Centre for Energy, Petroleum
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Nuclear power – a clean energy transition fuel in Europe?; An analysis of legal and policy developments about nuclear power under the European Union law, and a perspective on decommissioning frameworks for nuclear power plants

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Abstract

Nuclear energy has been long considered by policy makers as a low carbon energy source. However, current trends in national policies indicate threats to nuclear energy's favoured position as a preferred driver of clean energy transition. This thesis aims to examine the status of nuclear power in the energy transition policies in France, Germany and the UK. It investigates the legal and policy framework for nuclear power as directed by the Euratom Treaty and the Lisbon Treaty. The work also investigates decommissioning of nuclear plants in three European countries (France, Germany, and the United Kingdom (UK) in the context of their liabilities and obligations. Two of these (France and Germany) are Member States of the European Union (EU) and the UK, is a former Member State. The thesis uses comparative and historical methodology to critically consider international covenants, the multi-national aquis of the EU (which body of law holds legal primacy across the bloc), and both national legal and policy frameworks to explore nuclear energy's potential role in the energy transition. The work also investigates the role of state in a liberalised EU market for promotion of nuclear energy as a clean source of power. The works finds out that EU law does not bar adoption of preferential national choice in favour of nuclear power, and the recent jurisprudence on the EU competition law also permits Member State measures to adopt nuclear power as a preferential source of energy subject to their compliance with both EU state-aid rules and environmental law.

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Declaration

I, Muhammad Maroof Mittha, hereby certify that I am the author of this work; that I have consulted all the references cited; that the work, of which this dissertation is a record, has been completed by me and that it has not previously been accepted for a higher degree.

Signature

10 September 2021

Figures, Tables and Acronyms

Figures

Tables

Acronyms

ANDRA	-	*French National Agency for Radioactive Waste Management*
APWR	-	*Advanced Pressurized Water Reactor*
Cion	-	*European Commission*
ECJ	-	*European Court of Justice*
ETS	-	*Emissions Trading System*
EU	-	*European Union*
GCR	-	*Gas Cooled Reactors*
GTS	-	*Gigatonnes*
General Court	-	*European General Court*
GHG	-	*Greenhouse Gases*
IPCC	-	*Inter-governmental Panel on Climate Change*
MW	-	*Megawatt*
NDA	-	*Nuclear Decommissioning Authority*
NDC	-	*Nationally Determined Contribution*
NPP	-	*Nuclear Power Plant*
NS Deal	-	*Nuclear Sector Deal*
NST Deal	-	*North Sea Transition Deal*
ONS	-	*Office for National Statistics*
TFEU	-	*Treaty for Functioning of European Union*
UNFCCC	-	*United National Framework Convention for Climate Change*
VRE	-	*Variable Renewable Energy sources*

Everyone is entitled to his own opinion but not his facts

US Senator Patrick Daniel Moynihan

Contents

1. Introduction

The concept of atom as a basic unit of matter existed since the time of Greek philosophers. In the last decade of the nineteenth century, Roentgen and Becquerel respectively discovered X-rays (1895) and ‘Radioactivity’ (1896) followed by discovery of electron in 1911.[1] Smyth argued that these discoveries, among many other contributions, led to the development of atomic physics into the fields of nuclear physics.[2] The field of nuclear physics also influenced the idea of producing energy by breaking atomic elements (nuclear fission) and by 1939, the possibility of nuclear chain reactions for energy production was established.[3]

In 1942, the first nuclear reactor, ‘Pile,’ had been assembled and constructed at the University of Chicago.[4] It took less than fifty years for humans after the discovery of X-rays and radioactivity, to execute the nuclear chain reaction for energy production into a technological reality. Troman termed this short time as salutary as compared to the timescale of radioactive effects.[5]

The discovery of nuclear fission gained popular attention for its military use by the United States of America (US) in the second world war bringing the world war to an abrupt conclusion.[6] After the war many European nations were involved in a race for developing their nuclear capacity. However, the use of atomic power for peace and energy production was mentioned, for the first time, on an international forum in 1953.[7]

The post war scenario in the context of Europe also included joint collaborative efforts to thwart conflict at the scale of the concluded war. These efforts included establishment of North Alliance Treaty Organisation (NATO), creation of the Council of Europe, formulating economic cooperation plan for European countries (Schuman Plan).[8]

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[1] HD Smyth, 'From X-rays to nuclear fission' (1947) 35 American Scientist 485,
[2] Ibid
[3] Manhattan Project;, 'The Discovery of Fission' (*US Department of Energy,* 2021) <https://www.osti.gov/opennet/manhattan-project-history/Events/1890s-1939/discovery_fission.htm> accessed 22-Jun-2022
[4] Stephen Tromans, *Nuclear law: the law applying to nuclear installations and radioactive substances in its historic context* (Bloomsbury Publishing 2010), 7
[5] Ibid, 6
[6] Manhattan Project;, '1945 Dawn of the Atomic Era (1945)' (*US Department of Energy,* 2021) <https://www.osti.gov/opennet/manhattan-project-history/Events/1945/1945.htm> accessed 22-Jun-2022
[7] Mara Drogan, 'The Nuclear imperative: Atoms for Peace and the development of US policy on exporting nuclear power, 1953-1955' (2016) 40 Diplomatic History 948
[8] European Union., 'History of the European Union 1945-59' (*EU,* 2021) <https://european-union.europa.eu/principles-countries-history/history-eu/1945-59_en> accessed 22-Jun-2022

A study titled 'History of European Union Research Policy' links the nuclear power with the emergence of an early social and political movement in favour of a continental 'European Project', which momentum in the year 1957 led to the establishment of the European Coal and Steel Community, the main institutional fore-runner to the EU, and the European Atomic Energy Community Treaty (Euratom Treaty).[9] The International Atomic Energy Agency (IAEA) was also established in 1957, signifying international cooperation required for monitoring the developments in nuclear power.

Nuclear energy for electricity also started gaining momentum, and during 1960s, the nuclear power plants had reached commercial acceptability. Char et al commented that robust support and promotion for nuclear power plants was observed in response to the earlier fossil fuel supply shock in 1970s.[10] Many states, including France, Germany, and the UK embarked on expanding their civil nuclear capacity which seemed advantageous due to economies of scale for nuclear power and abundance of nuclear fuel reserves.[11]

The vigorous expansion in civilian nuclear power noted in 1970's, however, could not continue for many reasons which included financial, technical, and political reasons. It was significantly stalled by major nuclear incidents at Three Miles Island (in the US) and Chernobyl (in the Ukrainian Soviet Socialist Republic/modern-day Ukraine).[12,13] Nevertheless, a 'nuclear renaissance' was being heralded again in Europe in the early 2000s in light of the sector's potential to substantially meet the challenges of climate change.[14]

The discussion, however, stalled due to another major nuclear incident at Fukushima Daiichi, Japan (2011). This incident was at once followed by the vigorous nuclear phase-out policies from some EU countries. For instance, the German Parliament resolved on phasing out the nuclear power and many decisions were adopted to regulate the German phase out.[15] One notable event was about France's presidential election campaigns in 2012 which also revolved around plans and proposals of reducing share of nuclear power in the energy mix. President Francois Hollande campaigned for reduction of nuclear share in the energy

[9] Luca Guzzetti;, *A brief history of European Union Research Policy* (European Commission 1995) ,7
[10] NL Char and BJ Csik, 'Nuclear power development: History and outlook' (1987) 3 IAEA Bulletin 1987
[11] Ibid
[12] Spencer Wheatley, Benjamin Sovacool and Didier Sornette, 'Of disasters and dragon kings: a statistical analysis of nuclear power incidents and accidents' (2017) 37 Risk analysis 99
[13] Hoseok Nam, Satoshi Konishi and Ki-Woo Nam, 'Comparative analysis of decision making regarding nuclear policy after the Fukushima Dai-ichi Nuclear Power Plant Accident: Case study in Germany and Japan' (2021) 67 Technology in Society 101735
[14] William J Nuttall and Simon Taylor, 'Financing the nuclear renaissance' (2008) Cambridge Working Paper in Economics 0829
[15] Lars Kramm, 'The German Nuclear Phase-Out After Fukushima: A Peculiar Path or an Example for Others?' (2012) 3 Renewable Energy Law and Policy Review 251

mix from 75% to 50%; he eventually won the elections.[16] Yet, despite, these incidents, nuclear power has not been completely ruled out or abandoned by the policy makers for low carbon energy transition to meet the temperature targets.*

Meanwhile, the World leaders had agreed in 2015 on mitigating the temperature increase through a series of international agreements. Implementing the resulting mitigation measures requires plans, strategies, and cooperation. The energy sector, heavily dependent on fossil fuels and being one of the largest contributors to Greenhouse Gas (GHG emissions) also require the energy transition to low carbon and clean sources. In this regard, it has been widely agreed that this energy transition is necessitated by climatic changes, not by economic or technological reasons, only. Therefore, the policy response for this energy transition must be swift with due consideration to all available clean energy sources.

This dissertation will discuss climate change and the need of energy transition towards low carbon sources. Chapter 1, besides delving on the climate changes and energy transition, will compare and examine the national strategies of France, Germany and the UK adopted to deal with the climate change. The work will investigate how the policy makers have considered and decided on the question of nuclear power in energy mix in the EU's and UK's energy transitions. Chapter 2 will further examine whether the energy policy and legal framework in the EU permits any state measures to adopt and or prefer nuclear energy in a liberalised energy market in view of the Euratom Treaty and the Treaty on the Functioning of the European Union (TFUE also referred as the Lisbon Treaty). Chapter 3 will analyse the legal and policy mechanisms and frameworks to deal with concerns about decommissioning nuclear plants in France, Germany (EU members) and the UK (erstwhile EU member).

France, Germany, and the UK developed their first commercial nuclear programs in the same time frame (1950-1970).[17] However, their current pathways towards energy transition show a varying attitude towards nuclear power. These varying pathways make an interesting

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[16] World Nuclear News;, 'Hollande wins French presidential election' (*WNN,* 2012) <https://www.world-nuclear-news.org/NP-Hollande_wins_French_presidential_election-0805124.html> accessed 22-Jun-2022

* At the time of this publication, the discussion nuclear power as a relevant fuel for Europe had been brought up again in the wake of recent geo-political developments due to war in Ukraine. Reference can be made to Ian Palmer;, 'Natural Gas Versus Nuclear Energy In Europe: The Challenges Of War And Climate' (Forbes 2022) < https://www.forbes.com/sites/ianpalmer/2022/03/20/natural-gas-versus-nuclear-energy-in-europe-the-challenges-of-war-and-climate/?sh=f1fba4b63ec0> accessed 22-Jun-2022

[17] IAEA, 'Country Nuclear Power Profiles' (*IAEA,* 2018) <https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2018/pages/index.htm> accessed 22-Jun-2022

case for comparison of challenges and issues faced by nuclear power across Europe. The comparison also draws attention after withdrawal of the UK to from the European Union (EU) also referred as 'Brexit'.

The energy mix primarily has remained a national choice in the EU; however, a supranational EU energy policy integration had been observed and discussed as early as 2013.[18] In this context, study of development of nuclear laws and policies in France and Germany (both members of EU) and the UK (now not an EU member) will be a significant exercise.

1.1 Climate Change, Nuclear Energy in Energy Transition, and Policy Response by France, Germany and UK

Climate changing is happening, and in the words of Jay Robert Inslee, an American politician, 'we would be the last generation who can do something about it.' Energy has played an enormous role in the industrial and technological progress in last 150 years. Nevertheless, this progress has come at the cost of adverse effects on the earth ecology and environment. This chapter will discuss the impact of climate change and the international response for its mitigation; the development of energy transition policies for decarbonisation, and potential of nuclear energy as a clean power; the EU's and the UK's strategies and actions about energy transition to deal with climate change and energy security issues.

1.2 Code Red

Global warming has been widely agreed to be attributed to the anthropogenic greenhouse gas emissions due to industrialisation of human societies.[19] However, the scale and pace of climate change and climatic threats attained global attention when the Working Group I of the International Panel of Climate Change (IPCC), a UN body, shared (9 August 2021) its findings reiterating that global warming was already causing extreme weather events.[20]
The increased climatic effects of the global warming were already ringing bells even before the issuance of this report. For instance, the EU's European Environment Agency (EEA)

[18] Maltby T, 'European Union energy policy integration: A case of European Commission policy entrepreneurship and increasing supranationalism' (2013) 55 Energy policy 435
[19] Kevin E. Trenberth, 'Climate change caused by human activities is happening and it already has major consequences' (2018) 36 Journal of Energy & Natural Resources Law 463
[20] Intergovernmental Panal on Climate Change, *AR6 Climate Change 2021: The Physical Science Basis* (IPCC 2021), Ch 11, 120

issued a report (17 November 2021) indicating an increased risk of forest fires due to climate change.[21] Another example of these climatic changes was recorded through a surge in Greenland's glacial meltdown, and it was reported that 8.5 billion (bn) tonnes (BT) of surface mass were lost on one day (27 July 2021) stated as 'enough to drown the entire US state of Florida in two inches.'[22] Increases in global temperatures since the year 1850, and the glacial meltdown trend in 2021, are illustrated in Figures 1 and 2 below, respecitively.

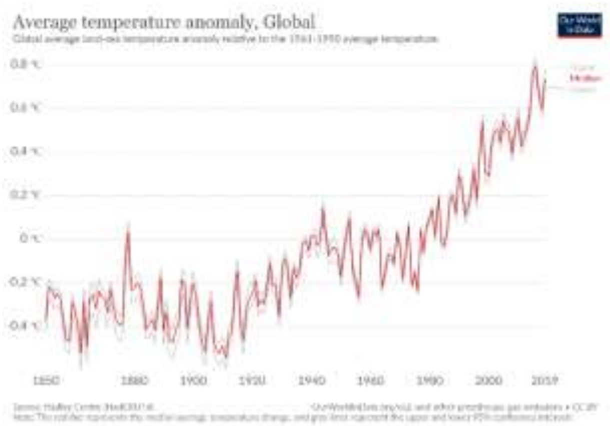

Figure 1: A global increase in temperature[23]

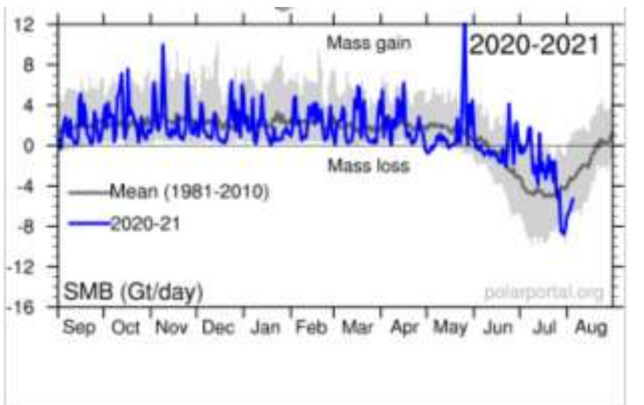

Figure 2: Glacial meltdown for Greenland in 2020-2021[24]

[21] European Environment Agency, 'Europe's changing climate hazards — an index-based interactive EEA report' (*EEA,* 2021) < https://www.eea.europa.eu/publications/europes-changing-climate-hazards-1> accessed 22-Jun-2022

[22] Oliver Milman, 'Greenland: enough ice melted on single day to cover Florida in two inches of water' (*The Guardian,* 2021) <https://www.theguardian.com/environment/2021/jul/30/greenland-ice-sheet-florida-water-climate-crisis> accessed 22-Jun-2022

[23] Hannah; Ritchie and Max Roser, 'Global average temperatures have increased by more than 1℃ since pre-industrial times' (*Our World in Data,* 2020) <https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions> accessed 22-Jun-2022

[24] Polar Portal, 'Greenland: Surface conditions' (*Polar Portal,* 2021) <http://polarportal.dk/en/greenland/surface-conditions/> accessed 22-Jun-2022

1.3 Paris Agreement – Agreeing on Goals and Formulating Pathways

To much acclaim at the time, the international community attempted to respond to the global warming in 2015, resulting in a largely voluntary agreement (meaning greater flexibility in response but also, potentially, less coherence and efficacy of global action on climate in the aggregate) that was 'bottom-up' in terms of nationally determined commitments, rather than prescriptive and 'top-down' as per the previously agreed Kyoto Protocol of 1992.[25] The agreement of 2015 is named after the city in which it was negotiated: the "Paris Agreement".

Over time, the United Nations General Assembly has adopted various resolutions and treaties for prevention of global warming, i.e., Convention for the Protection of the Ozone Layer, 1985 (Vienna Convention), and the Protocol on Substances that Deplete the Ozone Layer, 1987 (Montreal Protocol).

The United Nations adopted the United National Framework Convention for Climate Change (UNFCCC) in 1994, under which auspices the Paris Agreement was negotiated twenty-one years laters.

The primary objectives of all these international initiatives were to stabilize GHG concentration at livable levels for humanity.

The Paris Agreement has received global acceptance as one hundred ninety-three State* parties have ratified the Paris Agreement.[26] The Paris Agreement is as an international legal covenant directing member parties to strengthen global response to the threats of climate change by adaptation and mitigation. In adopting the Paris Agreement, the Conference of Parties noted with concern that more extraordinary efforts would be required by the parties to reduce the emissions up to 40 gigatons (Gts).[27] The Paris Agreement set the target to restrain global temperatures rise to well below 2.0°C in relation to pre-industrial times and pursue efforts to limit it to 1.5°C above pre-industrial times. The obligation was agreed in view of earlier reports issued by international climate change organisations.

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[25] United Nations, 'The Paris Agreement' (*UN,* 2015) <https://www.un.org/en/climatechange/paris-agreement> accessed 22-Jun-2022

* At the time of this publication, the number of state members have increased to 196. Reference is made to the note above.

[26] Nations, 'The Paris Agreement'

[27] United Nations Framework Convention for Climate Change, *Addendum Report of the Conference of the Parties on its twenty-first session* (UNFCC 2016)

1.4 Energy Transition and Potential Role of Nuclear Energy

1.4.1 Energy and Climate Change

The IPCC, a UN body established to provide scientific assessments on climate change, had in one of its report (2010) pointed out that energy was the most significant contributor (35%) to GHG emissions.[28] The IPCC's Report had established that the contribution from the energy sector amplified due to economic growth and additional usage of coal in the energy mix.[29] The contribution of energy sector is also confirmed by later data illustrated in Figure 3.

While reviewing the energy mix the above mentioned IPCC's report confirmed that coal, oil, and gas represented 84% of the energy production worldwide. These statements are also concurred by other data published in 2021. The illustrations of sector-wise contribution to the GHG emissions; and energy production from the major source are shown in Figures 3 and 4.

This data suggests that the energy sector remains one of the significant contributors to the global warming and more than three quarters of energy is produced from hydrocarbons. International Energy Agency (IEA), in one of its reviews (2021) of the energy sector, quantified the CO_2 emissions from the energy sector at 31.5 Gt, 50% higher in annual average than what was at the start of the industrial revolution.[30] The findings of Working Group I of the IPCC, the climatic incidents, and current position of carbon intensive energy sector demands a swift energy transition to low carbon energy sources.

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[28] Intergovernmental Panel on Climate Change, *Climate Change 2014 Mitigation of Climate Change* (Cambridge University Press 2014)
[29] Ibid, 516
[30] International Energy Agency, *Global Energy Review 2021: Assessing the effects of economic recoveries on global energy demand and CO_2 emissions in 2021* (IEA 2021), 10

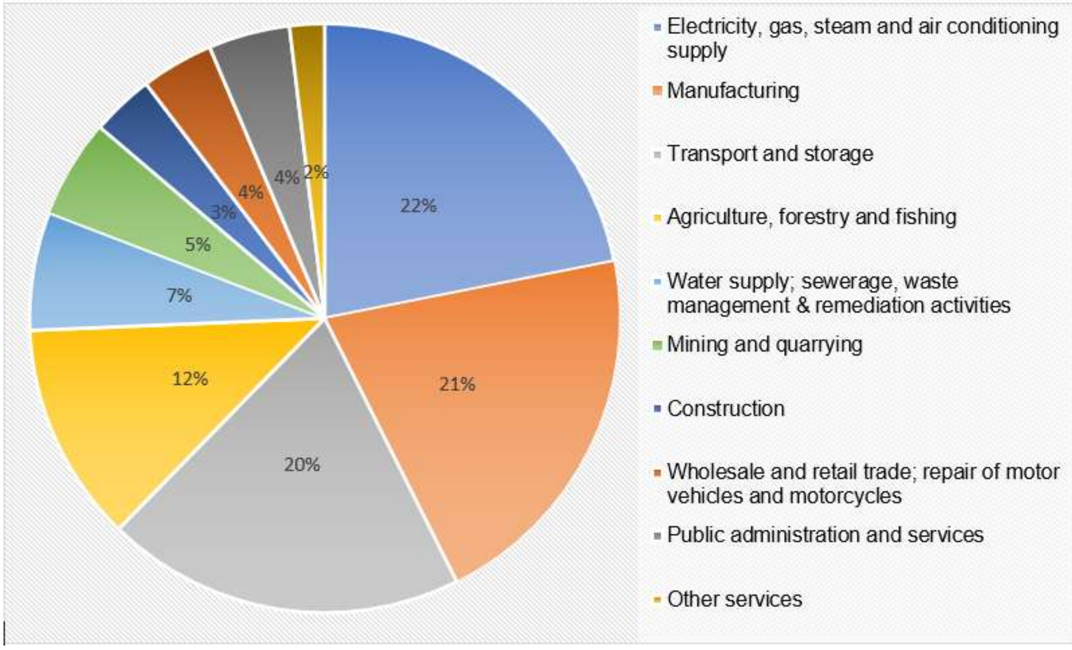

Figure 3: Contribution of major sectors to GHG emissions as shared by ONS UK[31]

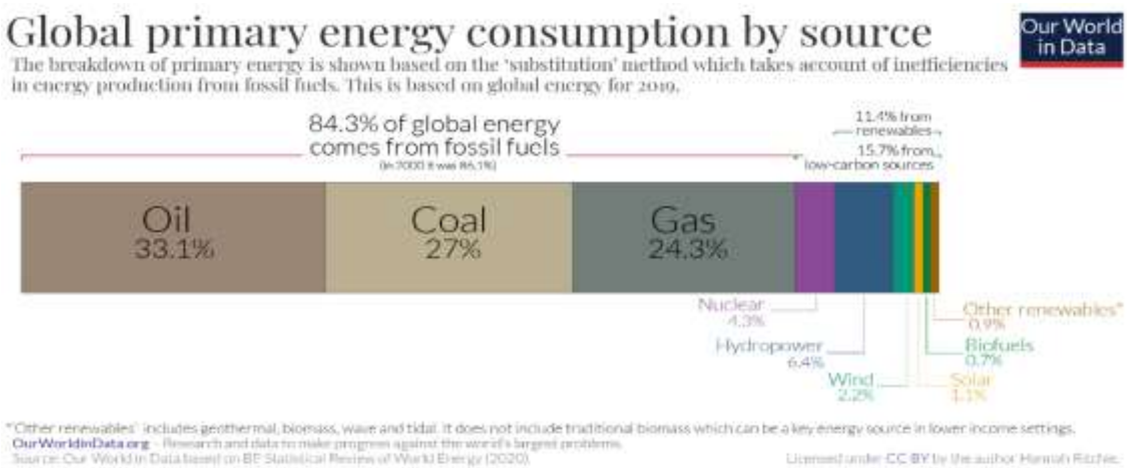

Figure 4: A global energy consumption by source[32]

1.4.1 Energy Transition to Low Carbon Fuels

The energy transition to low carbon sources had been indicated in one of the earlier reports of the IPCC in 1990.[33] The IPCC while exploring strategies to respond to climate changes

[31] Office of National Statistics, 'Atmospheric emissions: greenhouse gases by industry and gas' (*ONS UK,* 2021) <https://www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsatmosphericemissionsgreenhousegasemissionsbyeconomicsectorandgasunitedkingdom> accessed 22-Jun-2022, Illustration by author

[32] Hannah
Roser Ritchie, Max,, 'Global primary energy consumption by source' (*Our World in Data,* 2019) <https://ourworldindata.org/energy-mix?country=> accessed 22-Jun-2022

[33] Intergovernmental Panal on Climate Change, *FAR Climate Change: The IPCC Response Strategies* (IPCC 1990), XXXV

also considered the role of carbon-dominant energy sector. IPCC appreciated the critical role of energy supply for economic growth and advised constructing a comprehensive strategy for dealing with environmental impact of the energy sector.[34]

The transitions in a liberalised energy market usually occur due to technological advancement leading to commercial and economic benefits, without any external intervention. However, in its treatise on energy transition, Rojey, a former director of Sustainable Development at Institut Français du Pétrole – IFP, aptly put the major hurdle for energy transition by suggesting that the energy transition for low carbon sources would be imposed by climatic considerations without any obvious substitution options.[35] The statement also implied that available substitution options were not to be naturally adopted by the market due to technological or economic restraints, rather they will require an active policy guidance and interference to a drive towards low carbon energy generation.

The concerns faced by low-carbon energy transition also draw attention towards 'energy trilemma' faced by the energy policy agenda in a similar situation. Heffron elaborated energy trilemma as a concept that the energy agenda would be driven by three driving factors namely, politics (security of supply), economics (finance), and the environment (climate mitigation issues).[36] Similarly, in this energy transition towards decarbonisation, national energy systems globally suffer from environmental constraints, security of supply, and energy costs. Figure 5 is an illustrative explanation of the energy trilemma.

Figure 5: Energy trilemma[37]

[34] Ibid
[35] Alexandre Rojey, *Energy and Climate: How to achieve a successful energy transition* (John Wiley & Sons 2009), 35
[36] Raphael J. Heffron, Darren McCauley and Benjamin K. Sovacool, 'Resolving society's energy trilemma through the Energy Justice Metric' (2015) 87 Energy Policy 168
[37]ibid

The drive towards low carbon energy transition faces unique challenges which would require a detailed consideration of all commercially available clean energy sources and their potential role in this transition. This work would explore the potential role of nuclear power in a clean energy transition due to its advantages.

1.4.3. Potential of Nuclear Power in the Energy Transition

Since its first age of development, nuclear energy has also been viewed as a clean source of energy and has low GHG emissions.[38] A report by IEA (2019) states that from 1971 to 2018, nuclear power avoided carbon dioxide emission to the amount of 63 Gt CO_2.[39] This characteristic of nuclear power of being a low carbon energy source has also got the attention of policy makers to determine and allocate a possible role for energy transition. Figure 6 shows the cumulative global CO_2 emissions avoided by nuclear power up till 2018.

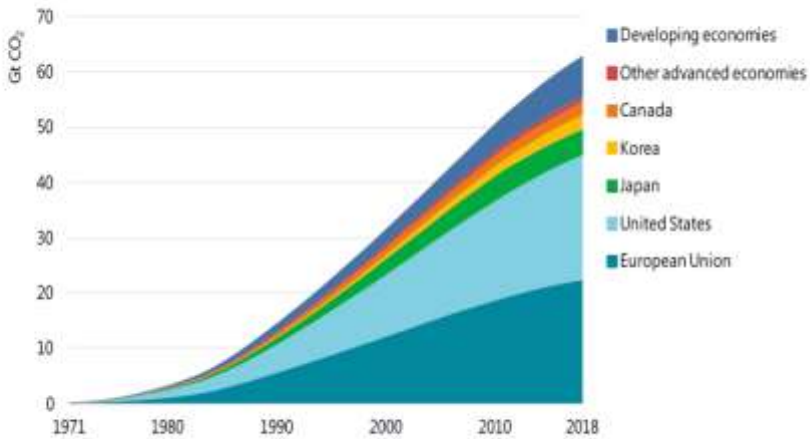

Figure 6: Cumulative CO_2 global emissions avoided till 2018[40]

IAEA elucidated the position in their report in 2020. It stated that an energy mix in a low carbon scenario would be based on a contribution from variable renewable energy sources (VRE) and low carbon dispatchable energy sources.[41] Following is a brief account of reasons to develop a case for the potential role of nuclear power in energy transition policy.

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[38] International Atomic Energy Agency, *Climate Change and Nuclear Power 2020* (IAEA 2020), 19
[39] International Energy Agency, *Nuclear Power in a Clean Energy System* (IEA 2019), 9
[40] Ibid, 9
[41] Note 38, 39

A. Firm power and energy security

Cook noted that a specific portion of the energy demand is fixed, which must be supplied continuously, and be predictable. [42] This portion of energy demand is the baseload, and nuclear energy is a good source that can be used to supply the baseload. Fox also stated that nuclear power provides the firm power (energy available during an agreed period) to the grid, giving flexibility of 24/7 operation to the grid.[43]

The nuclear chain reaction creates an immense amount of energy through nuclear fission. An illustration of the nuclear chain reaction to produce energy is described in Figure 7. The capacity factor of a nuclear power plant is contrary to the VRE, which are mainly dependant on the wind to blow or the sun to shine. This capacity and flexibility to provide dispatchable energy qualify one element of the energy trilemma concerning energy security. Bodel et al. state that the UK, until recently, viewed nuclear power as a means to meet the baseload capacity.[44]

B. Fuel facts

Sufficiency of fuel:

Uranium (U) has abundant reserves for nuclear power production. Peel indicates that Uranium reserves are sufficient to support the current fleet of nuclear plants for the next two decades, even in the high demand scenario.[45] The Red Book more specifically states that 28% and 22% of identified resources available at the cost of $130/kgU[46] and $260/kgU respectively would be consumed for meeting high projected growth in next two decades.[47]

It has also been asserted that the reserves of thorium are more than that of uranium.[48] Tsoulfanidis states that the identified and estimated sources of thorium across the globe are 3.6 Million Tonnes (MT).[49] For instance, India has six times more thorium than uranium, and

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[42] Helen G Cook, *The law of nuclear energy* (Sweet & Maxwell, Thomson Reuters 2018), section 1-03
[43] Michael H Fox, *Why we need nuclear power: The environmental case* (Oxford University Press 2014), 103
[44] William Bodel, Gregg Butler and Juan Matthews, 'Nuclear energy for net zero: a strategy for action' 1 District heating 2
[45] Ross Peel, 'Nuclear Fuel Reserves' in Claudia Ley (ed), *Kirk-Othmer Encyclopedia of Chemical Technology* (2021), 29
[46] All dollars quoted are United States Dollars.
[47] Joint Report by IAEA and NEA, *Uranium 2020 : Resources, Production and Demand* (OECD 2020), 113
[48]Ross Peel, 'Nuclear Fuel Reserves' in Claudia Ley (ed), *Kirk-Othmer Encyclopedia of Chemical Technology* (2021), 27
[49] Nicholas Tsoulfanidis, *Nuclear energy: selected entries from the Encyclopedia of sustainability science and technology* (Springer 2012), 468

it has been advancing on the thorium reactor technology.[50] In this context, nuclear power, either from uranium or thorium as fuel, has sufficient reserves, and this sufficiency of supply enlarges the potential of nuclear power in a change towards low carbon energy.

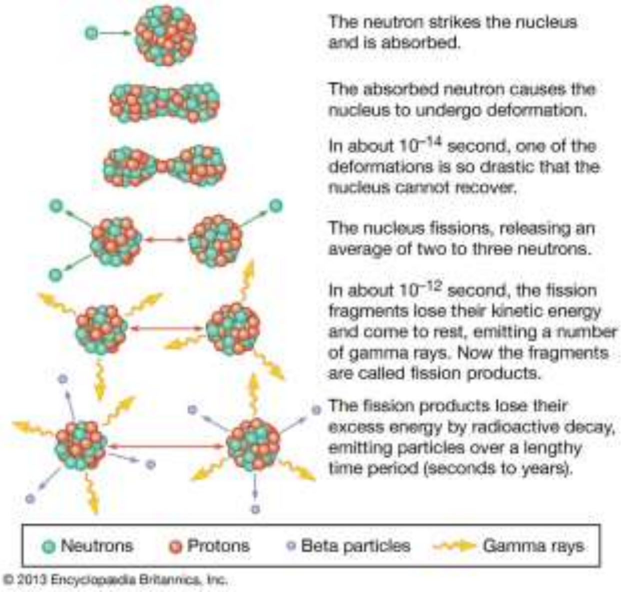

Figure 7: Fission of uranium nucleus (chain reaction) to produce energy[51]

The efficiency of fuel and transportation:

Nuclear fuel has a much higher energy density than fossil fuels. The IAEA reported that one kilogram of uranium, coal, and oil produce 50,000kw/h, 3kw/h, and 4 kw/h of electricity.[52] The efficiency of Uranium makes no comparison in terms of energy density with fossil fuels. Hence, a lower volume of nuclear fuel is required as compared to fossil fuels. Cook comments that this lower fuel volume would also mean a lesser environmental impact on mining, and other concerns, i.e., transport and storage compared to fossil fuels.[53]

Fuel cost:

Tsoulfanidis stated that the fuel costs remain 10-16% of the total cost of electricity in nuclear energy production.[54] Hence the fuel price has minimal effect on the cost of electricity. The fuel cost mentioned above also include prices of Uranium enrichment and fabrication-transport costs. Tsoulfanidis also commented that in all these components of fuel cost, only

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[50] Roy Nersesian, *Energy for the 21st century: a comprehensive guide to conventional and alternative sources* (Routledge 2014), 286
[51] Britannica Encyclopaedia, 'Sequence of events in the fission of a uranium nucleus by a neutron.' (*Britannica,* 2013) <https://www.britannica.com/technology/nuclear-reactor> accessed 22-Jun-2022
[52] International Atomic Energy Agency, *Climate Change and Nuclear Power* (IAEA 2016), 60
[53]Helen G Cook, *The law of nuclear energy* (Sweet & Maxwell, Thomson Reuters 2018), section 1-03
[54] Nicholas Tsoulfanidis, *Nuclear energy: selected entries from the Encyclopedia of sustainability science and technology* (Springer 2012), 2

the cost of Uranium has remarkably changed in the last five decades.[55] The proportion of cost of fuel in the entire power production indicates a less margin of volatility as compared to the construction costs.

C. Operating costs

The operations and maintenance costs (O&M costs) for nuclear plants are primarily fixed. However, these O&M costs may fluctuate depending on the power production from that power plant. Thomas commented that large power production would reduce the O&M costs per MWh.[56] Cook also concurred with the observation and further commented that Nuclear Power Plants (NPPs) would be immune from carbon pricing and emission penalties (implemented to curb GHG emissions), lowering operating costs.[57] The comparatively less volatile fuel and O&M costs and the impact of carbon pricing and emission penalties advances the case of nuclear power production in relation to other conventional means of power production.

D. Land use

The land required for setting up power projects impact the environment and biodiversity in terms of land usage. Brook et al. conducted a study about the impact of energy in biodiversity conservation. The indicators used for concluding the results included GHG emissions, electricity costs, dispatchability, land use (for generation and fuel mining both), safety, solid waste, and radiotoxic waste.[58]

The study employed land-use indicators and found nuclear the lowest for land use and a better option for biodiversity conservation.[59] An illustration of land used for the low carbon energy sources is described in Figure 8 below.

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[55] Nicholas Tsoulfanidis, 'Nuclear Energy, Introduction' in Nicholas Tsoulfanidis (ed), *Nuclear Energy: Selected Entries from the Encyclopedia of Sustainability Science and Technology* (Springer New York 2013), 3
[56] Stephen Thomas, 'The economics of nuclear power: analysis of recent studies' (2005) , 16
[57] Note 41 Cook, *The law of nuclear energy*, section 1-03
[58] Barry W Brook and Corey JA Bradshaw, 'Key role for nuclear energy in global biodiversity conservation' (2015) 29 Conservation Biology 702
[59] Charles McCombie and Michael Jefferson, 'Renewable and nuclear electricity: Comparison of environmental impacts' (2016) 96 Energy Policy 758

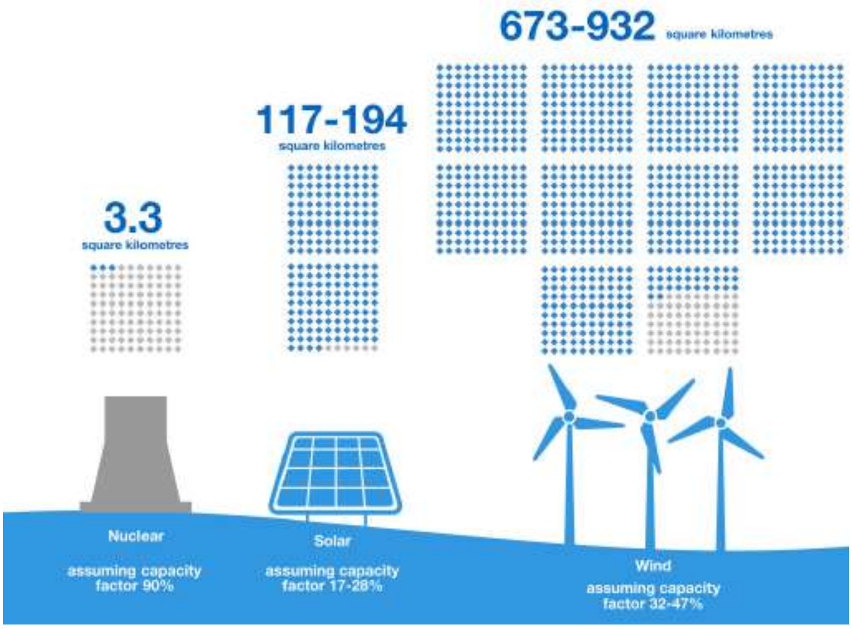

Figure 8: Land requirement per 1000MW of capacity[60]

E. Producing clean hydrogen

Clean hydrogen through electrolysis has emerged as an essential energy source. European Commission (the Cion) in its strategy titled 'A hydrogen strategy for a climate-neutral Europe' also advocated its potential role in heavy industrial activity (steel making) and transport (local city buses, commercial fleet, heavy-duty road vehicle).[61] However, the production costs for clean hydrogen from other conventional sources have not proved to be cost-effective.

Based on comparative analysis of reactors, IAEA suggested that Advanced Pressurized Water Reactor (APWR) of 719 MW may help produce hydrogen in less than USD 3.5/kg of hydrogen.[62] Another report by the IAEA also highlights that complimenting hydrogen production with electricity production may allow the NPP to operate at its full potential for the desired output. This continuous operation may also impact the costs of energy production for the NPP.

The above mentioned characteristics of nuclear power elaborate the relevance of nuclear power in the energy transition. However, despite the above listed benefits about economy and scale, nuclear power faces the concerns associated with initial capital cost, safety

[60]International Atomic Energy Agency, *Climate Change and Nuclear Power* (IAEA 2016), 51
[61] European Commission, *A hydrogen strategy for a climate-neutral Europe (COM(2020) 301)* (EC 2020), 10
[62] J-H Kim, *Examining the Techno-Economics of Nuclear Hydrogen Production and Benchmark Analysis of the IAEA HEEP Software (Republic of Korea)*, 2018), 61

issues, radioactive waste management, and decommissioning costs. Nonetheless, the climatic considerations have provided the policy makers with an opportunity to take a step back and re-evaluate the available options for tackling the dangers of climate change. The section below will discuss the development of energy transition strategies and policies developed by France, Germany, and UK in view of the role allocated to the nuclear power.

1.5 The EU's and UK's Energy Transition Strategies

The EU, including then-Member State the UK, ratified the Paris Agreement and submitted its first Nationally Determined Contribution (NDC) in 2016. It committed to 40% of GHG reduction by 2030, considering 1990 as the base year. After the UK's decision to part from the EU (applicable from 2020), the EU and UK submitted their NDCs to the IPCC in 2020 separately. The EU set a target to reduce GHG emissions for at least 55% of the reference year of 1990 by 2030 in its recent NDC. UK committed to reducing the GHG emissions to at least 68% of the reference year 1990 (for CO_2, methane, and nitrous oxide) and 1995 (for hydrofluorocarbons perfluorocarbons, Sulphur hexafluoride, and nitrogen trifluoride).

In 2018, the European Commission (Cion), being the central executive body and standing centralised civil service of the EU, issued a long-term strategic vision emphasizing the significance of climate change and energy transition. The communication asserted that 80% of electricity would be generated from renewables along with the nuclear capacity of 15% by 2050.[63] The vision was primarily reflected in the European Green Deal (Green Deal).[64] A list of legislative directives issued by the EU is shown in Table 1.

[63] European Commission, *A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy COM(2018) 773*, 9
[64] European Commission, *The European Green Deal COM(2019) 640* (EC 2019),

Umbrella (Articles 192(1) and 194(2) TFEU)	
Regulation on the Governance of the Energy Union and Climate Action (2018/1999)	
Climate Component (Article 192(1) TFEU)	**Energy Component (Article 194(2) TFEU)**
Revised Emissions Trading Directive (2018/410)	Recast Renewable Energy Directive (2018/2001)
Regulation 2018/842 on Effort Sharing	Revised Energy Efficiency Directive (2018/2002)
Regulation on Land Use, Land-Use Change and Forestry (2018/841)	Revised Energy Performance of Buildings Directive (2018/844)
	Recast Electricity Market Regulation (2019/943)
Regulation (EU) 2020/852 (Taxonomy)	Recast Electricity Market Directive (2019/944)
	Regulation on Risk Preparedness (2019/941)
	Recast Regulation on the Agency for the Cooperation of Energy Regulators (2019/942)

Table 1: Key EU legal instruments for energy and climate[65]

In 2019 the Cion proposed the GHG reduction goals to at least 50% and towards 55% for the European Union by 2030. It expressed its intent to carry out this reduction through: a) directing the power sector to be mainly based on renewables sources; b) by enacting the EU's transition initiatives into the European Climate Law; and c) enforcement of effective carbon pricing through revising and expanding the scope of the Emissions Trading System (ETS).

The ETS was established through Council and Parliament's directive,[66] and it was subsequently amended in 2018.[67] ETS is founded on the cap-and-trade principle on specific permissible GHG emissions for certain installations. The principle is based on the EU setting cap on the amount of the annual GHG emissions permitted for the regulated entities every year. These caps are reduced over time to mitigate emissions. The cap for power stations (listed in the stationary installation) was set at 1572 $MTCO_2$ with a linear cap reduction of 2.2% per year with no sunset clause after 2030.[68] The allowances can be traded and bought

[65] Kati Kulovesi and Sebastian Oberthür, 'Assessing the EU's 2030 Climate and Energy Policy Framework: Incremental change toward radical transformation?' (2020) 29 Review of European, Comparative & International Environmental Law 151
[66] European Commission, *Scheme for greenhouse gas emission allowance trading within the Community Directive 2003/87/EC* (EC 2003)
[67] European Commission, *Amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments Directive (EU) 2018/410* (OJ L 76, 19.3.2018, p. 3–27 2018)
[68] International Carbon Action Partnership, *EU Emissions Trading System (EU ETS)* (ICAP 2021), 3

within the permitted caps. The non-ETS sectors, which are not covered and regulated under the ETS Regulations, are also regulated through another Effort Sharing Regulation.

In July 2021, the EU Parliament passed the EU's Climate Law.[69] The law aims to translate the EU's emission targets and initiatives into binding obligations on the Member States. In addition to the above actions, the EU has also adopted the Governance Regulation to plan, report and monitor the progress of all its Member States about national energy plans following the Paris Agreement. The regulation empowers the Cion to recommend the sufficiency of the implementation of policies and measures indicating overarching authority of the Cion in relation to climatic consideration. However, Kulowesi highlights that the Governance regulations align with the Paris Agreement, where the members were required to devise the long-term strategies.[70] The legal developments on the climatic front also imply an increased role and precedence of EU climate law and enforcement famework on other EU laws.

EU adopted a directive about the promotion of sources of renewable energy in the Union.[71] These regulations set the target for renewable energy to contribute 32% to the Union's gross energy consumption by 2030. However, the Cion has been empowered to submit the revised submission on the conditions: a) if the costs of production of renewable energy are substantially reduced; or b) if there is a sufficient decrease in the Union's energy consumption.[72] Oberthur commented that national targets for the contribution of renewable energy for individual states were reduced under the regulation.[73]

A closer careful monitoring of the long-term national strategies for climate change mitigation has been placed under the EU Governance Regulations.[74] The situation grants more autonomy to the Member States to select the source of generation in line with EU's NDCs and emissions reduction targets.

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[69] European Union, *Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality ('European Climate Law')* (OJ L 243, 9.7.2021, p. 1–17)

[70] Kati Kulovesi and Sebastian Oberthür, 'Assessing the EU's 2030 Climate and Energy Policy Framework: Incremental change toward radical transformation?' (2020) 29 Review of European, Comparative & International Environmental Law 151

[71] European Commission, *Promotion of the use of energy from renewable sources Directive (EU) 2018/2001* (OJ L 328, 21.12.2018, p. 82–209 2018)

[72] Ibid, art 3(1)

[73] Sebastian Oberthür, 'Hard or soft governance? The EU's climate and energy policy framework for 2030' (2019) 7 Politics and Governance 17

[74] European Union, *Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action* (OJ L 328, 21.12.2018, p. 1–77)

The UK promulgated the Climate Change Act, 2008, prescribing the climate obligations towards carbon neutrality. At the time of enactment, the law obliged the state to reduce GHG emissions by 80% with reference to 1990 as baseline year. The law was amended in 2019 for committing to complete carbon neutrality by 2050.[75] UK formulated and issued its Clean Growth Strategy – Leading the way to a low carbon future' pursuant to its Climate Change Act. The strategy described the plan to grow renewables and nuclear to generate 80% of the power. The strategy also aimed to phase out the unabated coal.

In furtherance of these ambitions, the UK Government concluded the 'Nuclear Sector Deal' (NS Deal) agreeing on the cost reduction for new power plant and savings of costs for decommissioning.[76] In 2021, the UK Government also entered the North Sea Transition Deal (NST Deal) with the oil and gas sector, aiming to transition North Sea oil and gas production towards lows carbons. The arrangement provided a sectoral investment of £14-16 bn by 2030 in carbon capture, utilisation, and storage (CCUS) and hydrogen.[77] The NST Deal indicates the relevance of oil and gas to mitigate energy security and affordability, focusing on upskilling or reskilling of the workforce to the new low carbon sources. The UK Government had also launched its strategy to utilise 'low carbon hydrogen' for the energy transition.[78]

Nuclear power as a sustainable activity has been scrutinised by EU bodies. A technical assessment report (2020) on the EU's Taxonomy Regulations concluded that no evidence could be found that nuclear energy does more harm to human health or the environment than other electricity production technologies already included in the regulations.[79] The assessment was carried out to determine whether nuclear energy production can be termed as a 'sustainable' activity under EU's Taxonomy Regulations.

The findings of JRC's assessment report were scrutinised and reviewed by the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) and Group of Experts

[75] The Climate Change Act, 2008; s 1(1)
[76] UK Department of Business Energy and Industrial Strategy, *Industrial Strategy - Nuclear Sector Deal* (UK Government 2018), 7
[77] UK Department of Business Energy and Industrial Strategy, *North Sea Transition Deal* (UK Government 2021), 10
[78] Uk Department of Business Energy and Industrial Strategy, *UK Hydrogen Strategy* (UK Government 2021)
[79] Said; and others Abousahl, *Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation'), EUR 30777 EN* (Publication Office of the European Union 2020), 3

on radiation protection and waste management under Article 31 of the Euratom Treaty in their review reports of the assessment undertaken by Joint Research Centre.[80,81] *

An informed assessment of the UK and EU's policy actions towards decarbonisation suggests varying attitude towards the nuclear power. It becomes clear that UK has considered and categorised nuclear as a relevant source of energy for the energy transition towards low carbon economy. However, the EU as a whole seems committed to renewables for the energy transition towards low carbon sources. This commitment may be taken as a policy choice by the EU, but it puts no bar on national preference for nuclear power as a relevant energy source for decarbonising the energy systems.

The energy transition towards the low carbon sources is happening for the compulsion of climatic factors. The EU and the UK are taking steps to mitigate the effects of GHG emissions with multi-pronged strategies devised to take mitigation and efficiency measures as agreed in the Paris Agreement. The transition towards low carbon sources must ensure the security of supply which does not seem viable with the role of renewables alone due to their intermittence.

Nuclear power due to economies of scale, insignificant emissions, and dispatchability can complement energy transition as a green resource, also ensuring the security of supply. The relevance of nuclear as a low carbon energy source seems promising in the UK, France, and some other EU jurisdictions. However, the space of development of nuclear energy may only be comprehensively realised in context of legal and policy developments before the courts and authorities. The section below discusses the development of nuclear activity for energy production and laws relating to development of nuclear power in the EU and the UK.

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[80] Scientific Committee on Health Environmental and Emerging Risks, *SCHEER review of the JRC report on Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation')* (Publication Office of the European Union 2021)

[81] Group of Experts under Euratom Treaty, *Opinion of the Group of Experts referred to in Article 31 of the Euratom Treaty on the Joint Research Centre's Report on Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria* (Publication Office of the European Union 2021)

* In a press release issued by the Cion on 22-Feb-2022, the Cion has determined and decided the status of nuclear as sustainable activity informed by the JRC Assessment Report, Scientific Committee Review, and Opinion of Experts. The announcement can be accessed on https://ec.europa.eu/commission/presscorner/detail/en/QANDA_22_712 (last accessed 22-Jun-2022)

2. Nuclear Energy in France, Germany and the United Kingdom: Policy Development and Legal Frameworks

In 1953, in his speech before UN General Assembly, President Eisenhower advocated for nuclear energy's civilian usage by appealing to "mankind's never-ending quest for peace" and "God-given capacity to build".[82] Weart critiqued that the speech was delivered against the backdrop of other nations military prowess and competitive success in nuclear field.[83] As mentioned earlier the post second world war scenario also involved a race for developing the nuclear capacity for weapons. However, before UN General Assembly, this speech opened the discussion on an international forum to use atomic technology for civilian use. This chapter will discuss the development of national policies of France, Germany and the UK for nuclear energy, the legal framework for nuclear energy (the Euratom Treaty and the Lisbon Treaty), nuclear energy and state support (state aid, capacity mechanism).

2.1 Development of Nuclear Energy Industry

The first nuclear reactors (Type Magnox: a gas-cooled reactor, also called Generation I reactors) for commercial energy production were constructed at Calder Hall in the UK to produce both electricity and plutonium for nuclear weapons.[84] The plant was closed after almost forty-seven years of service in 2003, and it is currently under the process of decommissioning.[85]

Nuclear as a source of energy production emerged as a promising option after the oil crisis of 1973.[86] Scurlock noted that the industrialised oil-importing countries looked for other options in response to the oil crisis and ensure supply security, and nuclear emerged as a

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[82] International Atomic Energy Agency;, 'Atoms for Peace Speech' (*IAEA,* 1953) <https://www.iaea.org/about/history/atoms-for-peace-speech> accessed 22-Jun-2022

[83] Spencer R Weart and Spencer R Weart, *Nuclear fear: A history of images* (Harvard University Press 2009), 162

[84] Charles N Hill, *An atomic empire: a technical history of the rise and fall of the British Atomic Energy Programme* (World Scientific 2013), 219

[85] Curwen I, 'Decommissioning the world's first commercial nuclear power station' (*NDA,* 2019) <https://nda.blog.gov.uk/2019/09/03/decommissioning-the-worlds-first-commercial-nuclear-power-station/> accessed 22-Jun-2022

[86] Jonathan Scurlock, 'A Concise History of the Nuclear Industry Worldwide' in David Elliott (ed), *Nuclear or Not? Does Nuclear Power Have a Place in a Sustainable Energy Future?* (Palgrave Macmillan UK 2007), 28

primary candidate.[87] He also observed that this preference for nuclear emanated from the comparative independence of energy supply as uranium reserves were more widely distributed than the oil reserves. Many industrialised countries embarked on an expansion of nuclear programs for energy production. For instance, *Electricité de France* (EDF) accomplished an enormous program taking the nuclear share in total energy production in 1973 from 7% to 20% in 1980.[88]

Toth observed that other benefits also triggered this energy policy shift, i.e., low fuel costs, low fuel and waste volumes, the diversified geographic distribution of fuel reserves, fuel storage options, and economy of scale.[89] Despite many apparent advantages with nuclear as a source of energy, the potential expansion could not maintain its projected momentum due to various concerns and nuclear incidents.

Sculock noted that by 1986 growth in the nuclear industry had slowed down due to the safety concerns raised after incidents at Three Miles Islands, Chernobyl, and other economic reasons.[90] The economic reasons identified by Sculock included a decrease in prices of oil, the discovery of gas reserves, and the availability of coal as an internationally available commodity. It was also viewed that the lack of state support for nuclear projects in the liberalised energy markets also stalled the possible growth of the nuclear industry.[91]

2.2 Nuclear Policy Development in France, Germany and UK

Basu highlighted that nuclear energy generation faces the most contradictory attitudes (protectionism, liberalism, and discrimination) than any other form of energy production.[92] These attitudes vary, and in some cases, express stagnation trends or complete abandonment of nuclear power.

In 2020, IAEA reported that nuclear energy contributes 10% of the world's total electricity.[93] It was also stated that it was the second-largest source of electricity produced from low

[87] Ferenc L. Toth and Hans-Holger Rogner, 'Oil and nuclear power: Past, present, and future' (2006) 28 Energy Economics 1
[88]Jonathan Scurlock, 'A Concise History of the Nuclear Industry Worldwide' in David Elliott (ed), *Nuclear or Not? Does Nuclear Power Have a Place in a Sustainable Energy Future?* (Palgrave Macmillan UK 2007), 28
[89] Ferenc L. Toth and Hans-Holger Rogner, 'Oil and nuclear power: Past, present, and future' (2006) 28 Energy Economics 1
[90]Scurlock, 'A Concise History of the Nuclear Industry Worldwide', 32
[91] Ibid, 32
[92] Dipak Basu and Victoria W Miroshnik, *The Political Economy of Nuclear Energy* (Springer 2019), 97
[93] Shant Krikorian, 'Preliminary Nuclear Power Facts and Figures for 2019' (*IAEA,* 2020) <https://www.iaea.org/newscenter/news/preliminary-nuclear-power-facts-and-figures-for-2019> accessed 22-Jun-2022

carbon sources after hydro having a total installed capacity of 398.9 GW. However, a report (2020) by IEA stated that twelve nuclear reactors closed from July 2019 to June 2020, and it estimated a fall of 4.5% in output from the preceding year.[94]

Nuclear contributed 13% to the energy mix of the EU.[95] The UK Government's statistics from 2021 show that energy through nuclear generation contributed 6.6% to the total generation in the UK.[96] It was also stated that the production plunged to 11.6 TWh in the first quarter of 2021 due to a maintenance outage at the Dungeness B nuclear power plant.[97] In 2021 the EU had 106 operable nuclear reactors in 13 out of 27 member countries.[98]

Following is the discussion of the nuclear policy framework in the UK and the France and Germany (later two being EU members). The scope of this policy analysis would be on the placement of nuclear power in energy landscape of these jurisdictions.

A. France

France has the maximum number of nuclear reactors (58)[99] in the EU, and these NPPs produce 70% of the electricity in France.[100] The nuclear power fleet expanded remarkably in France after the oil crisis of the 1970s, which exhibited atomic absolutism in its nuclear policy. Almost all nuclear sector is heavily concentrated in state-controlled structures, Electricité De France (EDF), Alternate Energies and Atomic Energy Commission (CEA) and other State-owned enterprises.

Through its Energy Transition Act, 2015, France declared its intentions to reduce the share of nuclear in its total electricity production by keeping it at 50%.[101] IAEA reported (2021) that France has indicated the retirement of 14 reactors, and it would be constructing another

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[94] International Energy Agency, *World Energy Outlook 2020* (IEA 2021), 71
[95] EuroStat, 'Where does our energy come from?' (*Eurostat,* 2021) <https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2a.html#:~:text=In%202019%2C%20the%20energy%20mix,fossil%20fuels%20(both%2013%20%25).> accessed 22-Jun-2022
[96] Department of Business Energy and Industrial Strategy, *UK Energy in Brief 2021* (UK Government 2021), 13
[97] Department of Business Energy and Industrial Strategy, *Statistical Release - Energy Trends* (UK Government 2021)
[98] European Nuclear Safety Regulation Group, 'Nuclear energy in the EU' (*ENSREG,* 2021) <http://www.ensreg.eu/members-glance/nuclear-eu> accessed 22-Jun-2022
[99] Ministere De La Transition Et Soildaire, *Draft French Strategy for Climate and Energy* (Government of France 2020), 131
[100] European Nuclear Safety Regulation Group, 'Profile - France' (*ENSREG,* 2021) <http://www.ensreg.eu/country-profile/France> accessed 22-Jun-2022
[101] Die Bundesregierung, 'Energy' (*Bundesregierung,* 2021) <https://www.bundesregierung.de/breg-de/themen/energiewende/energiewende-im-ueberblick-229564> accessed 22-Jun-2022

nuclear reactor (Flamanville-3) with a gross capacity of 1650MW.[102] The Draft French Strategy of Clean Energy and Climate circulated for comments, in 2020, stated that this nuclear reactor would be commissioned by 2022.[103]

EDF reacted to these reduction targets in nuclear energy, in 2012, by stating a negative impact on the electricity tariff and GHG emissions. The EDF's response analysed by Schneider concluded that it had been based on unlikely scenarios.[104] However, the targets were transformed into the law. The French energy policy is inclined to the forced shutdown of the existing nuclear plants to meet the reduction targets. However, in its analysis of the Energy Transition Law, Mauger pointed out that the current policy and legal measures (cap on the nuclear capacity of 63.2GW, appointment of government commissioner for NPPs) for reducing nuclear energy's share are inadequate to meet the reduction target.[105]

The national targets for a cap on the nuclear capacity increased costs for construction delays. Furthermore, the retirement of 14 reactors in the first half of this decade indicate that the French energy policy landscape is influenced by the EU's policy towards alternate energy sources. However, shutting down the nuclear reactors without giving ample time and opportunity to the operator may lead to revenue losses and a price spike for consumers in the EU market. These actions would also require more clarity and investigation for the mechanism employed to decommission the nuclear plants.

B. Germany

The Fukushima Daiichi incident (Japan, 2011) was the turning point for the German nuclear program. Jahn et al. stated that Germany had announced an eight-year extension to the older reactors (built before 1980) and fourteen years of renewed permissions to the newer reactors just a year before the incident. The study cited *The Economist 2010* that the eight-year extension would have produced profits between €27-73bn for the public utilities.[106]

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[102] International Atomic Energy Agency, 'Country Nuclear Power Profiles - France' (*IAEA,* 2021) <https://cnpp.iaea.org/countryprofiles/France/France.htm> accessed 10-Sep-2021
[103] Ministere De La Transition Et Soildaire, *Draft French Strategy for Climate and Energy* (Government of France 2020), 132
[104] Mycle Schneider, 'Nuclear power and the French energy transition: It's the economics, stupid!' (2013) 69 Bulletin of the Atomic Scientists 18
[105] Romain Mauger, 'Forced nuclear energy reactors shutdown in France: the Energy Transition Act's mechanisms' (2018) 11 The Journal of World Energy Law & Business 270
[106] Detlef Jahn and Sebastian Korolczuk, 'German exceptionalism: the end of nuclear energy in Germany!' (2012) 21 Environmental Politics 159

In the wake of the Fukushima incident, Germany amended the Atomic Energy Act, permanently closed the eight plants, and the remaining six (6) nuclear reactors were decided to be closed by 2022. [107] *Energieweind* (Energy Transition) has since dominated the German Energy Policy. These actions were complemented by the Renewable Energy Sources Act's amendments that set out the energy targets from renewable sources in 2050. The Act was amended to replace the Feed-in-Tariff with the market premium if the producer sells the electricity directly and allows the system operator to sell the energy produced from renewables.[108] Figure 8 illiustrates the gross power production from renewable energy sources in 2019.

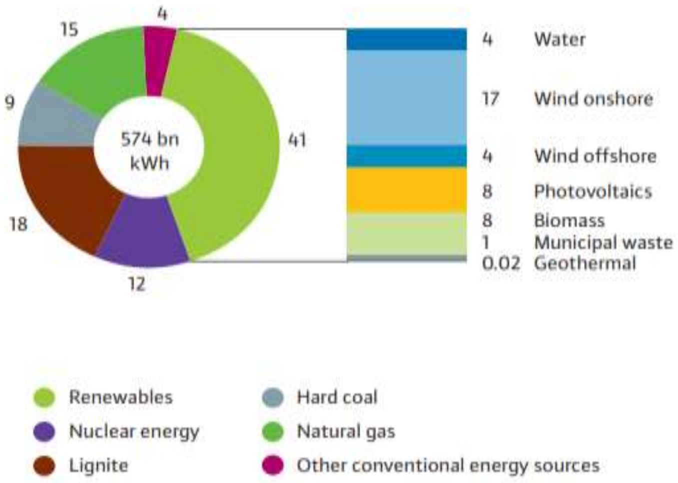

Figure 9: Net power production 2019[109]

Murray noted that this energy transition has resulted in an increased share of renewables in the electricity, but it has also enhanced the GHG emissions.[110] In another paper by Jarvis et al., the trends suggest that electricity imports and coal substituted the nuclear phase-out capacity. The analysis also indicated an annual cost of this forced nuclear phase-out at $12bn. The central portion of this cost was estimated to come from the almost 1,100 deaths excess deaths caused by air pollution burning coal.[111]

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[107] Paschke Marian, 'Legal challenges of the new energy policy in Germany' (2017) 226 Записки Горного института
[108] Lorcán Murray, 'The need to rethink German nuclear power' (2019) 32 The Electricity Journal 13
[109] Bundesverband der Energie und Wasserwirtsch, 'Energy Market Germany 2020' (*BDEW,* 2020) <https://www.bdew.de/media/documents/Energiemarkt_Deutschland_2020_englisch.pdf> accessed 10-Sep-2021
[110] Lorcán Murray, 'The need to rethink German nuclear power' (2019) 32 The Electricity Journal 13
[111] Stephen Jarvis, Olivier Deschenes and Akshaya Jha, *The Private and External Costs of Germany's Nuclear Phase-Out* (National Bureau of Economic Research 2019)

The legal merits of Germany's nuclear phase out program were analysed by Rochetto in the context of her obligations under the Euratom Treaty. Rochetto asserted that this phase-out policy was in contravention of the legal obligations under the Lisbon Treaty, the consequent EU Directives and Regulations for climate change and security of supply, and the Euratom Treaty. The critique contended that the obligations to promote the growth of nuclear industries under the Euratom Treaty could not be unilaterally withdrawn to determine the status of nuclear industries.[112]

Thus far, Germany nuclear phase-out has happened, and the shut-down plants are at various stages of decommissioning. Wealer et al. noted that the shutdown nuclear plants are under long term enclosure or have been dismantled and awaiting regulatory release.[113]

C. United Kingdom

In his critique on the role of nuclear power in UK energy policy, Thomas asserted that the government issued programs for nuclear ordering on five occasions after the perceived success of the first-generation reactors.[114] The criticism was placed on the poor economic performance of the nuclear reactors.

The UK has eight operational nuclear plants, across seven of which there are 14 Advanced Gas-cooled reactors.[115] The eighth and the latest one at Sizewell B has one pressurised water reactor. A special feature on nuclear electricity in the UK in 2018 reported that construction is underway for Hinkley Point C, and it would start operating commercially by 2025.[116] Despite the UK government's best efforts to make the nuclear cost-competitive in the market (by agreeing on a strike price of £92.50/MWh with EDF), the project had seen delays due to the Cion's inquiry (and subsequent court cases) into the matter of state aid, and the withdrawal by investment partners.[117] The report also indicated plans for Sizewell C, Bradwell B, Wylfa and Moorside nuclear power plants.

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112 Gustavo Rochette, 'Is the German Nuclear strategy lawful under EU law? Article 194 (2) TFEU and its limitations' (2021) The Journal of World Energy Law & Business

113 Ben Wealer, Jan Paul Seidel and Christian von Hirschhausen, 'Decommissioning of Nuclear Power Plants and Storage of Nuclear Waste', *The Technological and Economic Future of Nuclear Power* (Springer VS, Wiesbaden 2019)

114 Steve Thomas, 'Energy Policy: The role of nuclear power', *Delivering Energy Law and Policy in the EU and the US : A reader* (Edinburgh University Press 2016), 219

115 International Atomic Energy Agency, 'Country Nuclear Power Profiles - United Kingdom' (*IAEA,* 2018) <https://cnpp.iaea.org/countryprofiles/UnitedKingdom/UnitedKingdom.htm> accessed 22-Jun-2022

116 Department of Business Energy Industrial Strategy, *Nuclear electricity in the UK* (UK Government 2018)

117 Philips Johnstone, 'Delivering UK Nuclear Power in the context of European Energy Policy : The challenges ahead' in Raphael Heffron and Gavin FM Little (eds), *Delivering Energy Law and Policy in the EU and the US : A reader* (Edinburgh University Press 2016), 237

An illustration of the existing and projected nuclear capacity in the UK is shown in Figure 6. The application for obtaining Development Consent Order was submitted (2021) before National Infrastructure Planning for scrutiny for Sizewell C nuclear power station.[118]

The UK declared its intentions to continue using nuclear for meeting its climate obligations and energy security. UK Clean Growth Strategy issued in 2017 indicated an increased contribution of nuclear in the energy mix.[119] The UK entered the NS Deal with the stakeholders with the objectives of 30% cost reduction for new plants, reduced decommissioning costs up to 20%, and contract grants or exports in the nuclear industry up to £2 billion by 2030.[120]

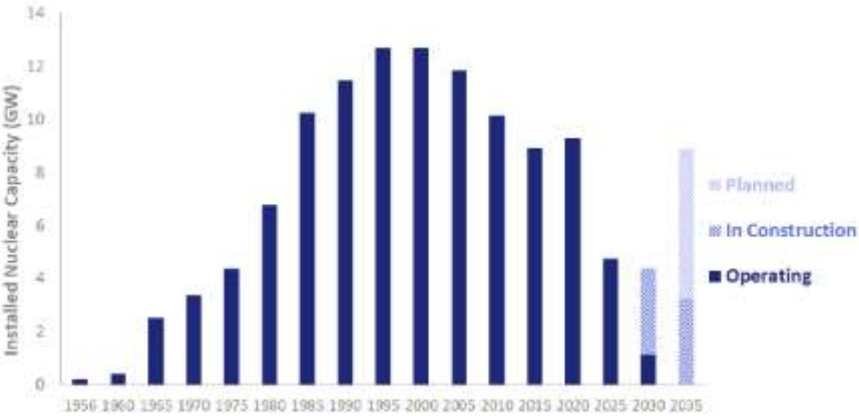

Figure 10: UK installed nuclear capacity: operational, under construction and planned[121]

The NS Deal indicated the government's intention for considering direct government investment for the proposed Wylfa Newyyd Project. It also mentioned viability review for employing regulated asset-based (RAB) model as a sustainable funding choice. The UK published its views after public consultation and expressed its inclination to utilise this model for one largescale nuclear before the end of the tenure of this parliament.[122] *

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[118] National Infrastructure Planning, 'The Sizewell C Project' (*NIP,* 2021) <https://infrastructure.planninginspectorate.gov.uk/projects/eastern/the-sizewell-c-project/?ipcsection=exam> accessed 22-Jun-2022

[119] UK Department of Business Energy and Industrial Strategy, *The Clean Growth Strategy - Leading the way to a low carbon future* (UK Government 2017), 96

[120] UK Department of Business Energy and Industrial Strategy, *Industrial Strategy - Nuclear Sector Deal* (UK Government 2018), 16

[121] Department of Business Energy Industrial Strategy, *Nuclear electricity in the UK* (UK Government 2018)

[122] Department of Business Energy Industrial Strategy, 'Regulated Asset Base (RAB) model for nuclear' (*BEIS,* 2019) <https://www.gov.uk/government/consultations/regulated-asset-base-rab-model-for-nuclear> accessed 22-Jun-2022

* At the time of publication, the UK has already passed Nuclear Energy (Financing) Act 2022 and adopted the regulated assets based model for nuclear energy.

Notwithstanding the proposals to adopt the untested RAB model for nuclear projects, the challenges of financial costs for new construction and decommissioning of retiring plants, construction delays in Hinkley C, and future procurement under the RAB model in the existing market conditions require more clarity to realise the deal. The legal and regulatory changes UK's energy market after Brexit also require further inquiry and investigation to determine and project the nuclear power's placement and projection in the energy market for the UK.

2.3 Legal Frameworks for Nuclear Energy in France, Germany and the UK

The legal framework analysis for nuclear power will cover nuclear energy under the Euratom Treaty and the Lisbon Treaty in the EU and its impact on the post-Brexit UK. Given European liberalisation and market integration, it would also analyse the permissibility of state support (state aid, capacity mechanisms) to nuclear power under the Lisbon Treaty.

2.3.1 The Euratom Treaty and the European Union

The Euratom Treaty is the principal legal instrument of governance for nuclear energy in the EU. The Euratom Treaty expressly laid down the aims and objectives of the treaty to provide necessary conditions for expeditious establishment and growth of nuclear industries.[123] Cameron commented that as a *lex specialis,* the objectives of the Euratom Treaty were to promote civil nuclear energy and regulate issues associated with the sector.[124]

The Lisbon Treaty is the governing law for economic activity in the EU, including the competition rules and state aid. It also prescribes the principles to be followed by the standard energy policy. The principles about energy policy allow the Member States to have their preference of energy source in the energy mix.[125]

In the context of current opposite nuclear policy developments across the EU and market development, the obligations under the Euratom Treaty remain relevant. This section intends to analyse the jurisprudence developed in the view of the Euratom Treaty, the Lisbon Treaty rules for competition, and state aid.

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[123] European Union, *The Treaty establishing the European Atomic Energy Community* (OJ C 327, 26.10.2012, p. 1–107 1957), art 1
[124] Peter D Cameron, *Competition in Energy Markets : Law and Regulation in the European Union* (2nd edn, Oxford University Press 2007), 246
[125] European Union, *Treaty on the Functioning of the European Union* (OJ C 326, 26.10.2012, p. 47–390 2007), art 194 (2)

The subjects would be addressed by analysing the EU's nuclear energy law, the relationship *inter se* between the treaty regimes, and the obligations on states regarding the competition in the EU energy market. The impact on the UK after its withdrawal from the EU and the Euratom will also be discussed.

Fouquet criticised the Euratom Treaty as leading the EU's energy policy to a distortive pathway. He further asserted that the Treaty failed to deliver a common nuclear policy for its members.[126] In elaborating the tasks delivered by the Euratom Treaty, Soedersten noted that it actively played its role in concluding the Conventions concerning safety.[127] As no common EU nuclear policy existed, EU Member States developed different national nuclear policies and programs.[128]

The relationship between the Treaty of European Union (TEU) also known as the Maastricht Treaty, the Euratom Treaty, and the Lisbon Treaty is now governed by Article 106a of the Euratom Treaty, which applies provisions of the Maastricht Treaty and Lisbon Treaty on the Euratom Treaty. However, article 106a (3) of the Euratom Treaty also states that an application of these treaties would not derogate from the Euratom Treaty's provisions. The relationship between the Euratom Treaty's provisions and other EU treaty law have been brought before the European General Court (the General Court) and European Court of Justice (the ECJ), in numerous cases. However, the landmark cases are discussed as follows:

A. European Parliament v Council of the European Union[129]

In 2009, the Cion submitted a proposal to replace its regulations about notification to the European Community (succeeded by the EU through the Lisbon Treaty) about the investment projects of interests in petroleum, natural gas, and electricity sectors. The Regulations also included reporting of the project of interest in the nuclear sector. Therefore, the Council chose Article 284 (powers of the EU Cion to collect information) of of the Treaty of Rome (later Article 337 of the Lisbon Treaty) and Article 187 (powers of the EU Cion to collect information) of the Euratom Treaty as the legal basis of the proposed regulations.

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[126] Dörte Fouquet, 'Nuclear Policy in the EU from a Legal and Institutional Point-of-View', *The Technological and Economic Future of Nuclear Power* (Springer VS, Wiesbaden 2019), 170
[127] Anna Soedersten, *Euratom at the crossroads* (Edward Elgar Publishing Limited 2018), 167
[128] The European Union is extremely divisive on their approach to nuclear programs.
[129] *European Parliament v Council of the European Union* ECLI:EU:C:2012:525 (European Court of Justice)

The proposal was submitted to the Council. The Council resorted to the consultation with the EU parliament. The European Parliament invited the Cion to choose the correct legal basis that it claimed to be article 194 (powers of EU for the energy policy) and passed a resolution in this regards.

The Council chose not to amend the proposed regulations as directed by the EU parliament's resolution and adopted the regulations on the provisions proposed by the Cion, based on the reporting inclusive of nuclear projects. However, the EU parliament resorted to the ECJ for annulment of the Regulations because the Regulation should have been based on article 194 of the Lisbon Treaty.

The Parliament asserted that the Cion was responsible for undertaking the cross-sector analysis about the energy system of the EU to identify gaps of supply and demand for European energy policy. The issues were within the competence of article 194 of the Lisbon Treaty. Article 187 of the Euratom Treaty could only be invoked to promote or coordinate investments in the nuclear field. The Cion argued on the valid application of article 337 and justified its stance that the regulations also covered nuclear power stations. Therefore article 187 of the Euratom Treaty was the correct basis for requiring information under the regulation.

ECJ awarded the claim of the EU Parliament and held that article 194, being the more specific provisions about the energy policy and energy security, would be the correct basis of the proposed regulations. Regarding article 187 of the Euratom Treaty, the court stated that it would be applicable for the acts entrusted to it.

In deciding this case, ECJ gave credence to the applicability of article 194 of the Lisbon Treaty. It held the matter of reporting of information about the nuclear projects (which were covered by the Euratom Treaty, itself) as a matter of energy policy within the powers and domain of the EU. In a way through this case, ECJ also broadened the role of EU on nuclear projects by invoking scope of article 194 of the Lisbon Treaty.

B. Kernkraftwerke Lippe-Ems GmbH v Hauptzollamt Osnabrück (KLE case)[130]

Kernkraftwerke Lippe-Ems (KLE), a private company based in Germany, challenged the nuclear fuel duty imposed upon it by the Principal Customs Office (under a German Law on excise duty on nuclear fuel issued in 2010) in Germany.

The nuclear fuel was to be used by KLE in the Emsland nuclear power station reactor to start a chain reaction. After initially submitting a declaration for nuclear fuel duty, KLE opposed it. The opposition was rejected and was later assailed before Finance Court, Hamburg. KLE also took position that German Law on excise duty on nuclear fuel is also contrary to article 107 (about competition and state aid regime) of the Lisbon Treaty. The German Law affected the competition in favour of non-CO_2 emmitting power plants leaving the nuclear power plants.

The Finance Court referred the matter before the ECJ primarily to determine whether the levy of the German duty on nuclear duty was contrary to the Euratom Treaty in view of EU Treaty Law and other directives?

The questions involved an interpretation of article 107 of the Lisbon Treaty, articles 1, 2(d) 93A, 191, 192 of the Euratom Treaty. ECJ also considered EU Council's directive about taxation of energy products (Council Directive 2008/118/EC), EU Council's directive on general arrangements for excise duty.

Article 93A of the Euratom Treaty prohibited all customs duties on imports and exports of the prescribed products between the EU member states. The nuclear fuel was covered under the prescribed products. Among other questions before ECJ, the question of paramount significance was to interpret and analyse the relationship between the state aid regime under the Lisbon Treaty and a legal prohibition on custom duties under the Euratom Treaty.

ECJ held that the duty introduced by the German Law on excise duty on nuclear fuel did not constitute a custom duty under the ambit of article 93 of the Euratom Treaty (para 92). The court was also confronted with the question whether the duty levied by KernbrStG would vitiate the Euratom Treaty's objectives of establishment and growth of nuclear industries. The court held that the alleged contested duty would not jeopardise the Euratom

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[130] *Kernkraftwerke Lippe-Ems GmbH v Hauptzollamt Osnabrück* ECLI:EU:C:2015:354 (European Court of Justice)

Community's duty to ensure a regular and equitable supply of fuels to all community members.[131]

In reaching this conclusion, the court scaled down the scope of *'custom duty or any other charge equivalent to that effect'* as envisaged under article 93 and the obligations under article 192 of the Euratom Treaty. The provision expressly prohibits between members all custom duties or charges having an equivalent effect.

These judgments by the ECJ affirmed the views expressed by Roeben on his treaties that courts harmonise both the treaties (the Euratom Treaty and TFEU) by transferring principles from the Lisbon Treaty.[132] The principles of the EU competition regime were applied to adjudicate nuclear industry issues because of the common market established under the the Lisbon Treaty with the effect of giving more credence to the provisions of the Lisbon Treaty and in an instance (cited above) scaling down the provisions of the Euratom Treaty.

C. UK and Europe on nuclear energy (post-Brexit)

UK carried out its intentions of withdrawal from the EU and Euratom in 2020. Therefore, the literature is scarce on the impact of this withdrawal on the EU market and UK. The withdrawal from Euratom would have resulted in a significant legal and regulatory gap for nuclear safety applicable under Euratom.

Callen et al. apprehended that the UK's issues after its withdrawal from Euratom would include difficulty in access to long-term fuel supply, risks of immediate shortage of medical isotopes, and a limitation on its participation on research and funding.[133] However, in May 2021, UK entered an Agreement with the EU for cooperation on the peaceful use of nuclear energy.[134]

The Agreement covers cooperation for supply and transfer of nuclear technology, nuclear material, nuclear fuel cycle, spent fuel and radioactive waste, safety and radiation protection, radioisotopes for agricultural, medicinal, and industrial use, and development and

[131] Ibid, para 105
[132] Volker Röben, *Towards a European Energy Union : European energy strategy in international law* (Cambridge University Press 2017), 126
[133] Jessica Callen, Asako Takamasa and Hideki Toma, 'Insights to the UK's impending departure from Euratom: Case study of UK nuclear safeguards and radiation protection in light of Brexit' (2019) 129 Energy Policy 1416
[134] Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the European Atomic Energy Community for cooperation on the safe and peaceful uses of nuclear energy

enrichment of uranium sources.[135] Besides this agreement, the UK Government has also entered bilateral agreements with Australia and Japan to cooperate in civil nuclear use.

The UK-EU Agreement sufficiently covered the concerns raised by Callen et al. about the sufficiency of supply in cooperation between the EU and the UK. The concerns about nuclear safety were addressed through a law about nuclear safeguards.[136] The Office of Nuclear Regulator was established to conduct permissioning inspection, compliance inspection, enforcement of safety, and safeguard provisions under the UK Law.

2.3.2 EU's Energy Market, Competition, and State Aid Regime for Nuclear Energy

Basu suggests that state participation in the nuclear sector not only have a positive impact on the investment, but it is also essential, unlike other industries.[137] However, the situation for the nuclear industry in the context of the EU faces two-fold complications. The Euratom Treaty governs the nuclear industry, which stands on the broader principles of community cooperation to promote the nuclear industry. EU Member States seems divided on the future role of nuclear energy in the energy policy. Additionally, EU competition law for a common European market, also discourages state intervention in the market, except in few permitted instances of state aid, largely ruling out the community cooperation enshrined in the Euratom Treaty. However, a careful analysis of the EU's state aid regime and jurisprudence becomes essential to assess the legal and policy space to develop and adopt nuclear power as clean source by any EU member states.

The discussion on the promotion of the nuclear industry in the context of the EU's competition law is discussed below.

Goldberg stated that the EU's competence in energy matters had seen the transformation from the member state's exclusive domain to the shared competence of the EU.[138] This transformation towards energy integration is also reflected in the Lisbon Treaty. The Treaty provision empowers the EU to ensure the functioning of the internal energy market. These powers have been based on the considerations of ensuring energy security, promoting efficient energy, and renewables.[139]

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[135] Ibid, art 3
[136] The Nuclear Safeguards Act, 2018
[137] Dipak Basu and Victoria W Miroshnik, *The Political Economy of Nuclear Energy* (Springer 2019), 97
[138] Silke Goldberg and Anne Eckenroth, 'Governance of the energy market in the European Union', *Elgar Encyclopedia of Environmental Law* (Edward Elgar Publishing Limited 2021)
[139] Note 125, art 194

The issues for electricity supply are governed by the Electricity Directive of 2019[140] and Regulation on Internal Market 2019[141] , which have replaced and amended the earlier EU Directives on the electricity market. The legal framework also includes other directives and regulations considering climatic obligations and energy security (Oil Stock Directives 2009/199/EC and Regulation 2019/94). These legal developments suggest a more decisive role and influence of the EU for affordable, sustainable, and secure energy supply. However, even the enhanced role of the EU would be limited to energy policy and actions within the permissible domains of the Lisbon Treaty and community law.

In the absence of community-wide common nuclear policy, the policies for development of nuclear industry in the EU member states were developed nationally. The Euratom Treaty did not explicitly provide for the provisions about competition in a common, integrated market as envisioned under later the Lisbon Treaty. Hencher commented that EU members states are generally obliged (Article 192 of the Euratom Treaty) to abstain from measures that would jeopardise the objectives under the Euratom Treaty.[142] Hence, the question arise in the context of the complex nature of the relationship between the Euratom Treaty and the other Community regimes which has not been fully clarified by the European courts. However, the European General Court (General Court) and the European Court of Justice (ECJ) have addressed the nuclear industry issues in the context of competition and state aid measures based on the Lisbon Treaty and other community laws in various cases. The landmark cases adjudicated by the European courts on the issue of state aid in the context of the Euratom Treaty are discussed below:

A. French Republic v European Commission (Transparency Directive Case)[143]

The complex relationship of the Euratom Treaty and other relevant EU treaty laws came before courts in 1982.

In 1980, the Cion issued a directive (Directive No 80/723/EEC) concerning the transparency of financial relations between member states and public undertakings exercising its power under article 173 of the Treaty establishing the European Economic Community (EEC), which legal body superseded the ECSC and later was to evolve, in 1993 pursuant to the

[140] European Union, *Directive on common rules for the internal market for electricity Dir (EU) 2019/944* (OJ L 158, 14.6.2019, p. 125–199 2019)
[141] European Union, *Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity* (OJ L 158, 14.6.2019, p. 54–124 2019)
[142] Leigh; and others Hancher, *EU Competition Law and Energy Markets*, vol II (EU Energy Law, Claeys & Casteels Law Publishers 2019), 684
[143] *French Republic v Commission* ECLI:EU:C:1982:257

Treaty of Maastricht, into the EU.[144] The Directives was assailed by the French government and other Member States on the basis (*inter alia*) that they applied to the sectors (such as steel, coal, and nuclear sector) specifically dealt with by other treaty regimes, such as the Euratom Treaty).

The ECJ held the principle in this case in 1982 that has been applied in later matters brought before the ECJ. The principle stated that when a particular sector-specific EU Treaty did not contain any provision on a legal subject covered under the EEC Treaty, then the law promulgated under the EEC Treaty would be applicable.

Following this principle, the ECJ held that the contested Directives would not apply to the activities covered by ECSC because the ESCS Treaty contained provisions on state aid. However, the Euratom Treaty did not contain any provisions on the state aid, therefore, articles 92 and 93 (state aid) of the EEC would apply to the nuclear sector.

Consequently, the contested Directives were held to be applied to the nuclear sector if they did not derogate from the Euratom Treaty provisions.[145]

The principle has also been followed in subsequent cases.[146,147] The case identified that the Euratom Treaty provisions did not contain provisions on the state aid and the EEC Treaty provisions on state aid provisions (article 92 and 93) shall be invoked to complement the Euratom Treaty on these matters.

B. Republic of Austria v European Commission (Hinkley Point C case)[148]

In 2020, the ECJ handed down the judgment in an appeal preferred by the Austrian Government against the judgment of the General Court. The judgment of ECJ analysed and discussed the action of the Cion about UK's actions notified to Cion for a nuclear plant at Hinkley Point C. The appeal before the ECJ was dismissed, and the judgment of the General Court was confirmed. The details of the case before the Cion, the General Court and the ECJ are as follows:

[144] European Commission, *Directive 80/723/EEC of 25 June 1980 on the transparency of financial relations between Member States and public undertakings* (OJ L 195, 29.7.1980, p. 35–37 1980)
[145] Note 143, 2558
[146] *Hellenic Republic v Council of the European Communities* European Court Reports 1990 I-01527, para 17
[147] *Commission of the European Communities v United Kingdom of Great Britain and Northern Ireland* ECLI:EU:C:2005:210, para 44
[148] *Republic of Austria v European Commission* ECLI:EU:C:2020:742

The Government of the UK entered an arrangement with NNB Generation Company Limited, a subsidiary of EDF. The arrangement was to offer three supporting measures for the nuclear plant, Hinkley Point C: a) a contract for difference for NNBG (revenue support based on pre-determined strike price), b) an agreement of the Secretary of State for compensation in case of early plant closure due to political reasons, and c) a credit guarantee for the debt it would issue for the timely payment of principle amount and interest on the qualifying debt.

These measures were notified to the Cion as state aid under article 107 of the Lisbon Treaty and, after a contested investigation, found to be compatible with existing market regulations.[149] The Financial Times reported that the project costs had soared from Sixteen Billion Pounds to Twenty-Four and a Half Billion Pounds after the conclusion of this investigation.[150] Consequently, Austria filed a claim before EU General Court contesting the Cion's adoption of the UK's state aid measures.[151]

Austria advanced an argument that the Cion erred in concluding that the state measures by the UK were necessary and were compatible with EU competition law.[152] The Claimant's argument was reasoned on the premises that the measures could only be declared compatible if a market failure for generation of electricity has occurred in the entire liberalised electricity sector. It was alleged that the Cion erroneously proceeded without considering whether a market existed for the construction and operation of nuclear power plants.[153] It was further alleged that the Cion should have considered other forms of investment, for instance, international syndication or financiers aid, instead of allowing this state support.[154]

The EU General Court rejected these arguments and held that market failure had not been stated as a pre-condition for state aid; hence the argument could not be accepted.[155] The court also acknowledged that the Cion rightfully considered advantages and disadvantages for distorting competition through state aid measures in the context of the liberalised market

[149] *Commission decision on the aid measure which the United Kingdom is planning to implement for support to the Hinkley Point C nuclear power station* OJ L 109, 2842015, p 44–116, 55
[150] Alex;
Clark Parker, Pilita,, 'Brussels backs Hinkley Point C as cost forecasts soar' (*Financial Times,* 2014) <https://www.ft.com/content/372216e6-4ec0-11e4-b205-00144feab7de> accessed 22-Jun-2022
[151] *Republic of Austria v European Commission* ECLI:EU:T:2018:439
[152] Ibid, para 148
[153] Ibid, para 147
[154] Ibid, para 167
[155] Ibid, para 151

for the generation and supply of electricity.[156] It noted that the Cion was not obliged to give its findings on the 'relevant market' definition.[157]

The EU General Court acknowledged the inherent risks (high upfront costs, uncertainty in the wholesale price, construction delays) for nuclear energy that precluded the private investment. The court further noted the lack of market-based investment instruments due to political 'hold up' risks and complete abandonment as risks faced by nuclear energy.[158] The General court rejected Austria's assertion on the ground that it had failed to substantiate its assertion of the possibility of private investment options through international syndicate financing.[159]

The ECJ, while resorting to Article 2(c) and 194(2) of the Euratom Treaty, declared that promoting nuclear energy would form a public interest objective under article 107(3)(c) of the Lisbon Treaty, if those measures were appropriate, necessary, and not disproportionate.[160] The EU General Court rejected the claim in 2018. The Claimant preferred an appeal against the decision of the EU General Court before ECJ.

The Appellate Court (ECJ) deliberated upon state aid in the context of the Euratom Treaty and the TFEU and elaborated the Court's findings below. It stated that the Euratom Treaty and the Lisbon Treaty were legally at par in light of Article 106a (3) of the Euratom Treaty. The ECJ confirmed the earlier position that the rules of the Lisbon Treaty would apply to the nuclear energy sector when the Euratom Treaty did not have the specific rules. The ECJ confirmed the Cion's action about the validity of UK's state aid measure and held that the state aid rules could be applied to the nuclear energy sector.

It further noted that the state aid by the UK (EU member at that time) for new nuclear construction would not be in contravention of the objectives of the Euratom Treaty, hence valid. However, the ECJ recalled the findings (without any effect on the outcome of the appeal) of the General Court on the point of common interest. It declared that if state aid contravened the EU environment law regime, it would not be compatible.

These state aid cases established that the rules of the Lisbon Treaty would apply on the matters not expressly provided in the Euratom Treaty. Hence, the state aid provisions

[156] Ibid, para 231
[157] Ibid, para 233
[158] Ibid, para 209
[159] Ibid, para 172
[160] Ibid, para 237

(Article 107) of the Lisbon Treaty would be attracted to the cases of the nuclear industry. The state aid measures aimed at promoting or developing the nuclear industry and in line with the objectives of the Euratom Treaty are to be deemed legal and permissible under the EU jurisprudence.

However, any state aid measures have been subjected to remedy and recourse under the EU environmental law regime. The jurisprudence on the state aid rules and the Euratom also divulge that a Member State's national choice and autonomy for energy mix would not be interfered with even under other EU Treaty Law (the exception to this principle has been held to be the EU environmental law).

Capacity mechanism, as one form of the state aid measures, also are a well-practiced tool to promote and protect the electricity generators to ensure security of supply under the energy trilemma. In May 2017, European Parliamentary Research Service in one of its briefing document for the EU Parliament defined 'capacity mechanism' as 'administrative measure to ensure the achievement of the desired level of security of supply by remunerating generators for the availability of resources.'[161] In the section below, the capacity mechanisms employed by the UK, France, and Germany impacting the nuclear industry activity will be discussed.

2.3.3 Capacity Mechanism and Nuclear Energy

Hancher states that the EU's drive towards liberalisation and market reforms had not included any market design. Nonetheless, the liberalisation had led to the adoption of the pool market model for whole-sale trading.[162] He further remarked that the model suffered due to the failure to meet demand and supply in extreme scarcity. The reasons frequently attributed to this failure included unreasonable demand and price caps. This paradox of supply and demand creates no price signals for the necessary investment – often described by economists as a missing money problem.

Bucksteeg commented that this lack of incentive for the necessary investment in generation (due to no price signal) to meet the demand have led to concerns about the security of supply issues.[163] Capacity mechanisms were devised to address this failure by offering the

[161] Gregor Erbach, *Capacity mechanisms for electricity* (EPRS 2017),
[162] Leigh Hancher, Adrien de Houteclocque and Malgorzata Sadowska, *Capacity mechanisms in the EU energy market: law, policy, and economics* (Oxford University Press, USA 2015), 1
[163] Michael Bucksteeg, Stephan Spiecker and Christoph Weber, 'Impact of coordinated capacity mechanisms on the European power market' (2019) 40 The Energy Journal

necessary payments, in addition to the revenue flows from the energy-only market, for supporting investment in generation adequacy.[164] Capacity mechanism designs may vary based on the mechanism's regulated or competitive nature (capacity markets). Capacity mechanism models can be categorised broadly in the following manner (See Figure 11 below).

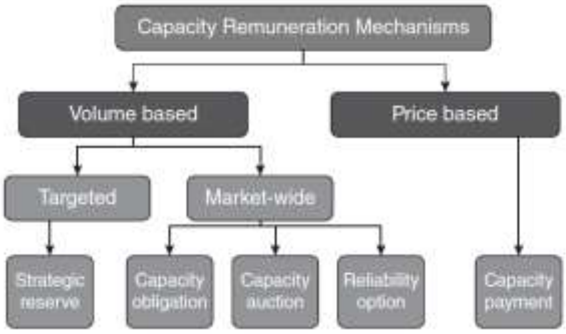

Figure 11: Possible models for a capacity mechanism[165]

The Cion, in a sector inquiry report, found out that there were thirty-five (35) capacity mechanisms (including past or intended to be applied in future) in only eleven (11) countries from the EU.[166] Leiren et al. commented that these capacity mechanisms adopted by the member states for the capacity market and strategic reserves created unease with the Cion favouring a policy of cross-country cooperation devoid of market-distorting subsidies.[167] Nonetheless, the Cion in 2019 issued the regulations for the capacity market setting out the principles for capacity mechanisms.[168] The national policies adopted for the capacity mechanism are briefly explained below.

A. France

Hancher noted that the consumption peak had been increasing much faster than the average consumption in French Energy Market dominated by the nuclear fleet owned by EDF (partly due to its successful execution of nuclear program commencing in 1970). The electricity producers had concerns about the possible investment opportunities in new

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[164]Leigh Hancher, Adrien de Houteclocque and Malgorzata Sadowska, *Capacity mechanisms in the EU energy market: law, policy, and economics* (Oxford University Press, USA 2015), 6
[165] Alberto Pototschnig and Martin Godfried, *Capacity mechanisms and the EU internal electricity market. The regulators' view: ACER's report on capacity mechanisms* (2014), 4
[166] European Commission, *Final Report of the Sector Inquiry on Capacity Mechanisms COM(2016) 752 final* (EC 2016), 9
[167] Merethe Dotterud Leiren and others, 'Energy security concerns versus market harmony: The Europeanisation of capacity mechanisms' (2019)
[168] European Union, *Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity*

capacities and the likelihood of cost recovery in the energy-only market.[169] The concerns also existed on the dominant position of the EDF in a competitive market envisioned by the Lisbon Treaty.

Through an official decree, the French Government promulgated the *Nouvelle Organisation du Marché de l'Électricité* (NOME Law), introducing a model of the decentralised capacity mechanism. It has been stated that through this law EDF was to reserve 25% of its nuclear power for other retails distributors at a lower price (access price) than the wholesale market value.[170] The author stated that the EDF, being a dominant player in French market, had to take this measure to ensure fair competition for other market players. The access price for other market players was to be determined by the Commission de regulation de l'énergie (CRE). Creti et al states that the law holds field until 2025 and this access price will safeguard the interests of the French consumers, only.[171] Although, the law attracted criticism for allegedly being in disregard of competition in common market, however, the Cion in 2012 determined the law to be compatible with electricity liberalisation under the EU and EU's state aid rules.[172]

Pugl-Pichler observed that the earlier auctions for the years 2017 to 2022 showed an upward trend in price.[173] The State-owned nuclear energy fleet still dominates the electricity market in France. The capacity remuneration mechanisms under the NOME Law were apparently adopted to allow new entrants into the markets for renewables and French ambitions to diversify the energy mix. Yet, as mentioned in the preceding para, the law is known to serve a purpose of safeguarding the interests of its French consumers.

B. Germany

Germany's nuclear phase-out policy was followed by the *Energiewinde* (the Energy Transition), *Strommarktgesetz* (Electricity Market Act) *Kapazitatsreserveverordnung* (capacity reserve regulation). The capacity mechanism adopted is based on the strategic reserves. In this mechanism, some generators and suppliers are kept outside the electricity market as reserve capacity. Pugl-Pitcher noted that the reserve capacity had been set as 2

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[169] Hancher, de Houteclocque and Sadowska, *Capacity mechanisms in the EU energy market: law, policy, and economics*, 257

[170] Emil Kraft, 'Overview French electricity system', *Analysis and Modelling of the French Capacity Mechanism* (Springer 2017), 6

[171] Anna Creti, Jerome Pouyet and María-Eugenia Sanin, 'The NOME law: implications for the French electricity market' (2013) 43 Journal of regulatory Economics 196

[172] Ibid

[173] Christian Pugl-Pichler and others, 'Capacity remuneration mechanisms on European electricity markets—legal basis and actual implementation status' (2020) 13 The Journal of World Energy Law & Business 498

GW until 2025, which is determined every two years. The reserve capacity is procured through competitive bidding, and the TSOs are responsible for contracting in the reserve capacity. The capacity provider is paid for the reserve capacity, and in case of the utilisation of the reserve power

C. United Kingdom

After the liberalisation reforms, the UK identified the market failures and adopted the capacity markets as the capacity remuneration mechanism to meet the needs of security of supply.[174] Leiren noted that the adopted capacity mechanism in the UK is a centralised capacity auction system that must be delivered in the event of system stress during a defined 'delivery period'. [175] The capacity market involves the capacity auction phase. The successful bidders are awarded various durations of capacity agreement depending on the time of entry, condition of the generation plant. This contracted capacity is to be delivered at the pre-defined delivery period when the system is under stress.

It is to be noted that the capacity mechanism in France, Germany, the capacity mechanism does not align with the common policy objectives of the market integration for sustainable and affordable energy as envisioned by article 194 of the Lisbon Treaty. To accommodate the concerns of member states about national autonomy for the security of supply, the EU accommodated these capacity mechanisms as state aid if they were in line with the competition regime. In 2019, it issued a directive defining 'capacity mechanism'[176] and setting out the broad principles of the capacity mechanisms to be adopted by EU member states.[177]

Fridolfsson et al. proposed that capacity auction could effectively raise investment for new nuclear capacity.[178] However, it is essential to note that nuclear energy is inherently different due to the extended operation times of its plant, upfront capital costs, the scale of economies. Therefore, resorting to the capacity mechanism (capacity is arranged or reserved for a shorter period from one to two years) for nuclear projects may not be a viable form of state support for nuclear industrial development. As noted in the case of France, the

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[174] Hancher, de Houteclocque and Sadowska, *Capacity mechanisms in the EU energy market: law, policy, and economics*, 372

[175] Merethe Dotterud Leiren and others, 'Energy security concerns versus market harmony: The Europeanisation of capacity mechanisms' (2019)

[176] European Union, *Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity*, art 2(22)

[177] Ibid, art 21

[178] Sven-Olof Fridolfsson and Thomas P Tangeras, 'Nuclear capacity auctions' (2015) 36 The Energy Journal

capacity mechanism is being utilised to diversify the sources by reducing nuclear power's shares in the energy mix. Similarly, in the UK, the Contract of Differences was concluded to support the development of Hinkley Point C.

Nuclear policy development, being a subject of national competence, has seen the two extreme responses within the EU. The EU intends to adopt renewable energy sources as sustainable means of energy, leaving nuclear energy at the whims of national policy. The formal determination by the Cion about nuclear as a sustainable activity in the Taxonomy Regulations may also influence influence the possible growth of nuclear as an industry.*

In view of the cases cited above, the relationship of the Euratom Treaty and the Lisbon Treaty to the extent of matters not covered by the Euratom Treaty has provided some clarity that all matters of state aid about the nuclear power plants would be amenable to the test of competition regime under the Lisbon Treaty. Besides elaborating on the complex inter se relationship between the Euratom Treaty and the Lisbon Treaty, the decisions of the Cion, General Court, and the European Court of Justice in the Hinkley Point C have also elaborated the state aid conditions for the nuclear sector.

Given the legal developments on the Euratom Treaty and the Lisbon Treaty, the state support for promoting nuclear is permissible under the European jurisprudence when they qualify as 'state-aid measures'. The EU Member States may also chose to engage with nuclear industry on the state aid arrangements to meet the energy transition and climate goals.

* In a press release issued by the Cion on 22-Feb-2022, the Cion has determined and decided the status of nuclear as sustainable activity informed by the JRC Assessment Report, Scientific Committee Review, and Opinion of Experts. The announcement can be accessed on https://ec.europa.eu/commission/presscorner/detail/en/QANDA_22_712 (last accessed 22-Jun-2022)

3. Decommissioning Liabilities of Nuclear Plants as a Legal and Policy Concern

In 2019, the IAEA reported that 186 nuclear reactors had been shut down until that year.[179] Germany's nuclear phase-out resulted in an immediate shutdown and later decommissioning of eight nuclear plants. Nuclear plants in France and UK have also been phased out/retired due to the completion of their life cycle.

Decommissioning of nuclear plants has been stated as one of the significant challenges of the civilian nuclear legacy among safety, other economic issues about upfront costs, and construction delays. Numerous international obligations and commitments exist that cover the state obligations for a nuclear accident, spent fuel radioactive management, and liability due to nuclear damage. A list of international regimes covering these topics is described in Table 2 below. However, this work would confine itself to decommissioning of the nuclear plants in the EU and UK.

This chapter will discuss the legal framework, obligations, and status for decommissioning in France, Germany, and the UK.

TOPIC	INSTRUMENTS
Emergency preparedness and response	• Convention on the Early Notification of a Nuclear Accident • Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency
Nuclear safety	• Convention on Nuclear Safety • Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
Liability for nuclear damage	• Paris Convention on Third Party Liability in the Field of Nuclear Energy (as amended by the Protocols of 1964 and 1982) and 2004 Protocol to the Paris Convention • Brussels Supplementary Convention (as amended by the Protocols of 1964 and 1982) and 2004 Protocol to the Paris Convention • Vienna Convention on Civil Liability for Nuclear Damage • Additional Protocol to the Vienna Convention on Civil Liability for Nuclear Damage • Joint Protocol relating to the Application of the Vienna Convention and the Paris Convention • Convention on Supplementary Compensation for Nuclear Damage

Table 2: List of international conventions

179 International Atomic Energy Agency, 'IAEA Releases 2019 Data on Nuclear Power Plants Operating Experience' (*IAEA,* 2019) <https://www.iaea.org/newscenter/news/iaea-releases-2019-data-on-nuclear-power-plants-operating-experience> accessed 22-Jun-2022

3.1 Legal Framework for Decommissioning of Nuclear Plants

3.1.1. International Law and EU Legal Regime

International law puts an obligation on the signatory members to take appropriate measures for the safety of decommissioning of a nuclear facility.[180] The EU under the auspices of the Euratom Treaty ratified the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management in 2006.[181] Therefore, all the EU Member states are obligated to ensure safe decommissioning of the nuclear sites.

The Euratom Treaty has been criticised for the absence of sufficient rules and obligations of the member states about decommissioning.[182] Nonetheless, the European courts have applied the principles of the Lisbon Treaty (as discussed in the preceding section) to harmonise the relationship between the Euratom Treaty and other EU Treaty Laws to fill in the gaps about decommissioning and associated issues of the state obligations under international law.

The EU's applicable legal framework on the radioactive spent fuel management was issued through council directive in 2011.[183] The Directive fixed the responsibility of establishing a national policy on the EU Member States' spent fuel and radioactive management.[184] The provision further required the Member States to follow the principles as prescribed under the Directive. In 2021, the Council has issued another directive about the nuclear decommissioning for nuclear plants in Slovakia and Bulgaria.[185]

3.1.2 Decommissioning Liabilities and Obligations

The IAEA defines the decommissioning of nuclear plants as a series of administrative and technical actions taken to release a nuclear site from regulatory control.[186] The term is distinct from 'closure' which refers to the disposal facility wherein the radioactive waste is

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180 Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, art 26

181 Tromans, *Nuclear law: the law applying to nuclear installations and radioactive substances in its historic context*, 343

182 Fouquet, 'Nuclear Policy in the EU from a Legal and Institutional Point-of-View', 176

183 European Union, *Council Directive 2011/70/Euratom establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste* (OJ L 199, 2.8.2011, p. 48–56 2011)

184 Ibid, art. 3

185 European Union, *Regulation (Euratom) 2021/100 establishing a dedicated financial programme for the decommissioning of nuclear facilities and the management of radioactive waste, and repealing Regulation (Euratom) No 1368/2013* (OJ L 34, 1.2.2021, p. 3–17 2021)

186 International Atomic Energy Agency, *Decommissioning of facilities : General safety requirements* (IAEA 2007), 1

placed. Another IAEA Safety Guidelines elaborated that the decommissioning actions would 'include decontamination, dismantling, and removal of structures, systems and components.'[187] The report noted that the decommissioning process might take from six months to decades, depending on the nature and capacity of the nuclear plant. The IAEA Safety Guidelines also referred to the 'permanent shut down' of a nuclear plant as a stage where the facility has ceased operations for good.[188]

Stoiber et al. discussed the essential elements of a legal regime about decommissioning in their report and highlighted that any decommissioning regime should delineate the role of the regulator in the decommissioning in all the stages of the decommissioning. He further pointed out the significance of the structure of decommissioning codified plans in the legal regime. The law must specify the role and responsibility of the plant operator, process any subsequent change of ownership about the operator and nuclear plant. Finally, the author commented that the law should state and define financial obligations about decommissioning of the plant.[189]

In 2021, IAEA reported that 194 reactors had been ordered to be permanently shut down throughout the world.[190] The permanent shutdown is followed by decommissioning of the nuclear site with the ultimate objective of making the site inhabitable in line with the international and national environmental standards. Samseth et al. highlighted three decommissioning approaches: immediate dismantling, deferred dismantling, and entombment.[191] The suitable approach to any nuclear plant would vary on a case to case basis. However, Irrek commented that the most critical challenge about decommissioning is its costs, which are otherwise to be collected during the nuclear reactor operations.[192]

A. Decommissioning costs and 'polluter pays' principles

The liberalisation of the electricity market further requires all the accumulated costs to be socialised during the operations of the nuclear power plant by the operator. Irrek commented that the nuclear-decommissioning costs, in theory, are the liability of the operator under the

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[187] International Atomic Energy Agency, *Decommissioning of nuclear power plants, research reactors and other nuclear fuel cycle facilities : Specific safety guide* (IAEA 2018), 1
[188] International Atomic Energy Agency, *Decommissioning of facilities : General safety requirements*, 1
[189] Carlton Stoiber and others, *Handbook on nuclear law: implementing legislation* (IAEA 2010), 61
[190] International Atomic Energy Agency, 'Permanent Shutdown Reactors' (*IAEA,* 2021) <https://pris.iaea.org/PRIS/WorldStatistics/ShutdownReactorsByCountry.aspx> accessed 22-Jun-2022
[191] Jon Samseth and others, 'Closing and decommissioning nuclear power reactors' (2012) UNEP Year book 35, 37
[192] Wolfgang Irrek, 'Financing nuclear decommissioning', *The Technological and Economic Future of Nuclear Power* (Springer VS, Wiesbaden 2019), 141

‘polluter pays’ principle and have to be assessed during the operations of the plant. However, in practice, this becomes unrealistic for the reasons of an extended timeframe (in the UK, it is expected to be upto 85 years) from final shut down to disposal of the radioactive waste, limited experience on the decommissioning, and unexpected radioactive experience.[193]

The states are responsible for taking appropriate measures to ensure the safety and decommissioning of the nuclear site under international law.[194] Therefore, the financial obligations are partly transferred to the states and the plant operators.[195] One such case was brought before the Cion when the UK Government notified measures to render rescue aid about nuclear liabilities to British Energy.[196]

British Energy (BE), a nuclear electricity generator with a capacity of 9820MW, was privatised by the UK in 1996. It had been operating in the electricity market after its liberalisation. The substantial fall in the electricity prices and non-avoidable costs in its cost structure deteriorated BE’s cash position. A restructuring agreement was entered between BE and the Government of the UK, which covered a state measure to take the nuclear liabilities about the non-avoidable high costs (decommissioning costs to be paid to Nuclear Liabilities Fund by BE). These measures were reported to the Commission.

The Cion, based on Article 1, 2(b), 2(e), and 30 of the Euratom Treaty, adopted the decision of the UK Government and noted that the rescue measures addressed the risks that would affect objectives of the Euratom Treaty. This intervention by the UK government for continuity of safe and secure nuclear industry operations was necessary and provided responsibly.[197]

This validation of transfer of liability from BE to the UK government about the decommissioning illustrates a deviation from polluter pays principle. Irrik indicated that following the polluter pays principle may *not be 100% possible*. Nonetheless, he observed

[193] Ibid, 141
[194] Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, art 26
[195]Wolfgang Irrek, 'Financing nuclear decommissioning', *The Technological and Economic Future of Nuclear Power* (Springer VS, Wiesbaden 2019), 143
[196] *Commission decision on the state aid which the United Kingdom is planning to implement for British Energy plc* OJ L 142, 662005, p 26–80
[197] Ibid, para 241-243

that despite the apprehension of unforeseen eventuality, the polluter pays principle should become a legal requirement, and it must be applied as far as possible.[198]

3.1.3. Decommissioning Framework in France, Germany, and the UK

The details of national policies and pursuant actions about decommissioning nuclear plants in France, Germany, and the UK are described below.

France announced the targets for reducing the share of nuclear in its Multiyear Energy Plan from almost 70% to 50%. Wealer et al. noted that thirteen French nuclear plants were in the state of permanent shut down.[199] In their work, EDF, being the operator of the nuclear power plants, would finance the decommissioning of the nuclear plants.[200]

The French National Agency for Radioactive Waste Management (ANDRA), being the waste management company, is to be fed from the operator's funds. The (French) Waste Law of 2006 requires the operators to maintain a segregated account for the decommissioning. EDF funds this by charging 0.14 Euro cent/kwh (14 cents of a €) in the price of electricity. The financial costs of decommissioning were estimated as €27bn for 58 reactors. However, these costs had been questioned and criticised for being underestimated.[201]

The external controls also supervise these internal funds to be maintained by EDF. Despite these controls, an extended timeframe is expected as the decommissioning of the Gas Cooled Reactors (GCRs) have not started. Wealer et al. also reported that in the case of France, the decommissioning experience has been insufficient.[202] The insufficient decommissioning experience, internal decommissioning funds and underestimated costs of decommissioning by EDF may add to the issues about decommissioning nuclear plants in France.

German nuclear reactors are at different stages of decommissioning. Wealer reported decommissioning these shutdown nuclear plants and pointed out that three plants have been successfully dismantled and released from the regulatory control. They also pointed out that two of the shutdown NPPs were under the long phase of Long-Term Enclosure – one of the three known strategies of decommissioning in which the facility to be

[198] Irrek, 'Financing nuclear decommissioning', 144
[199] *Commission decision on the state aid which the United Kingdom is planning to implement for British Energy plc* OJ L 142, 662005, p 26–80, 265
[200] Ibid, 269
[201] Ibid, 268
[202] Ibid, 270

decmmissioned is placed into a safe condition and decontamination and decommissoining is delayed for 50-60 years. [203,204]

It has also been reported that, initially, decommissioning was being executed through private contractors. Most of the publicly-owned nuclear plants were funded through a budgetary allocation from the federal and state governments. The costs for decommissioning private plants were initially done through the internal unsegregated fund, which was reviewed. All the funds were maintained in an external segregated account after the change in the law (2016).

The fund had received €23bn as an initial premium. Decommissioning responsibility is still on the utilities, but it has to be carried out by the public companies through the external fund. The public exchequer would bear the burden of these costs in case of operator bankruptcy or loss of the funding provisions.[205]

The UK's National Decommissioning Authority is responsible for the decommissioning of nuclear plants in the UK. In its ten years plan, NDA projects defueling all magnox plants and further expects four magnox plants to be in the stage of care and maintenance.[206] Wealer et al. reported that NDA had outsourced all the nuclear-decommissioning sites to the private contractor's consortia (by spending £12bn) except the Sellafield nuclear power site, which the NDA itself manages.[207] It has been reported that 26 out of 30 shut down reactors (since 1977) have been dismantled through the Long Term Enclosure Approach. A road map for nuclear site decommissioning shared by the NDA Strategy 2021 is described in Figure 12.

Wealer et al. reported different financing streams: for the NDA owned facilities, EDF owned reactors, and the possible new construction build.[208] The UK Government funds the decommissioning of nuclear sites owned by the NDA. The total planned expenditure for

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[203] Ibid, 277

[204] International Atomic Energy Agency, *Safe enclosure of nuclear facilities during deferred dismantling* (IAEA 2002)

[205] *Commission decision on the state aid which the United Kingdom is planning to implement for British Energy plc*, 282

[206] National Decommissioning Authority, 'Nuclear Decommissioning Authority: priorities and progress' (*NDA,* 2021) <https://www.gov.uk/government/collections/nuclear-decommissioning-authority-priorities-and-progress> accessed 10-Sep-2021

[207] *Commission decision on the state aid which the United Kingdom is planning to implement for British Energy plc*, 271

[208] Ibid, 273

2020/2021 had been estimated to be £3.4bn.[209] £2.8bn of this money has been funded by the UK Government, and the rest of it is to be earned by NDA's commercial operations.[210]

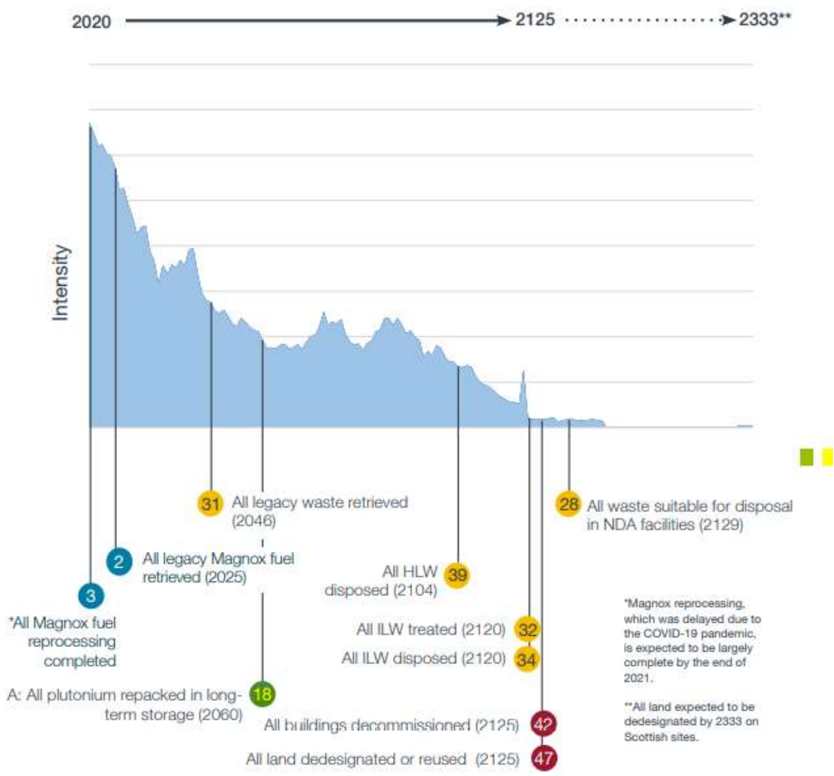

Figure 12: Roadmap for NDA decommissioning[211]

In light of France, Germany, and the UK developments, it is safe to assume that the national governments have to take all appropriate measures (including post-shutdown financing) about decommissioning the nuclear plants. However, the challenges of limited decommissioning experience and the longer operational and post-shutdown life of nuclear plants are immense. These challenges add up when the decommissioning costs appear as only partly assessable. These financial difficulties associated with post-shutdown life appear to be a significant problem associated with nuclear energy that may be resolved through appropriate policy development and state support.

[209] National Decommissioning Authority, *Business Plan : Cleaning up the UK's earliest nuclear sites, caring for people and the environment* (NDA 2021), 31
[210] Ibid, 32
[211] National Decommissioning Authority, *Business Plan : Cleaning up the UK's earliest nuclear sites, caring for people and the environment* (NDA 2021), 11

4. Conclusion

The preceding chapters have discussed and analysed the policy development and legal problems associated with nuclear energy in France, Germany, and the UK. Nuclear energy has the advantages and potential of complementing the energy transition to the low carbon economy. Nuclear energy's economies of scale, disptachability, the abundance of fuel reserves, fixed operations costs, status as a low emissions energy source, and minimal impact on biodiversity make it a suitable and appropriate source for meeting energy transition demands.

The statistics on the safety of nuclear power suggests that it is safer than other sources of energy.[212] The legal and policy developments in the EU and the UK through state support for nuclear energy would be necessary to face the challenges of climate change.

When scrutinised on the touchstone of energy policy trilemma, it becomes evident that nuclear energy ensures the security of supply in a low carbon energy system at comparatively low and fixed operating costs. As an environmentally sustainable, reliable energy source, nuclear energy is entitled to earn its place in the energy mix of low carbon policies. It also has the capability of assisting in the production of other low carbon technologies. It can produce blue hydrogen, a critical factor in the global pathway towards net-zero emissions.

A formal determination by the Cion on the Taxonomy Regulations would influence its acceptability as a sustainable activity for possible investment.[*] In terms of the EU's Emissions Trading System, nuclear energy would have the advantage of no or low carbon taxation, which may also be an essential consideration for possible investment in nuclear energy. However, this alone may not be enough to promote the industrial development of nuclear energy as envisaged in the Euratom Treaty.

Heffron explained nuclear energy's industry dynamics and elaborated that the nuclear industry had seen growth when it was introduced as a program and not as a single project. He added that this situation of viewing the industry on a project basis has also led to the

[212] Anil Markandya and Paul Wilkinson, 'Electricity generation and health' (2007) 370 The lancet 979

[*] In a press release issued by the Cion on 22-Feb-2022, the Cion has determined and decided the status of nuclear as sustainable activity informed by the JRC Assessment Report, Scientific Committee Review, and Opinion of Experts. The announcement can be accessed on https://ec.europa.eu/commission/presscorner/detail/en/QANDA_22_712 (last accessed 22-Jun-2022)

industry's shrinking. It was also indicated that the UK policy for nuclear development has the program to develop eight nuclear plants. However, he mentioned that the UK's intentions on this development of the program are not clear.[213] The UK government has expressed its intentions to utilise nuclear energy to meet its emissions targets. Though France has committed to reducing the share of nuclear energy in the energy mix (apparently to give the energy system more diversity and economic flexibility), it would still require a new capacity to meet that reduction target. Germany has phased out eight plants, and the rest of these plants will be permanently shut down by 2022.

The existing legal framework in the EU does not bar development of the nuclear energy as a national preference in line with Article 194 of TFEU and the Euratom Treaty. The decision of the ECJ in 2020 regarding Hinkley Point C indicates that states would also have the powers to support nuclear energy as far as it is in line with state aid regulations of the competition regimes in the Lisbon Treaty.

The Euratom Treaty (Article 192) obliges all the Member States to ensure fulfilment of the obligations under the Treaty and not jeopardise the attainment of these objectives. The apparent contradiction of obligations under Article 192 of the Euratom Treaty and national autonomy over the energy mix under Article 194 of the Lisbon Treaty has not been sufficiently addressed under European Law. There is limited literature on whether the obligations under the Euratom Treaty would permit nuclear phase-out policies in the presence of the member's obligations under Article 192.

Nuclear energy can expedite the efforts towards the low carbon economy despite concerns about its cost-effectiveness. The development and adoption of nuclear as an energy source for energy transition would require multilateral actions and cooperation from all the stakeholders, such as governments and operators on construction, safety, decommissioning, and radioactive waste management.

Heffron suggested in his treatise that nuclear policy development would require a willing government, effective public administration, incentivisation and projects partners.[214] To incentivise the construction of Hinkley Point C, the Government of the UK had offered a contract of difference for the nuclear plant, among other measures, validated as legitimate state aid under the competition law.

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[213] Raphael J Heffron, *Deconstructing Energy Law and Policy* (Edinburgh University Press 2015), 129
[214] Ibid, 136

Such investment assurances and state support for nuclear energy would help achieve climate goals towards net-zero by 2050. In its report on Net Zero by 2050, IEA also emphasised the significance of investment in new nuclear technologies, Small Modular Reactors (SMRs), which involve a less upfront cost to improve the flexibility of nuclear power as projects. The new technological advancement may also be considered for usage under the national nuclear policy programs.

There is a segregated internal fund for the decommissioning in France, contrary to Germany, which has established an external fund. In the case of the UK majority of the fund is supported by the public exchequer. These cases about decommissioning manifest that the government has rendered or would render the financial support to carry out the decommissioning in France, Germany, and the UK.

Similarly, the nuclear-decommissioning costs financial risks may be dealt with positive futuristic decisions about issues due to an extended timeframe of decommissioning after permanent shutdown. The uncertainty of the partial assessment of the post-shutdown costs may be mitigated by devising a positive policy response to incentivise the market for future investment. The governments ultimately responsible for decommissioning and safety under international law may opt to step up, set a reasonable cap of time and costs for the operator's liabilities, and share the decommissioning costs to mitigate the uncertain and unlimited liability attached to nuclear site decommissioning.

The IEA suggests that in case of our inaction to decide on the concerns about nuclear energy, we may face the risk of missing the temperature targets under the Paris Agreement by placing extra pressure on solar and wind. [215] IEA report also warns that any failure to take the necessary measures for nuclear energy and other low carbon energy sources now may prove to be irreversible and would enhance the costs of net-zero pathways.

The above discussion effectively demonstrates that nuclear energy appears to be a powerful option in the wake of urgent and immediate actions required by climate change. EU's legal framework does not bar the development of national nuclear policies. Nor does it preclude state aid measures for the promotion of the nuclear industry as far as they are in line with other requirements of the competition and environmental law. And not considering and adopting nuclear energy in our net-zero pathways may cost us time, money, and the opportunity to deal with the dangers of climate change.

[215] International Energy Agency, *Net Zero by 2050 : A roadmap for global energy sector* (IEA 2020), 121

But in the end, one needs more courage to live (Albert Camus)

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