: <https://www.globalconstructionreview.com/finlands-olkiluoto-3-goes-online-after-12-year-construction-delay/> [Accessed 8 January 2025].

Rolls-Royce, 2025. *Small Modular Reactors.* Rolls-Royce, [online] Available at: <https://www.rolls-royce.com/innovation/small-modular-reactors.aspx#/> [Accessed 20 April 2025].

Rosemain, M. and Thomas, L. 2022. *France to pay $10 billion to take full control of EDF.* Reuters, [online] Available at: <https://www.reuters.com/markets/europe/france-offers-12-euros-per-share-take-full-control-edf-2022-07-19/> [Accessed 25 January 2025].

Ruuska, I., Ahola, T., Artto, K., Locatelli, G. and Mancini, M. 2011. A new governance approach for multi-firm projects: Lessons from Olkiluoto 3 and Flamanville 3 nuclear power plant projects. *International Journal of Project Management*, 29 (6): 647-660. DOI: https://doi.org/10.1016/j.ijproman.2010.10.001

Schneider, M., 2008. *Nuclear Power in France: Beyond the Myth*. [online] NIRS. Available at: <https://www.nirs.org/wp-content/uploads/international/westerne/258614beyondmythfr.pdf> [Accessed 19 February 2022].

Schwikowski, M. 2023. *Are Niger’s uranium supplies to France under scrutiny?* DW, [online] Available at: <https://www.dw.com/en/are-nigers-uranium-supplies-to-france-under-scrutiny/a-66711717> [Accessed 19 January 2025].

Seife, C. 2023. *World’s Largest Fusion Project Is in big Trouble, New Documents Reveal.* Scientific American, [online], edited by Billings, L. Available at: <https://www.scientificamerican.com/article/worlds-largest-fusion-project-is-in-big-trouble-new-documents-reveal/> [Accessed 2 April 2025].

Stanway, D. 2025. *Global nuclear fusion project crosses milestone with world's most powerful magnet.* Reuters, [online] Available at: <https://www.reuters.com/sustainability/climate-energy/global-nuclear-fusion-project-crosses-milestone-with-worlds-most-powerful-magnet-2025-05-01/> [Accessed 1 May 2025].

Szarka, J. 2013. From exception to norm – and back again? France, the nuclear revival, and the post-Fukushima landscape. *Environmental Politics*, 22(4): 646-663. DOI: https://doi.org/10.1080/09644016.2013.806629

Szondy, D. 2025. *France runs fusion reactor for record 22 minutes.* New Atlas, [online] Available at: <https://newatlas.com/energy/france-tokamak-cea-west-fusion-reactor-record-plasma-duration/> [Accessed 2 April 2025].

Terminet, F. 2023. *C'est quoi un SMR? (What is an SMR?).* Académie 235, [online] (Last updated 15 February 2024). Available at: <https://www.sfen.org/vos-questions/cest-quoi-un-smr/> [Accessed 19 April 2025].

Thomas, A. 2025. *Les EPR2 coûteront le double du montant annoncé, calcule Greenpeace (The EPR2 will cost double the announced amount, calculates Greenpeace).* Ouest-France, [online]. Available at: <https://www.ouest-france.fr/environnement/nucleaire/nucleaire-les-epr2-couteront-le-double-du-montant-annonce-assure-greenpeace-71736522-e1fd-11ee-94a7-1385a6efe21e> [Accessed 19 April 2025].

Trading Economics, 2025. *France Interest Rate.* Trading Economics, [online]. Available at: <https://tradingeconomics.com/france/interest-rate> [Accessed 21 April 2025].

Turner, B. 2024. *World's largest nuclear fusion reactor is finally completed. But it won't run for another 15 years.* Live Science, [online] Available at: <https://www.livescience.com/physics-mathematics/worlds-largest-nuclear-

reactor-is-finally-completed-but-it-wont-run-for-another-15-years> [Accessed 2 April 2025].

Ursat, X. 2020. Les leviers industriels de la compétitivité du nucléaire. (Industrial leverage for competitiveness in the nuclear industry.) Responsabilité & Environnement, 97: 131-135,148,156.

United Nations, 2015. *Paris Agreement.* UNFCC, [online]. Available at: <https://unfccc.int/sites/default/files/english_paris_agreement.pdf> [Accessed 3 May 2025].

USNRC, 2024. *Three Mile Island Nuclear Station, Unit 1.* USNRC, [online]. Available at: <https://www.nrc.gov/info-finder/reactors/tmi1.html> [Accessed 12 April 2025].

Le Van-Lemesle, L. 2004. Les theories économiques et la crise de 1973 (The economic theories and the 1973 crisis)*. Vingtième Siècle,* 84 (2004/4): 83-92. [online] Available at: <https://shs.cairn.info/revue-vingtieme-siecle-revue-d-histoire-2004-4-page-83?lang=fr> [Accessed 19 January 2025].

Wajsbrot, S. 2024. *Nucléaire : la centrale accidentée de Three Mile Island va revivre grâce à Microsoft (Nuclear energy: Three Mile Island power plant will be revived thanks to Microsoft).* Les Echos, [online] (Last updated 23 September 2024). Available at: <https://www.lesechos.fr/industrie-services/energie-environnement/nucleaire-la-centrale-accidentee-de-three-mile-island-va-revivre-grace-a-microsoft-2120522> [Accessed 12 April 2025].

Wakim, N. 2018. *Areva devient Orano pour tourner la page des années Lauvergeon (Areva becomes Orano to turn the page on the Lauvergeon years)*. Le Monde, [online]. Available at: <https://www.lemonde.fr/economie/article/2018/01/23/areva-devient-orano-pour-tourner-la-page-des-annees-lauvergeon_5245799_3234.html> [Accessed 4 April 2025].

Wakim, N. and Mouterde, P. 2020. *« Echec opérationnel" et « dérive des coûts » la gestion de l'EPR, réacteur nucléaire de troisième génération, décriee par la Cour de comptes ("Operational failure" and "cost drifting" the management of the EPR, the third generation nuclear reactor, decried by the Cour de comptes)*. Le Monde, [online] Last updated on 10 July 2020). Available at: <https://www.lemonde.fr/economie/article/2020/07/09/nucleaire-la-cour-des-comptes-ereinte-l-epr_6045707_3234.html> [Accessed 3 December 2024].

World Nuclear Association, 2022. *Decommissioning Nuclear Facilities.* World Nuclear Association, [online] (Last updated on 3 May 2022) Available at: <https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/decommissioning-nuclear-facilities> [Accessed 21 April 2025].

World Nuclear Association, 2024. *Small Nuclear power Reactors.* World Nuclear Association, [online] (Last Updated 16 February 2024). Available at: <https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors> [Accessed 19 April 2025].

World Nuclear Association, 2025a. *Country Profiles: Nuclear Power in France.* World Nuclear Association, [online] Available at: <https://world-nuclear.org/information-library/country-profiles/countries-a-f/france> [Accessed 18 January 2025].

World Nuclear Association, 2025b. *Nuclear Reactors in France.* World Nuclear Association, [online] Available at: <https://world-nuclear.org/nuclear-reactor-database/summary/France> [Accessed 18 January 2025].

World Nuclear Association, 2025c. *Safety of Nuclear Power Reactors.* World Nuclear Association, [online] (Last updated on 11 February 2025). Available at: <https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors> [Accessed 19 April 2025].

World Nuclear News, 2022. *French regulator gives update on corrosion issue.* World Nuclear News, [online] Available at: <https://www.world-nuclear-

news.org/Articles/French-regulator-gives-update-on-corrosion-issue> [Accessed 8 February 2025].

World Nuclear News, 2025. *EDF may get state loan for six new reactors.* World Nuclear News, [online] Available at: <https://www.world-nuclear-news.org/articles/edf-may-get-state-loan-for-six-new-reactors> [Accessed 19 April 2025].

Yle News, 2022. *Olkiluoto 3 reactor plugged into national grid, 13 years behind schedulee.* Yle, [online] Available at: <https://yle.fi/a/3-12356596> [Accessed 8 January 2025].

Appendices

Appendix 1

International Energy Agency – Electricity consumption per capita, France 2000-2023 (IEA 2025c)

International Energy Agency - Electricity consumption per capita, France

Year	Electricity consumption per capita, France	Units
2000	7.226	MWh / Capita
2001	7.343	MWh / Capita
2002	7.3	MWh / Capita
2003	7.531	MWh / Capita
2004	7.663	MWh / Capita
2005	7.654	MWh / Capita
2006	7.542	MWh / Capita
2007	7.521	MWh / Capita
2008	7.65	MWh / Capita
2009	7.344	MWh / Capita
2010	7.74	MWh / Capita
2011	7.344	MWh / Capita
2012	7.47	MWh / Capita
2013	7.502	MWh / Capita
2014	7.101	MWh / Capita
2015	7.198	MWh / Capita
2016	7.258	MWh / Capita
2017	7.2	MWh / Capita
2018	7.118	MWh / Capita
2019	7.011	MWh / Capita
2020	6.637	MWh / Capita
2021	6.902	MWh / Capita
2022	6.638	MWh / Capita
2023	6.417	MWh / Capita

Appendix 2

International Energy Agency – Total electricity production, France 2000-2023 (IEA 2025c)

International Energy Agency - Total electricity production, France

Year	Total electricity production, France	Units
2000	539954	GWh
2001	549530	GWh
2002	559063	GWh
2003	566838	GWh
2004	574053	GWh
2005	576061	GWh
2006	574869	GWh
2007	569768	GWh
2008	573806	GWh
2009	535925	GWh
2010	569287	GWh
2011	573123	GWh
2012	572786	GWh
2013	582317	GWh
2014	572587	GWh
2015	579441	GWh
2016	564056	GWh
2017	561942	GWh
2018	581685	GWh
2019	570774	GWh
2020	532255	GWh
2021	555082	GWh
2022	474744	GWh
2023	527001	GWh

Appendix 3

Collected data: demand estimates & the effect on nuclear energy production levels (National Academy of Technologies of France 2021: 5; IEA 2025c)

					Total Production (GWh)			Nuclear Production 50% (GWh)			Nuclear Production 65% (GWh)			Nuclear Production 70% (GWh)		
Year	Electricity consumption per capita, France	Change from 2000 %	Year to Year Change %	Year	Decrease	Average	Increase	Decrease	Average	Increase	Decrease	Average	Increase	Decrease	Average	Increase
2000	7,226	0%	0%	2023	527001	559873	527001	263501	279936	263501	338202	363917	338202	368901	391911	368901
2001	7,343	1,62%	1,62%	2024	524617	559873	534482	262309	279936	267241	336672	363917	347414	367232	391911	374138
2002	7,3	1,02%	-0,59%	2025	522244	559873	541964	261122	279936	270982	335149	363917	352277	365571	391911	379375
2003	7,531	4,22%	3,16%	2026	519882	559873	549445	259941	279936	274723	333633	363917	357139	363917	391911	384612
2004	7,663	6,05%	1,75%	2027	517530	559873	556927	258765	279936	278463	332124	363917	362002	362271	391911	389849
2005	7,654	5,92%	-0,12%	2028	515189	559873	564408	257595	279936	282204	330622	363917	366865	360632	391911	395086
2006	7,542	4,37%	-1,46%	2029	512859	559873	571890	256429	279936	285945	329126	363917	371728	359001	391911	400323
2007	7,521	4,08%	-0,28%	2030	510539	559873	579371	255269	279936	289686	327637	363917	376591	357377	391911	405560
2008	7,65	5,87%	1,72%	2031	508229	559873	586853	254115	279936	293426	326155	363917	381454	355761	391911	410797
2009	7,344	1,63%	-4,00%	2032	505930	559873	594334	252965	279936	297167	324680	363917	386317	354151	391911	416034
2010	7,74	7,11%	5,39%	2033	503642	559873	601815	251821	279936	300908	323211	363917	391180	352549	391911	421271
2011	7,344	1,63%	-5,12%	2034	501364	559873	609297	250682	279936	304648	321749	363917	396043	350955	391911	426508
2012	7,47	3,38%	1,72%	2035	499096	559873	616778	249548	279936	308389	320294	363917	400906	349367	391911	431745
2013	7,502	3,82%	0,43%	2036	496838	559873	624260	248419	279936	312130	318845	363917	405769	347787	391911	436982
2014	7,101	-1,73%	-5,35%	2037	494591	559873	631741	247295	279936	315871	317403	363917	410632	346214	391911	442219
2015	7,198	-0,39%	1,37%	2038	492354	559873	639223	246177	279936	319611	315967	363917	415495	344647	391911	447456
2016	7,258	0,44%	0,83%	2039	490126	559873	646704	245063	279936	323352	314538	363917	420358	343088	391911	452693
2017	7,2	-0,36%	-0,80%	2040	487909	559873	654186	243955	279936	327093	313115	363917	425221	341537	391911	457930
2018	7,118	-1,49%	-1,14%	2041	485702	559873	661667	242851	279936	330834	311699	363917	430084	339992	391911	463167
2019	7,011	-2,98%	-1,50%	2042	483505	559873	669148	241753	279936	334574	310289	363917	434946	338454	391911	468404
2020	6,637	-8,15%	-5,33%	2043	481318	559873	676630	240659	279936	338315	308885	363917	439809	336923	391911	473641
2021	6,902	-4,48%	3,99%	2044	479141	559873	684111	239570	279936	342056	307488	363917	444672	335399	391911	478878
2022	6,638	-8,14%	-3,82%	2045	476974	559873	691593	238487	279936	345796	306097	363917	449535	333882	391911	484115
2023	6,417	-11,20%	-3,33%	2046	474816	559873	699074	237408	279936	349537	304712	363917	454398	332371	391911	489352
Average	7,263	0,51%	-0,45%	2047	472668	559873	706556	236334	279936	353278	303334	363917	459261	330868	391911	494589
				2048	470530	559873	714037	235265	279936	357019	301962	363917	464124	329371	391911	499826
				2049	468402	559873	721519	234201	279936	360759	300596	363917	468987	327881	391911	505063
				2050	466283	559873	729000	233141	279936	364500	299236	363917	473850	326398	391911	510300

Appendix 4

Collected data: average capacity & energy production calculations (IEA 2025c; World Nuclear Association 2025a; World Nuclear Association 2025b)

Reactor	Type	Net Capacity	First Grid Connection	Decommissioning	Average capacity factor 2022	Production Share %	Contribution 69,88% (GWh)	Contribution 78% (GWh)	Contribution 100% (GWh)
Belleville 1	P4 REP 1300	1310	14/10/1987	14/10/2047	56%	2,08%	7032	7850	10064
Belleville 2	P4 REP 1300	1310	06/07/1988	06/07/2048	56%	2,08%	7032	7850	10064
Blayais 1	CP1	910	12/06/1981	12/06/2041	58%	1,44%	4885	5453	6991
Blayais 2	CP1	910	17/07/1982	17/07/2042	58%	1,44%	4885	5453	6991
Blayais 3	CP1	910	17/08/1983	17/08/2043	58%	1,44%	4885	5453	6991
Blayais 4	CP1	910	16/05/1983	16/05/2043	58%	1,44%	4885	5453	6991
Bugey 2	CP0	910	10/05/1978	10/05/2038	78%	1,44%	4885	5453	6991
Bugey 3	CP0	910	21/09/1978	21/09/2038	78%	1,44%	4885	5453	6991
Bugey 4	CP0	880	08/03/1979	08/03/2039	78%	1,40%	4724	5273	6761
Bugey 5	CP0	880	31/07/1979	31/07/2039	78%	1,40%	4724	5273	6761
Cattenom 1	P4 REP 1300	1300	13/11/1986	13/11/2046	58%	2,06%	6979	7790	9987
Cattenom 2	P4 REP 1300	1300	17/09/1987	17/09/2047	58%	2,06%	6979	7790	9987
Cattenom 3	P4 REP 1300	1300	06/07/1990	06/07/2050	58%	2,06%	6979	7790	9987
Cattenom 4	P4 REP 1300	1300	27/05/1991	27/05/2051	58%	2,06%	6979	7790	9987
Chinon B 1	CP2	905	30/11/1982	30/11/2042	55%	1,44%	4858	5423	6953
Chinon B 2	CP2	905	29/11/1983	29/11/2043	55%	1,44%	4858	5423	6953
Chinon B 3	CP2	905	20/10/1986	20/10/2046	55%	1,44%	4858	5423	6953
Chinon B 4	CP2	905	14/11/1987	14/11/2047	55%	1,44%	4858	5423	6953
Chooz B 1	N4 REP 1450	1500	30/08/1996	30/08/2056	61%	2,38%	8052	8989	11524
Chooz B 2	N4 REP 1450	1500	10/04/1997	10/04/2057	61%	2,38%	8052	8989	11524
Civaux 1	N4 REP 1450	1495	24/12/1997	24/12/2057	73%	2,37%	8026	8959	11485
Civaux 2	N4 REP 1450	1495	24/12/1999	24/12/2059	73%	2,37%	8026	8959	11485
Cruas 1	CP2	915	29/04/1983	29/04/2043	66%	1,45%	4912	5483	7030
Cruas 2	CP2	915	06/09/1984	06/09/2044	66%	1,45%	4912	5483	7030
Cruas 3	CP2	915	14/05/1984	14/05/2044	66%	1,45%	4912	5483	7030
Cruas 4	CP2	915	27/10/1984	27/10/2044	66%	1,45%	4912	5483	7030
Dampierre 1	CP1	890	23/03/1980	23/03/2040	71%	1,41%	4778	5333	6837
Dampierre 2	CP1	890	10/12/1980	10/12/2040	71%	1,41%	4778	5333	6837
Dampierre 3	CP1	890	30/01/1981	30/01/2041	71%	1,41%	4778	5333	6837
Dampierre 4	CP1	890	18/08/1981	18/08/2041	71%	1,41%	4778	5333	6837
Flamanville 1	P4 REP 1300	1330	04/12/1985	04/12/2045	31%	2,11%	7140	7970	10218
Flamanville 2	P4 REP 1300	1330	18/07/1986	18/07/2046	31%	2,11%	7140	7970	10218
Flamanville 3	EPR	1630	21/12/2024	21/12/2084	31%	2,59%	8750	9768	12523
Golfech 1	P4 REP 1300	1310	07/06/1990	07/06/2050	53%	2,08%	7032	7850	10064
Golfech 2	P4 REP 1300	1310	18/06/1993	18/06/2053	53%	2,08%	7032	7850	10064
Gravelines 1	CP1	910	13/03/1980	13/03/2040	61%	1,44%	4885	5453	6991
Gravelines 2	CP1	910	26/08/1980	26/08/2040	61%	1,44%	4885	5453	6991
Gravelines 3	CP1	910	12/12/1980	12/12/2040	61%	1,44%	4885	5453	6991
Gravelines 4	CP1	910	14/06/1981	14/06/2041	61%	1,44%	4885	5453	6991
Gravelines 5	CP1	910	28/08/1984	28/08/2044	61%	1,44%	4885	5453	6991
Gravelines 6	CP1	910	01/08/1985	01/08/2045	61%	1,44%	4885	5453	6991
Nogent 1	P4 REP 1300	1310	21/10/1987	21/10/2047	60%	2,08%	7032	7850	10064
Nogent 2	P4 REP 1300	1310	14/12/1988	14/12/2048	60%	2,08%	7032	7850	10064
Paluel 1	P4 REP 1300	1330	22/06/1984	22/06/2044	70%	2,11%	7140	7970	10218
Paluel 2	P4 REP 1300	1330	14/09/1984	14/09/2044	70%	2,11%	7140	7970	10218
Paluel 3	P4 REP 1300	1330	30/09/1985	30/09/2045	70%	2,11%	7140	7970	10218
Paluel 4	P4 REP 1300	1330	11/04/1986	11/04/2046	70%	2,11%	7140	7970	10218
Penly 1	P4 REP 1300	1330	04/05/1990	04/05/2050	46%	2,11%	7140	7970	10218
Penly 2	P4 REP 1300	1330	04/02/1992	04/02/2052	46%	2,11%	7140	7970	10218
St. Alban 1	P4 REP 1300	1335	30/08/1985	30/08/2045	68%	2,12%	7167	8000	10256
St. Alban 2	P4 REP 1301	1335	03/07/1986	03/07/2046	68%	2,12%	7167	8000	10256
St. Laurent 1	CP2	915	21/01/1981	21/01/2041	33%	1,45%	4912	5483	7030
St. Laurent 2	CP2	915	01/06/1981	01/06/2041	33%	1,45%	4912	5483	7030
Tricastin 1	CP1	915	31/05/1980	31/05/2040	72%	1,45%	4912	5483	7030
Tricastin 2	CP2	915	07/08/1980	07/08/2040	72%	1,45%	4912	5483	7030
Tricastin 3	CP3	915	10/02/1981	10/02/2041	72%	1,45%	4912	5483	7030
Tricastin 4	CP4	915	12/06/1981	12/06/2041	72%	1,45%	4912	5483	7030
Total	57	63000				100,00%	338202	377521	484001
Planned Reactors									
EPR2 1	EPR2	1630	01/01/2035	01/01/2095			8750	9768	12523
EPR2 2	EPR2	1630	01/01/2038	01/01/2098			8750	9768	12523
EPR2 3	EPR2	1630	01/01/2041	01/01/2101			8750	9768	12523
EPR2 4	EPR2	1630	01/01/2044	01/01/2104			8750	9768	12523
EPR2 5	EPR2	1630	01/01/2047	01/01/2107			8750	9768	12523
EPR2 6	EPR2	1630	01/01/2050	01/01/2110			8750	9768	12523

	Average capacity	Production (GWh)
Average 2022	60,89%	294731
Average 2023	69,88%	338202
High	78,00%	377521
Max	100,00%	484001

Appendix 5

Collected data: production capacity estimates & comparison against demand (National Academy of Technologies of France 2021: 5; World Nuclear Association 2025a; World Nuclear Association 2025b; IEA 2025c)

	Average capacity factor 67% (2023)			High capacity factor 78% (2022)			Max capacity factor 100% (2022)		
Year	Total Production	Increase	Decrease	Total Production	Increase	Decrease	Total Production	Increase	Decrease
2024	338202	0	0	376196	0	0	482303	0	0
2025	338202	0	0	376196	0	0	482303	0	0
2026	338202	0	0	376196	0	0	482303	0	0
2027	338202	0	0	376196	0	0	482303	0	0
2028	338202	0	0	376196	0	0	482303	0	0
2029	338202	0	0	376196	0	0	482303	0	0
2030	338202	0	0	376196	0	0	482303	0	0
2031	338202	0	0	376196	0	0	482303	0	0
2032	338202	0	0	376196	0	0	482303	0	0
2033	338202	0	0	376196	0	0	482303	0	0
2034	338202	0	0	376196	0	0	482303	0	0
2035	346952	8750	0	385930	9733	0	494782	12479	0
2036	346952	0	0	385930	0	0	494782	0	0
2037	346952	0	0	385930	0	0	494782	0	0
2038	345932	8750	-9770	384795	9733	-10868	493327	12479	-13933
2039	336484	0	-9448	374286	0	-10510	479853	0	-13474
2040	302449	0	-34035	336427	0	-37858	431317	0	-48537
2041	272226	8750	-38974	302808	9733	-43352	388216	12479	-55580
2042	262482	0	-9743	291970	0	-10838	374321	0	-13895
2043	242942	0	-19541	270234	0	-21736	346454	0	-27866
2044	217791	8750	-33901	242259	9733	-37709	310588	12479	-48345
2045	191460	0	-26331	212969	0	-29290	273037	0	-37551
2046	158177	0	-33283	175946	0	-37022	225572	0	-47465
2047	141025	8750	-25902	156868	9733	-28812	201113	12479	-36938
2048	126960	0	-14065	141223	0	-15645	181055	0	-20058
2049	126960	0	0	141223	0	0	181055	0	0
2050	114559	8750	-21151	127429	9733	-23527	163371	12479	-30163

	Estimated Production vs. Nuclear Energy Demand (units in GWh)		
Year	Average capacity factor 67% (2023) vs. Nuclear production 70% increase estimate	Max capacity factor 100% (2022) vs. Nuclear production 50% decrease estimate	Average
2024	-35936	220046	92055
2025	-41173	221284	90056
2026	-46410	222516	88053
2027	-51647	223742	86048
2028	-56884	224963	84040
2029	-62121	226178	82028
2030	-67358	227386	80014
2031	-72595	228590	77997
2032	-77832	229787	75978
2033	-83069	230979	73955
2034	-88306	232165	71930
2035	-84793	245825	80516
2036	-90030	247000	78485
2037	-95267	248169	76451
2038	-101524	247879	73178
2039	-116209	235564	59677
2040	-155481	188180	16350
2041	-190941	146227	-22357
2042	-205922	133474	-36224
2043	-230699	106744	-61977
2044	-261087	72009	-94539
2045	-292655	35585	-128535
2046	-331175	-10759	-170967
2047	-353564	-34103	-193834
2048	-372866	-53051	-212958
2049	-378103	-51946	-215024
2050	-395741	-68530	-232136

Appendix 6

Collected data: cost estimates between 2025-2050 in relation to the costs for retrofitting and decommissioning the old fleet (Day 2020; Maïzi & Assoumou 2014: 853; World Nuclear Association 2025a; World Nuclear Association 2025b).

Reactor Name	Model	Net Capaci	First Grid Connection	Decommissioning € (billions)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	Total
Belleville 1	P4 REP 13	1310	14/10/1987	0,63 €	0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0422 €	0,0422 €	0,0422 €	0,0422 €	0,7687 €
Belleville 2	P4 REP 13	1310	06/07/1988	0,63 €		0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0422 €	0,0422 €	0,0422 €	0,7265 €
Blayais 1	CP1	910	12/06/1981	0,44 €																	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,2930 €
Blayais 2	CP1	910	17/07/1982	0,44 €																		0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,2637 €
Blayais 3	CP1	910	17/08/1983	0,44 €																			0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,2344 €
Blayais 4	CP1	910	16/05/1983	0,44 €																			0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,2344 €
Bugey 2	CP0	910	10/05/1978	0,44 €														0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,3809 €
Bugey 3	CP0	910	21/09/1978	0,44 €														0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,3809 €
Bugey 4	CP0	880	08/03/1979	0,42 €															0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,3400 €
Bugey 5	CP0	880	31/07/1979	0,42 €															0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,0283 €	0,3400 €
Cattenom 1	P4 REP 13	1300	13/11/1986	0,63 €	0,1500 €	0,1500 €	0,1500 €																			0,0419 €	0,0419 €	0,0419 €	0,0419 €	0,0419 €	0,6593 €
Cattenom 2	P4 REP 13	1300	17/09/1987	0,63 €	0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0419 €	0,0419 €	0,0419 €	0,0419 €	0,7674 €
Cattenom 3	P4 REP 13	1300	06/07/1990	0,63 €				0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0419 €	0,6419 €
Cattenom 4	P4 REP 13	1300	27/05/1991	0,63 €					0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,6000 €
Chinon B 1	CP2	905	30/11/1982	0,44 €																		0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,2622 €
Chinon B 2	CP2	905	29/11/1983	0,44 €																			0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,2331 €
Chinon B 3	CP2	905	20/10/1986	0,44 €	0,1500 €	0,1500 €	0,1500 €																			0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,5957 €
Chinon B 4	CP2	905	14/11/1987	0,44 €	0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0291 €	0,0291 €	0,0291 €	0,0291 €	0,7166 €
Cruas 1	CP2	915	29/04/1983	0,44 €																			0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,2357 €
Cruas 2	CP2	915	06/09/1984	0,44 €	0,1500 €																			0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,3562 €
Cruas 3	CP2	915	14/05/1984	0,44 €	0,1500 €																			0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,3562 €
Cruas 4	CP2	915	27/10/1984	0,44 €	0,1500 €																			0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,3562 €
Dampierre 1	CP1	890	23/03/1980	0,43 €																0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,3152 €
Dampierre 2	CP1	890	10/12/1980	0,43 €																0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,3152 €
Dampierre 3	CP1	890	30/01/1981	0,43 €																	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,2866 €
Dampierre 4	CP1	890	18/08/1981	0,43 €																	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,0287 €	0,2866 €
Flamanville 1	P4 REP 13	1330	04/12/1985	0,64 €	0,1500 €	0,1500 €																			0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,5569 €
Flamanville 2	P4 REP 13	1330	18/07/1986	0,64 €	0,1500 €	0,1500 €	0,1500 €																			0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,6641 €
Golfech 1	P4 REP 13	1310	07/06/1990	0,63 €				0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0422 €	0,6422 €
Golfech 2	P4 REP 13	1310	18/06/1993	0,63 €							0,1500 €	0,1500 €	0,1500 €	0,1500 €																	0,6000 €
Gravelines 1	CP1	910	13/03/1980	0,44 €																0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,3223 €
Gravelines 2	CP1	910	26/08/1980	0,44 €																0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,3223 €
Gravelines 3	CP1	910	12/12/1980	0,44 €																0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,3223 €
Gravelines 4	CP1	910	14/06/1981	0,44 €																	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,2930 €
Gravelines 5	CP1	910	28/08/1984	0,44 €	0,1500 €																			0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,3551 €
Gravelines 6	CP1	910	01/08/1985	0,44 €	0,1500 €	0,1500 €																			0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,0293 €	0,4758 €
Nogent 1	P4 REP 13	1310	21/10/1987	0,63 €	0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0422 €	0,0422 €	0,0422 €	0,0422 €	0,7687 €
Nogent 2	P4 REP 13	1310	14/12/1988	0,63 €		0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0422 €	0,0422 €	0,0422 €	0,7265 €
Paluel 1	P4 REP 13	1330	22/06/1984	0,64 €	0,1500 €																			0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,4498 €
Paluel 2	P4 REP 13	1330	14/09/1984	0,64 €	0,1500 €																			0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,4498 €
Paluel 3	P4 REP 13	1330	30/09/1985	0,64 €	0,1500 €	0,1500 €																			0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,5569 €
Paluel 4	P4 REP 13	1330	11/04/1986	0,64 €	0,1500 €	0,1500 €	0,1500 €																			0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,0428 €	0,6641 €
Penly 1	P4 REP 13	1330	04/05/1990	0,64 €				0,1500 €	0,1500 €	0,1500 €	0,1500 €																			0,0428 €	0,6428 €
Penly 2	P4 REP 13	1330	04/02/1992	0,64 €						0,1500 €	0,1500 €	0,1500 €	0,1500 €																		0,6000 €
St. Alban 1	P4 REP 13	1335	30/08/1985	0,64 €	0,1500 €	0,1500 €																			0,0430 €	0,0430 €	0,0430 €	0,0430 €	0,0430 €	0,0430 €	0,5579 €
St. Alban 2	P4 REP 13	1335	03/07/1986	0,64 €	0,1500 €	0,1500 €	0,1500 €																			0,0430 €	0,0430 €	0,0430 €	0,0430 €	0,0430 €	0,6649 €
St. Laurent 1	CP2	915	21/01/1981	0,44 €																	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,2946 €
St. Laurent 2	CP2	915	01/06/1981	0,44 €																	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,2946 €
Tricastin 1	CP1	915	31/05/1980	0,44 €																0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,3241 €
Tricastin 2	CP2	915	07/08/1980	0,44 €																0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,3241 €
Tricastin 3	CP3	915	10/02/1981	0,44 €																	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,2946 €
Tricastin 4	CP4	915	12/06/1981	0,44 €																	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,0295 €	0,2946 €
				Total	2,8500 €	2,2500 €	1,6500 €	1,3500 €	0,9000 €	0,7500 €	0,9000 €	0,4500 €	0,3000 €	0,1500 €	- €	- €	- €	0,0586 €	0,1153 €	0,3194 €	0,5531 €	0,6116 €	0,7288 €	0,9321 €	1,0900 €	1,2896 €	1,4450 €	1,5294 €	1,5294 €	1,6562 €	23,4085 €

Appendix 7

Collected data: Cost estimates under different scenarios between 2027-2050 for the EPR2 construction project (Grubler (2010: 5182; Fertel cited in Davis 2012: 61; IAEA 2020; Wakim & Moutarde 2020; RFI 2024; Nuclear News 2024; Thomas 2025; World Nuclear Association 2025a; World Nuclear News 2025).

EPR2	Estimate Model	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Reactor 1	EDF Estimate in 2023	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €				
	Cost Reduction 20%	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €				
	Cost Reduction 30%	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €				
	Cost Escalation, 2,4	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €				
	Cost Escalation, 3,5	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €				
	Flamanville 3, EDF estimate	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,20 €	0,20 €	0,20 €	0,20 €
	Flamanville 3, CDC estimate	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,87 €	0,87 €	0,87 €	0,87 €
	Greenpeace Low Estimate	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €
	Greenpeace High Estimate	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €
Reactor 2	EDF Estimate in 2023				1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	
	Cost Reduction 20%				1,31 €	1,31 €	1,31 €	1,31 €	1,31 €	1,31 €	1,31 €	1,31 €	
	Cost Reduction 30%				1,26 €	1,26 €	1,26 €	1,26 €	1,26 €	1,26 €	1,26 €	1,26 €	
	Cost Escalation, 2,4				1,51 €	1,51 €	1,51 €	1,51 €	1,51 €	1,51 €	1,51 €	1,51 €	1,51 €
	Cost Escalation, 3,5				1,59 €	1,59 €	1,59 €	1,59 €	1,59 €	1,59 €	1,59 €	1,59 €	1,59 €
	Flamanville 3, EDF estimate				1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,20 €
	Flamanville 3, CDC estimate				1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,87 €
	Greenpeace Low Estimate				1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €
	Greenpeace High Estimate				1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €
Reactor 3	EDF Estimate in 2023							1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €
	Cost Reduction 20%							1,22 €	1,22 €	1,22 €	1,22 €	1,22 €	1,22 €
	Cost Reduction 30%							1,12 €	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €
	Cost Escalation, 2,4							2,00 €	2,00 €	2,00 €	2,00 €	2,00 €	2,00 €
	Cost Escalation, 3,5							2,25 €	2,25 €	2,25 €	2,25 €	2,25 €	2,25 €
	Flamanville 3, EDF estimate							1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €
	Flamanville 3, CDC estimate							1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €
	Greenpeace Low Estimate							1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €
	Greenpeace High Estimate							1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €
Reactor 4	EDF Estimate in 2023										1,40 €	1,40 €	1,40 €
	Cost Reduction 20%										1,12 €	1,12 €	1,12 €
	Cost Reduction 30%										0,98 €	0,98 €	0,98 €
	Cost Escalation, 2,4										2,49 €	2,49 €	2,49 €
	Cost Escalation, 3,5										2,90 €	2,90 €	2,90 €
	Flamanville 3, EDF estimate										1,40 €	1,40 €	1,40 €
	Flamanville 3, CDC estimate										1,40 €	1,40 €	1,40 €
	Greenpeace Low Estimate										1,25 €	1,25 €	1,25 €
	Greenpeace High Estimate										1,72 €	1,72 €	1,72 €
Reactor 5	EDF Estimate in 2023												
	Cost Reduction 20%												
	Cost Reduction 30%												
	Cost Escalation, 2,4												
	Cost Escalation, 3,5												
	Flamanville 3, EDF estimate												
	Flamanville 3, CDC estimate												
	Greenpeace Low Estimate												
	Greenpeace High Estimate												
Reactor 6	EDF Estimate in 2023												
	Cost Reduction 20%												
	Cost Reduction 30%												
	Cost Escalation, 2,4												
	Cost Escalation, 3,5												
	Flamanville 3, EDF estimate												
	Flamanville 3, CDC estimate												
	Greenpeace Low Estimate												
	Greenpeace High Estimate												
Total	EDF Estimate in 2023	1,40 €	1,40 €	1,40 €	2,81 €	2,81 €	2,81 €	4,21 €	4,21 €	2,81 €	4,21 €	4,21 €	2,81 €
	Cost Reduction 20%	1,40 €	1,40 €	1,40 €	2,71 €	2,71 €	2,71 €	3,93 €	3,93 €	2,53 €	3,65 €	3,65 €	2,34 €
	Cost Reduction 30%	1,40 €	1,40 €	1,40 €	2,67 €	2,67 €	2,67 €	3,79 €	3,79 €	2,39 €	3,37 €	3,37 €	2,11 €
	Cost Escalation, 2,4	1,40 €	1,40 €	1,40 €	2,91 €	2,91 €	2,91 €	4,92 €	4,92 €	3,51 €	6,00 €	6,00 €	6,00 €
	Cost Escalation, 3,5	1,40 €	1,40 €	1,40 €	2,99 €	2,99 €	2,99 €	5,24 €	5,24 €	3,84 €	6,74 €	6,74 €	6,74 €
	Flamanville 3, EDF estimate	1,40 €	1,40 €	1,40 €	2,81 €	2,81 €	2,81 €	4,21 €	4,21 €	3,00 €	4,41 €	4,41 €	3,20 €
	Flamanville 3, CDC estimate	1,40 €	1,40 €	1,40 €	2,81 €	2,81 €	2,81 €	4,21 €	4,21 €	3,68 €	5,09 €	5,09 €	4,56 €
	Greenpeace Low Estimate	1,25 €	1,25 €	1,25 €	2,50 €	2,50 €	2,50 €	3,75 €	3,75 €	3,75 €	5,00 €	5,00 €	5,00 €
	Greenpeace High Estimate	1,72 €	1,72 €	1,72 €	3,44 €	3,44 €	3,44 €	5,17 €	5,17 €	5,17 €	6,89 €	6,89 €	6,89 €

EPR2	Estimate Model	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Reactor 1	EDF Estimate in 2023												
	Cost Reduction 20%												
	Cost Reduction 30%												
	Cost Escalation, 2,4												
	Cost Escalation, 3,5												
	Flamanville 3, EDF estimate	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €							
	Flamanville 3, CDC estimate	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €							
	Greenpeace Low Estimate												
	Greenpeace High Estimate												
Reactor 2	EDF Estimate in 2023												
	Cost Reduction 20%												
	Cost Reduction 30%												
	Cost Escalation, 2,4	1,51 €	1,51 €										
	Cost Escalation, 3,5	1,59 €	1,59 €	1,59 €									
	Flamanville 3, EDF estimate	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €				
	Flamanville 3, CDC estimate	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €				
	Greenpeace Low Estimate	1,25 €	1,25 €	1,25 €									
	Greenpeace High Estimate	1,72 €	1,72 €	1,72 €									
Reactor 3	EDF Estimate in 2023	1,40 €	1,40 €										
	Cost Reduction 20%	1,22 €	1,22 €										
	Cost Reduction 30%	1,12 €	1,12 €										
	Cost Escalation, 2,4	2,00 €	2,00 €	2,00 €	2,00 €	2,00 €							
	Cost Escalation, 3,5	2,25 €	2,25 €	2,25 €	2,25 €	2,25 €	2,25 €						
	Flamanville 3, EDF estimate	1,40 €	1,40 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	
	Flamanville 3, CDC estimate	1,40 €	1,40 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	
	Greenpeace Low Estimate	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €						
	Greenpeace High Estimate	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €						
Reactor 4	EDF Estimate in 2023	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €							
	Cost Reduction 20%	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €							
	Cost Reduction 30%	0,98 €	0,98 €	0,98 €	0,98 €	0,98 €							
	Cost Escalation, 2,4	2,49 €	2,49 €	2,49 €	2,49 €	2,49 €	2,49 €	2,49 €	2,49 €				
	Cost Escalation, 3,5	2,90 €	2,90 €	2,90 €	2,90 €	2,90 €	2,90 €	2,90 €	2,90 €	2,90 €			
	Flamanville 3, EDF estimate	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €	0,20 €
	Flamanville 3, CDC estimate	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €	0,87 €
	Greenpeace Low Estimate	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €			
	Greenpeace High Estimate	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €			
Reactor 5	EDF Estimate in 2023	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €				
	Cost Reduction 20%	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €				
	Cost Reduction 30%	0,98 €	0,98 €	0,98 €	0,98 €	0,98 €	0,98 €	0,98 €	0,98 €				
	Cost Escalation, 2,4	2,98 €	2,98 €	2,98 €	2,98 €	2,98 €	2,98 €	2,98 €	2,98 €	2,98 €	2,98 €	2,98 €	
	Cost Escalation, 3,5	3,56 €	3,56 €	3,56 €	3,56 €	3,56 €	3,56 €	3,56 €	3,56 €	3,56 €	3,56 €	3,56 €	3,56 €
	Flamanville 3, EDF estimate	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,20 €	0,20 €	0,20 €	0,20 €
	Flamanville 3, CDC estimate	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,87 €	0,87 €	0,87 €	0,87 €
	Greenpeace Low Estimate	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €
	Greenpeace High Estimate	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €
Reactor 6	EDF Estimate in 2023				1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	
	Cost Reduction 20%				1,12 €	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €	1,12 €	
	Cost Reduction 30%				0,98 €	0,98 €	0,98 €	0,98 €	0,98 €	0,98 €	0,98 €	0,98 €	
	Cost Escalation, 2,4				3,47 €	3,47 €	3,47 €	3,47 €	3,47 €	3,47 €	3,47 €	3,47 €	3,47 €
	Cost Escalation, 3,5				4,21 €	4,21 €	4,21 €	4,21 €	4,21 €	4,21 €	4,21 €	4,21 €	4,21 €
	Flamanville 3, EDF estimate				1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,20 €
	Flamanville 3, CDC estimate				1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	1,40 €	0,87 €
	Greenpeace Low Estimate				1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €	1,25 €
	Greenpeace High Estimate				1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €	1,72 €
Total	EDF Estimate in 2023	4,21 €	4,21 €	2,81 €	4,21 €	4,21 €	2,81 €	2,81 €	2,81 €	1,40 €	1,40 €	1,40 €	- €
	Cost Reduction 20%	3,46 €	3,46 €	2,25 €	3,37 €	3,37 €	2,25 €	2,25 €	2,25 €	1,12 €	1,12 €	1,12 €	- €
	Cost Reduction 30%	3,09 €	3,09 €	1,97 €	2,95 €	2,95 €	1,97 €	1,97 €	1,97 €	0,98 €	0,98 €	0,98 €	- €
	Cost Escalation, 2,4	8,98 €	8,98 €	7,47 €	10,94 €	10,94 €	8,94 €	8,94 €	8,94 €	6,45 €	6,45 €	6,45 €	3,47 €
	Cost Escalation, 3,5	10,29 €	10,29 €	10,29 €	12,91 €	12,91 €	12,91 €	10,67 €	10,67 €	10,67 €	7,77 €	7,77 €	7,77 €
	Flamanville 3, EDF estimate	4,60 €	4,60 €	3,40 €	4,80 €	4,80 €	3,40 €	3,40 €	3,40 €	1,99 €	1,99 €	1,99 €	0,59 €
	Flamanville 3, CDC estimate	5,96 €	5,96 €	5,43 €	6,83 €	6,83 €	5,43 €	5,43 €	5,43 €	4,03 €	4,03 €	4,03 €	2,62 €
	Greenpeace Low Estimate	5,00 €	5,00 €	5,00 €	5,00 €	5,00 €	5,00 €	3,75 €	3,75 €	3,75 €	2,50 €	2,50 €	2,50 €
	Greenpeace High Estimate	6,89 €	6,89 €	6,89 €	6,89 €	6,89 €	6,89 €	5,17 €	5,17 €	5,17 €	3,44 €	3,44 €	3,44 €