IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138
INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Evaluate the Benefit realisation and Cost-Overrun of the Nuclear Energy Project Case Study of Hinkley Point C Nuclear Energy Project

Hitesh Kumar
Dissertation
Supervisor: Tarila Zuofa
MSc in Project Management
Faculty of Business and Law
Manchester Metropolitan University

Abstract

England which gave the first commercial nuclear energy plant to the world. Now, this country itself is facing delays and cost overrun problems in its nuclear plant. Hinkley Point C is one of the controversial nuclear plants which is facing the cause of delay problem. It has been under construction for the past decades and still, there is no certain deadline. There is huge mismanagement, lack of governance and planning problems in this project. The cost has been increasing up the 26 billion pounds. It is important to know the actual problem in HPC by using the academic papers. This research will help future projects and help to produce the low carbon electricity which ultimately help to achieve the net zero target by 2050.

Chapter 1. Introduction

1.1 Research Background

Energy plays a crucial role in our day-to-day life. It impacts our life in social, economic, political, and environmental ways. It means the projects which deal with energy also impact people's life. Every country looking for decarbonisation and net zero carbon emission by 2050 (International Atomic Energy Agency 2021). Nuclear energy projects are one of the critical projects which will help to achieve the net zero carbon goals which are vital for sustainability and a green climate. It is not possible without the implementation of nuclear energy project. Every project has its objective which decides its success rate. According to the project management institute, most projects are designed without understanding the management problem in the nuclear energy project (Ivars, 1974). It is crucial to make environment as sustainable. United Kingdom is one of the countries which is decommissioning its old nuclear energy plant and majority of decommissioning nuclear energy plant is more out of 15 operational nuclear energy plant. Decommissioning of nuclear energy plant will reduce 75% of the total nuclear energy of the UK which has already reduced by 7.4 GW of nuclear energy capacity. That is why, UK is working on nuclear energy project and has planned to build new energy plant. However, risk and uncertainty derail the nuclear energy project from its schedule deadline and desired budget.

The Hinkley Point C nuclear energy project is a significant example of a nuclear power plant that is currently under construction in the UK. The project is being developed by Électricité de France (EDF) and is expected to be the first new nuclear power facility to be built in the country in over 20 years. The Hinkley Point C project is expected to provide low-carbon electricity for around six million homes, create thousands of jobs, and bring lasting benefits to the UK economy. The project will create 25,000 employment opportunities, up to 1,000 apprenticeships, and 64% of the project's construction value is predicted to go to UK companies. The electricity generated by its two EPR reactors will offset 9 million tonnes of carbon dioxide emissions a year, or 600 million tonnes over its 60-year lifespan. However, the project has also faced criticism for being risky and expensive for taxpayers. In this report, we will evaluate the benefit realization and cost-overrun of the Hinkley Point C nuclear energy project, examining the reasons for the soaring cost of nuclear power plants and the main advantages and challenges of nuclear energy.

The Hinkley Point C Nuclear Energy Project is a significant infrastructure undertaking that seeks to establish a new nuclear power plant in the United Kingdom. As one of the most ambitious and expensive energy projects in the country's history, it promises to deliver a substantial boost to the nation's energy capacity, reduce carbon emissions, and create economic opportunities. However, with large-scale projects of this nature, there are always inherent risks, challenges, and complexities that can impact the overall success and efficiency.
This case study aims to comprehensively evaluate the benefit realisation and cost-overrun aspects of the Hinkley Point C Nuclear Energy Project. By closely examining the project's progress and outcomes, we will gain valuable insights into the advantages and disadvantages of nuclear energy as a sustainable power source, as well as the implications of budgetary overruns on such ventures.

1.2 Aim
The aim of this dissertation is to appraise key factors that cause delays in large energy projects using evidence from the Hinkley Point C plant.

1.3 Objective

1) Identify the factor which is responsible for the delay of the nuclear energy project.
2) Analyse the cause of the over-budget of the project.
3) investigate the cause of the lack of coordination among team members.
4) To review extant literature on project delays in large energy projects.

1.4 Contribution of research to the knowledge body
It will reveal the cause of delays and budget problems with nuclear energy projects which will boost the confidence of stakeholders in the Nuclear Energy Project. The research will contribute to the nuclear energy project towards its climate so that nuclear energy project could play a crucial role to achieve net zero carbon emission by 2050.

1.5 Structure of dissertation

Introduction
This chapter provided an overview of the research's background and context and illustrated the study's underlying logic and applicability to it. It also outlined the investigation's goals and objectives. It gave the brief background about the HPC nuclear projects.

Literature review
The literature on cost overrun and cause of delay of HPC project. This chapter critically reviews the project management, leadership, the project team, governance, and team coordination factors in the HPC project.

Methodology
This chapter will give the way of the research such as how did the research take place. It will give an idea about which method and data are used to justify this research such as secondary data or primary data.

Finding and discussion
This chapter will justify the whole research with the crucial data. It will clear the confusion regarding the cause of cost overrun, blame game, lack of policy framework and ineffective governance.

Conclusion
It will give the overall output of the research. this research will open the gate to manage the nuclear plant more effectively such as which technology and area are required for upgradation. There are lots of technological differences between the existing technology in the HPC project and advanced available technology in the marketer such as small modulator reactor.

Chapter 2. Literature review

Climate change is one of the worse complex problems for future generations which causes extreme weather, diminishing sea ice, year after year of record-breaking warmth, drought, fires, and stress to ecosystems. The energy project will play a crucial role to tackle these complex problems and to achieve net zero carbon emissions by 2050 for developed and developing nations. According to the British Integrated company which is known as EDF Nuclear energy project is one of the projects which will play a critical role to achieve net zero carbon emissions in the UK by 2050. EDF is wholly owned by France state which is called Electricite de France. However, it is dependent on the success rate of the nuclear energy project and whether it would be delivered on time and within the desired budget. The history of nuclear energy projects always teaches us that most nuclear projects are delayed and over budget, even the construction of some nuclear projects stopped. World Nuclear Industry Status Report (2022) mentioned that only two out of 17 units started on time in the last threeyear from 2019 to 2021. Nuclear energy projects delayed from their expected date in two ways. Firstly, the Construction of nuclear energy projects does not start on time. Secondly, the nuclear project does not deliver on its scheduled date. It takes more than five to six years from their expected delivery time. This delay impacted the overall budget of the budget. The budget is the most crucial aspect of any project which decides the boundary of the project. These aspects impact the efficiency and productivity of the projects also. This delay causes over the budget of the project. The Nuclear Project Management Specific Interest Group (2022) report is a joint initiative between the Association of Project Management and the Nuclear Institute to investigate the Hinkley Point C Nuclear energy project delayed up to ten years. Hernandez (2023) investigated in his report, that delay of Hinkley Project Point C impacted the budget of the project which increased up to 32.7 billion Pounds including inflation from 25 to 26 billion pounds in the last two decades which was estimated at the cost in 2015. Now, the new schedule deadline for Hinkley Point C nuclear Project is in 2027. It is hard to achieve the net zero carbon target without improving the efficiency of the nuclear project (Baraniuk, 2017). Nuclear energy project passes through an iteration process, safety regulation, procurement of land, identifying the stakeholders and by meeting the environmental guidance. These are the time taking processes which require proper initiation planning, executing, monitoring, controlling and finally delivering the project on time. Management of this phase required good leadership, efficient team coordination, and better communication with stakeholders so that the project could achieve its milestone. There are several causes which delay the project (Baraniuk, 2017).

Section 2.1 Characteristics and nature of nuclear energy project

The meanings of Characteristic and nature are slightly different where the characteristic is the specific quality of the nuclear energy project and nature is a spontaneous inherent quality of the nuclear energy project. These spontaneous qualities are the need of the project. It may vary at different-to-different projects because every nuclear project consists of multiple phases which need to change as per requirement. During the project run, there is a change of developing uncertainties such as the risk of nuclear project and its control which includes Regulatory, Project delivery, operation, decommissioning, electric generation and carbon market and politics However there are certain nuclear structures which are static and consider as nature of the nuclear project. Every nuclear project will pass through this structure (World Nuclear Association report, 2022)

- Development
- Stakeholders Involvement
- Construction Operation
- Decommissioning
- Role of government
- Finance

Cost overrun is crucial for mega projects. The mega project is generally defined by the involvement of more than one billion dollars in investment in the project. Nuclear projects are one of the mega projects. These mega projects describe as high risk, complex, high degree of uncertainty and huge social and environmental impact. Excessive cost overruns often place project viability at risk (Segelod, 2017). The implantation of the economic scale in mega projects faces the manifestation of risk which can generate an asymmetric financial economy which leads to cost overrun and delay in the projects. A cost overrun can be crucial for governance policies in terms of pricing of electricity based on economic cost because cost overrun would impact and thunder the consumer electricity bill. The financial uncertainty and impact due to cost overrun on the power utility create instability in the nation financial security which could lead to an increase the borrowing and credit of the government ultimately leads to inflation in energy bills (Callegari et al., 2018).

There is a distinctive characteristic of nuclear energy projects from other's ordinary projects because of the changeability of the project portfolio due to diversion, restructuring and emergency. Nuclear energy plant makes the long and short planning for the project to maintain safe operation. However, deliberate planning can create constancy in the project, but it is provision and speculation because there are so many exposures that can come during the ongoing nuclear energy project which are unpredictable such as maintenance, regulatory upgradation, and time-to-

time inspection (Alsharif and Karatas, 2016). This variability in the portfolio in the nuclear energy project brings a tight portfolio and risk to the project. This is a unique characteristic of nuclear energy projects where the plant must maintain the licence requirement thought process.

Section 2.2 Lack of team coordination

The schedule and Phase cycle of Nuclear Energy Projects is long. Projects run for a long duration of years. It means the Project team was replaced by new team members due to the completion of the tenure of old team members. The team which was present during the initiation of the project and the team which will deliver the project will be different. It creates a communication gap between old team members and new team members. It takes time to coordinate among team members. This impact on the project schedule leads to cause of delays in the project and ultimately leads to budgeting the project (Minney, 2022)

Impact of team coordination on the Project

- ➢ It reduces the commitment of team members toward the project such as a lack of enthusiasm, and confidence of the stakeholders towards the project.
- ➢ Sometimes, the company can also pull out of the project.
- ➢ It is found that many projects stopped due to the delay of the project because stakeholders were not ready to infuse more money into the project.

Section 2.3 Lack of predictability

The level of uncertainty and risk are high which makes the timeline for nuclear project unclear. It impacts the investment of the projects. There is no doubt government agencies and international lending institutes provide the loan for mega projects such as nuclear energy project (International Atomic Energy Agency, 2022). However, when the projects miss their scheduled date again and again than those stakeholders who are in direct link with these projects. they take less interest in the project, hesitate to infuse their money more and pull up their hand from the projects (Minney, 2022).

Section 2.4 Inefficient organisational culture

Nuclear Energy Projects consider mega projects. These project work with multiple organisations. Every organisation works on its own work culture (International atomic energy agency, 2022). It is vital to know How many types of different organisations are working on the project. One of the crucial facts is that each organisation is aware of each other's work and how they relate to each other. This inefficient organisation passes the responsibility and documentation from one organisation to another. However, Benefit realisation is a crucial fundamental technique to know the pulse of success of the project such as the outcome of the project. The benefit is a value that is created for the project sponsor or beneficiary after the successful completion of a project whereas benefit realisation means to ensure that benefit is derived from output (Project Management Institute, 2016). It is a measurable improvement and resultant from outcomes which are recognised by one or more stakeholders. That is why, a complex project is guided by the need to realise benefits throughout its life cycle but Identification of the ambiguity which comes during the life cycle of a complex project simultaneously to define these benefits at the initial stage makes it hard to achieve and manage benefits which can lead to failure of the project.

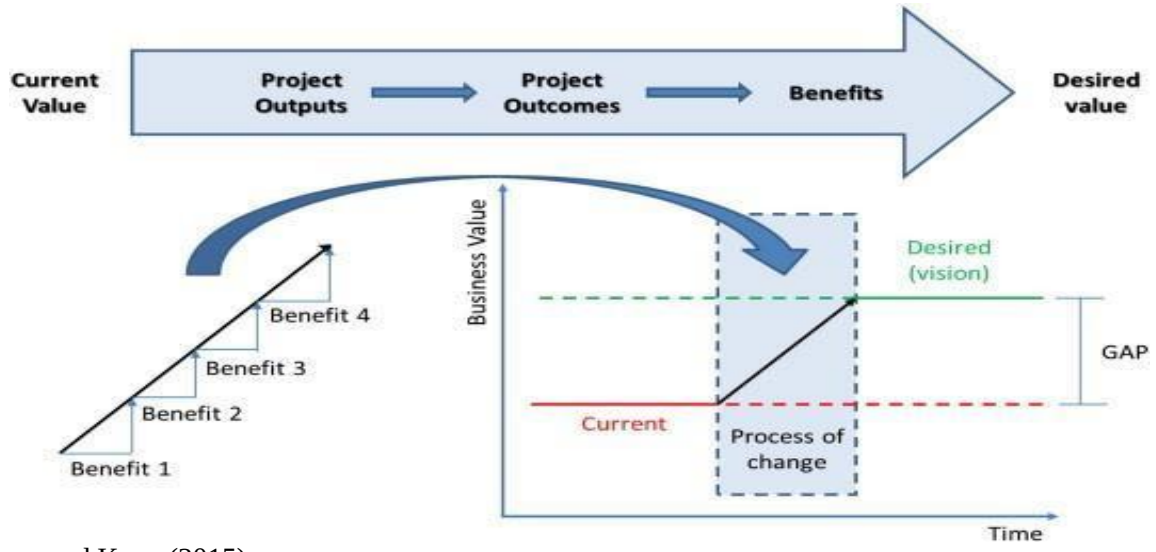
The ineffective use of benefits realisation can lead to failure of application of the benefits realisation and management in a complex and big infrastructure project. It means benefit realisation is an ongoing improvement process. That is why, it is a need for the project to move forward from traditional investment estimation and emphasis on active planning such as how the benefit will be perceived and measured. Nuclear projects are one of the most complex and notorious projects which consist of enormous stakeholders, rules and regulations, different-different organisations, governments, and policies. This multiple involvement of agencies requires a change of way of their work as per the need of the project which is not anticipated such as leading to inflation, increase in the budget, and time spent on the project. However, this can be overcome through effective benefits realisation plan and benefit realisation management using monitoring, reporting, and measuring benefits throughout the life cycle of a project. Benefit realisation is mandatory for all standard and complex projects. It is important to analyse the perception of project success and the application of benefit realisation. It is a process which recognises executing and measuring benefits. It enables the project to be defined and executed which leads to the delivery of output (University of Tasmania, 2018)

Section 2.4.1 Benefit Realisation Plan

It is an encapsulation of the main milestone detailed in each benefit character. It is a navigational management tool to monitor and track the benefits whether it have been sustained after the end of the project or not and manage the unified set of benefits which are related to the project (Department of Finance, 2022). It will improve the delivery of intended benefit which will ensure that resources which are assigned to the project are being fully utilised. It should be considered a primitive part of any improvement project, running from the initial stage of the project to its end. It assists to ensures a depiction and signposting of who is responsible for the delivery of those benefits. It is vital to describe what governance arrangement will be placed throughout and after post project (NHS, 2022). It is a collection of procedures designed to accelerate the implementation of the most important projects while bridging the gap between strategy development and execution. The project management team must define exactly how to determine whether each project is successful if they are to be successful. Ironically, there is no common consensus on the

definition of project success. It has been found in the last twenty years, more than 70% of all organisations were failing to implement their strategies by not delivering the desired outcomes of their change process.
(Breese et al., 2020).

Section 2.4.2 Project Management Maturity Models (PMMM)
The categories, domains, criteria, practises, etc. needed to assess the maturity of a project manager's routines are gathered in systematic ways by PMMMs. PMMMs cover both the operational aspects of how project managers carry out their practises during actual projects and the assessment of an organization's ability or capability to complete projects. The maturity level, an indication used by PMMMs to measure PMM, is computed. A perfection scale is used to measure maturity, with the first increment standing for informal PM or improvisation. By addressing the following research topic, we will attempt to add to the body of knowledge in project management based on the broad concepts mentioned in the preceding paragraph. How can we methodically develop BNs for large projects to increase project management maturity? The approach and model presented will take as input PM's best practises given in PMMMs, and will output expected cost overrun risk, through the study of historical data and the experts' expertise of significant engineering projects in the oil and gas sector. As the difference between real and estimated costs in percentage of estimated costs, we adhere to international convention and de novo cost development. Actual costs are defined as genuine, accounted costs that are established now a project is finished. At the time a project is decided to be built, estimated costs are considered budgeted or forecasted costs. There is often a certain point in the project planning process that can be identified as the time when the official decision to develop the project was made, even though the process varies depending on the project kind, country, and time.



Source: Serra and Kunc (2015)
Figure 1. Gap between current and desired value in project monitoring
The difference between the present situation and the target future situation lay the value gap. This value gap can be attained by a portfolio of initiatives defined by the organisation in its strategic plan. These strategic plans consist of positive changes which have its aim to achieve the organisation's objective. This strategic improvement develops through positive changes in the project called benefit. These benefits can be recognised such as improvement and gain in project value. These benefits are not only from the stakeholder's perspective but also for customers, suppliers and even societal perspectives like a better environment and net-zero carbon emission in climate. Therefore, the creation of value for the project by the successful execution of the project strategy strongly depends on the project delivering the expected benefits (Serra and Kunc, 2015). However, it is critical to distinguish the meaning of benefit and value. It looks similar but there is a thin line between them which separate them. The meaning of value is a broader concept than just only the financial outcome of the project. Value is beyond the simple collective of the performance of the project. Value focus on working for the future, continuously evolving and more than project objective. However, it is hard to quantify the value. Value is mainly around its future orientation and is considered a strategic, long-term outcome whereas benefit considered as the output of the present. Value is a more formal and embedded structure which brings the right outcome not output (Chakkol and Johnson, 2015)

Section 2.5 Decision Making Problem

- It is due to safety and environmental concerns. Nuclear energy project passes through numerous iterations, test, and safety approval process. The authority or agency which are responsible to decide on the approval of documents takes time to give their clearance because any wrong decision can convert the project into a disaster (Deehan, 2021)
- The false trade-off between safety and production thought halts the decision. It is generally considered that increasing the speed of the project will compromise the project. That is why, nuclear energy project passes through strict environmental regulation (Minney, 2022).

- However, these regulations increase the cost and time of the project.

Nuclear energy sites establish from the human population and habitation. In Asia, new nuclear projects follow the old path. However, the situation is reversed in USA and Europe where every nuclear project considers new and unique. It means every infrastructure passes through testing, and licencing before development. It causes significant delays. China is one of the live examples of this issue. China is planning to build 150 new nuclear reactors in the next 15 years. It would not take 15 years for each reactor (International Atomic Energy Agency, 2022).

The decision-making problem can be solved by increasing confidence and trust in the nuclear energy project. However, the Articulate of Confidence in decision-making is the process of dependability which is based on empirical evidence and that can access through transparency. This transparency is dependent on openness and trust. Ultimately, trust behave as the bridge between one project to another's or with in project itself which considers the behaviour of the organisation. Trust in the organisation and project work plays a crucial role when one organisation is willing to be vulnerable and give up its specific measure of control to another's one.

Section 2.6 Lack of ICT Communication in PMO

Most industries use ICT communication in their office. ICT communication system helps to project management office for automation of information together and report to other desired authority (Minney, 2022). Nuclear energy project work on the web of suppliers and complex supply chains. Nuclear energy runs on its own web. The nuclear project does not connect with outside networks due to security concerns such as hacking. However, ICT communication can make effective communication for nuclear energy projects which can improve time documentation approval, improve project schedule predictability and boost confidence in the stakeholder because of clear schedule projection (Larson, 2022). Digital PMO is vital for nuclear energy projects for implementation of a strong management plan which should meet the requirement and standard of high quality on time and desired budget (Baraniuk, 2017). Digital PMO will coordinate effectively with multiple experts such as environmental, Government, construction, safety and chemical (Minney, 2022).

Section 2.7 Governance and Leadership Quality Issue

There should be clear cut consist of strategies regarding governance (Whitmore, 2020). Hinkley Point C nuclear project started in 2008. Still, it is under construction and new dealing is in 2027. On the other side, after 2008, UAE established newly Emirates Nuclear Energy Company which selected a Korean contractor to build and design its four reactors at Barakah in Abu Dhabi. On 19 August 2020, Barakah 1 has been syntonised from the grid. It is a great achievement for the UAE country. The UAE does not have any previous experience in nuclear energy projects, no nuclear engineering, no regulatory, no heritage experience in the supply chain in the nuclear project (Nuclear Institute Project Management Specific Interest Group, 2022).

One of the arguments is that the UAE contractor was Kepco on board which scheduled the project on time and as per desired budget. However, Hitachi did not achieve the success in Wylfa project to build the nuclear energy project on the island of Anglesey in March 2021. Hitachi have a good track record in nuclear energy project in Japan and Taiwan, although it derailed on the Wylfa project (International Atomic Energy Agency, 2022). The ability to take good decisions on time is one of the crucial parts of good governance. Lack of governance quality jolts the confidence of the stakeholders (Nuclear Institute Project Management Specific Interest Group, 2022).

Nuclear energy project deal with high health security such as radiation causing cancer. Public acceptance is one of the challenges for the government and the project. However, this situation can be traced by the concept of consent which refer to the acceptance of the public community in an immediate environment. This consent is quite passive because the response of the community takes time to understand the project and it can be changed(Alsharif and Karatas, 2016). Government plays a critical role in this regard to pass the message of the benefits of the project. On the other side, Ownership is a very complicated situation for the governance. It is a challenge for the government to find a site for the nuclear energy project. Nuclear energy project requires a remote area, and it should be near enough water for its coolant. However, Hinkley Point C is situated just near the old reactor Hinkley Point A and B. It did not make big trouble for the project. The public community got the value addition in the form of electricity. However, Project sustainability is critical for the environment (Brans et al., 2015).

Section 2.8 The Jolt of Decision-Making on the Predictability

The main reason for worse prediction is the bad quality of governance. One of the factors is the political determination of political leaders. Prediction quality factors vary from country to country for nuclear energy project (Matthew and Walker, 2022). Every country has its nuclear energy policy which regulates its nuclear energy project. There is enormous nuclear agency such as Environment, safety, risk Regulation, energy, and climate change. These factors reduce the prediction quality. It is hard to estimate the project schedule date and desired budget. The bad prediction quality reduces the confidence of the stakeholder in the project also (Eastup, 2020).

Strategic misinterpretation is also one of the root causes of bad predictions Some leaders and decision-makers take decisions for political gain rather than long-term project aims and objectives. This extended hierarchy structure makes the structure as poor decision quality because the decision taken by that person who has a lack of feel and prediction quality for the project (Minney, 2022).

Predictability regarding the budget plays a crucial role in the nuclear energy project which is directly connected with the public money. One of the predictions about inflation is very complicated because of the uncertainty about globalisation. It increases the cost of the project also. Nuclear energy project generates electricity. Prices of electricity depend on the inflation and investment of stakeholders. In the Hinkley Point C nuclear energy project price mechanism was introduced to support the project. It considers a price guarantee scheme which is known as the contract for differences. Orayeva (2017) explained, the concept of Contract for the difference which is new idea used in the Hinkley point c to manage price with inflation however it is on paper because Hinkley point c nuclear energy project is still under construction. It means benefit cost realisation is under the carpet in the Hinkley point c nuclear project (Portugal-Pereira et al., 2018). Contract for differences is based on inflation. If the price of electricity per unit increased and stakeholders are not able to bear that much of the cost. It means this price increase will transfer to the consumer. However, In the contract for differences, the increased price will transfer to the government of the UK and if the inflation is reduced then the extra price will return to the government of the UK. However, in this price control mechanism price will manage by the imposition of taxes on the public because government get the money from tax not in its own way (Brans et al., 2015).

Section 2.9 Stakeholders' Complexity

Nuclear energy project considers mega project which requires huge money. It is vital to arrange the money through public and private partnerships, lending institutions or government guarantee (Paradigm technology, 2019). There is no doubt increasing the number of stakeholder quantity provide financial security to the project, but these numbers of stakeholder's existence make the project more complex in terms of communication, schedule date, design, procurement of the land (Minney, 2020). Every stakeholder has specific importance as per their influencing power. It makes the system more complex to put the stakeholders in the priority. The more numbers of stakeholders make decision complex and overlap in the governance (Nuclear Institute Project Management Specific Interest Group, 2022). However, complexity of stakeholder can be refined and control by increasing the confidence of stakeholder for nuclear energy project. However, it is vital to confidence remain high in all phases of the project which require certain element such as openness, transparency, technical competency, and procedural equity. In this confidence strategy, openness and transparency play a key role to infuse the confidence of stakeholders in the project.

Openness is an attitude comprising the desire to hear, modify and transform to achieve the objective. However, there is a limitation regarding its privacy such how much information should be change and transfer. Projects consist of multiple stakeholders, so it is hard to convince everyone. That is why, an open attitude might be work roughly in budget, time, policy. It is hard to change architecture and materials costs (Brans et al., 2015).

Transparency considers as a process to convert the action into visible and more apparent which enable the people to access the information and understand it. Transparency provides the clear-cut view regarding the information to the stakeholders and interested parties which consider as passive transparency. On the other hand, Transparency unlayered the logic behind the decision-making process which is known as active transparency. However, if someone change the any data and information, it can become disaster for the project (Alsharif and Karatas, 2016). That is why, it is vital make transparency more robust in a more secure manner and it should be implemented in a three level of decision making such as process, structure, and behaviour. It means that plan and procedure should be crystal clear, roles and responsibilities should be assigned to the right authorities and person as per their skills. Institutions and individuals should be open and transparent to inculcate the idea of other's also so that creativity and new idea can flourish for the project (Brans et al., 2015).

Section 2.10 Risk and Change Management

If there is any change in design, budget, or planning. It would be a new exercise to get approval from all the stakeholders within the desired schedule and inform them about the change. It is hard to manage the risk from this perspective, which is why, risk-management quality in nuclear energy projects is compromised and inefficient (Forrest Crellin, 2022)

It is vital to consider that any regulatory process takes place with the progress of the project. There is a need for an internal shareholder governance process which also take time such as the decision to decide which door should be installed either locked door or unlocked door for security reason and emergency evacuation. this risk mitigation plan takes time specifically for nuclear energy projects where every system has its safety regulation. It should be clear-cut regulatory guidelines which differentiate the safety measure and regulation (Kenzie Consulting Group, 2020).

Section 2.11 Safety Culture

Nuclear energy projects are linked with the high-security risk concern. The person or authority who is responsible for deciding on a certain aspect takes a negative decision rather to consider positive or give its clearance. Authority does not give the clearance in one shot or one chance even though the project meets all the regulation and guidelines (Deehan, 2021)

One of the trends in the UK is that authority is more focused on the project input specification rather focus on the objective or result of the project. It is occurred by a more commercial approach to project management which provide the clear crystal transfer of scope which passes the risk to the vendors or contractor. The contractor takes time to go proceed even though it is right due to its liability. The benefit of the value-driven management approach in the nuclear energy project (IAEA, 2012)

It is hard to define the input specification precisely and exactly even with the help of design engineering software. It means the project team will do some specific changes in the project to meet the regulation so that approval from the authority can take place. It vital crucial to manage these changes such as the implementation of new ideas, some adjustments, elimination of some areas to meet with requirement (Nuclear Institute Project Management Specific Interest Group, 2020). It takes time and complexity to analyse and understand this issue. The project team take time to gain a better understanding between change management and requirement (The Nuclear Institute, 2021).

Section 2.12 Complex and complicate operating model

Nuclear energy project work with different contractors and companies. It is vital to know the building modelling information for all managers and team members so that they can know the project details in a better way. There are lots of IT tools for operation models such as BIM paradox and PLM for manufacturing. When the design of nuclear energy project is made on 3D and 2D model structures and passes from one connected company, authority, and organisation to another (INTERNATIONAL ATOMIC ENERGY AGENCY, 2021). This is not a single platform or network which relates to environmental authority, safety, and government because every company does not want to share its technology with others. However, if the 3D environment model is shared with the concerned authority and at the same time progressed through the quality assurance cycle, improvement, and change throughout the project then leads to taking the decision on the time at least 90% of the approval (Minney, 2022).

One of the complexities is due to the technology used in the nuclear energy project which requires more labour, material intensive, license and public acceptance. It takes time which ultimately increases the cost of the project even though the project is just in its initial stages. It leads to the high overnight construction cost which impact on the budget of the projects. The main reason behind this is the longer time delay such as environmental clearance, licence standard, public acceptance, and government policy approvals (Brans et al., 2015).

2.12.1. A consequence of poor decision-making in nuclear energy project

1) It reduces the confidence of stakeholders in the nuclear energy project.
2) It affects the leadership quality which impact on the team members such as inefficient team coordination.
3) Nuclear energy project struggle with the late identification of project requirements. It means the decision takes time to be updated even though it is fixed the problem before moving to the next stage of the project which differs from the project schedule estimate date.
4) The root cause is not proceeding to make before meeting the standard. The root cause is the inefficient to manage the change which is not enough to take the decision as fast. This issue drives the slow decision-making process.

Therefore, causes of delay in nuclear energy projects can lead to the derailing of its objective, desired schedule, and budget. That is why, it is crucial for nuclear energy projects to make an advanced Integrated Project Control System so that policies and procedures can work effectively which will ensure to track and measure the project performance, forecasting time, cost, and cost realisation (Orayeva, 2017). The integrated system will also help to consistently identify, assess, and highlight the cause of delays in nuclear energy projects. To create the integrated system, causal factors must be captured, modify and upgrade as per the input of the higher authority and manager weekly or subsequently such as Gathering information weekly, highlighting the cause for delay, and evaluating and analysing the cause of delay (Portugal-Pereira et al., 2018).

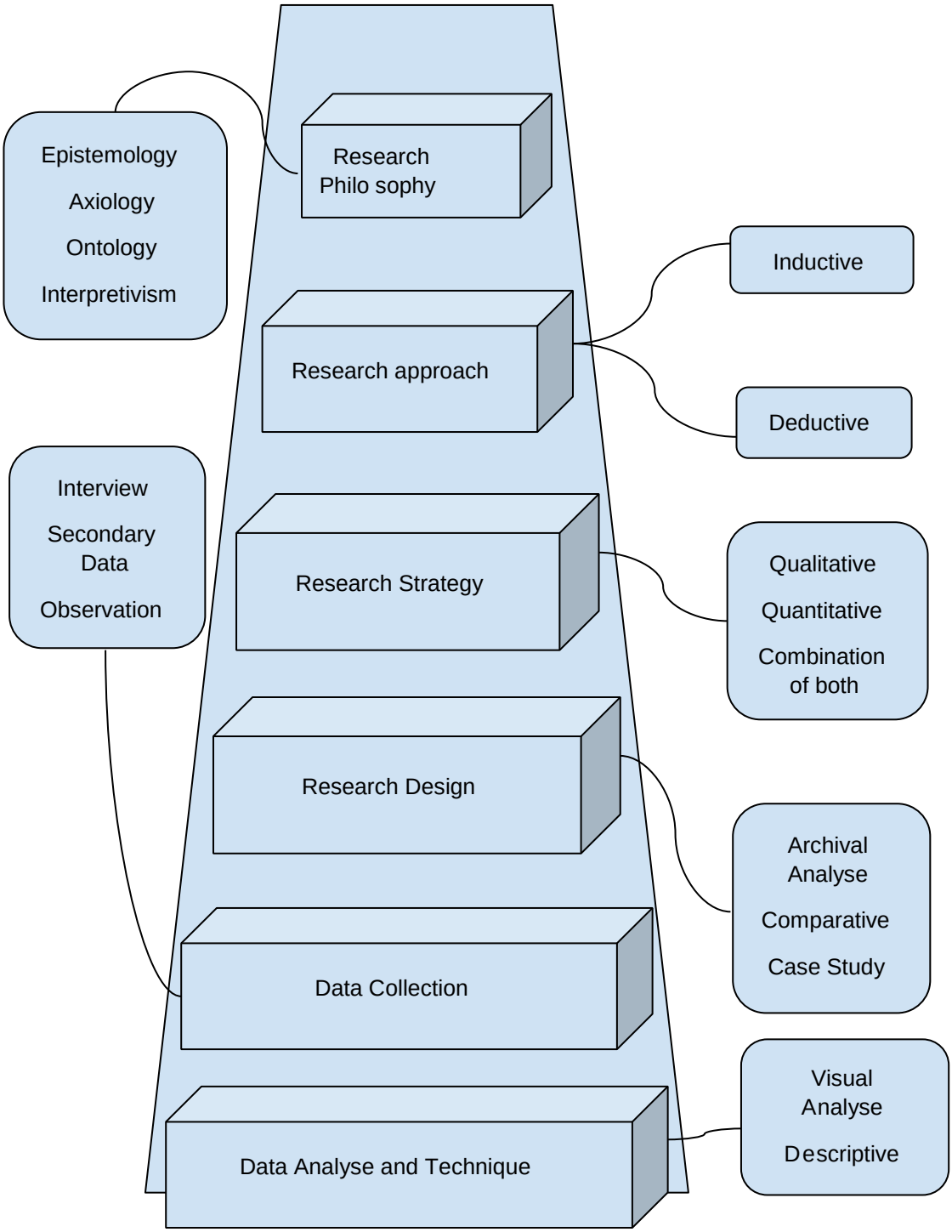
Chapter 3. Methodology

The methodology is referred to as the technique of simulation. It also discusses the scientific method to perform the task. It derived the thing how it is performed. It consists of how hypotheses become theories which is called scientific methodology (Lehaney, B. A. and Vinten, G., 1994). It is a technique which is used to address the problem and question of sponsorship. It helps to simplify the reality in which relevant variables or data are chosen for a model and at the same time it depicts the whole story which unlayered its performance.

Methodology is a term that can refer to the study of research methods, the methods themselves, or the philosophical discussion of associated background assumptions. In the context of inquiry, methods may be defined as systems of rules and procedures to discover the regularities of nature, society, and thought. This encompasses various issues pertaining to both the collection of data and their analysis. Research methodology is a way of explaining how a researcher intends to carry out their research. It involves studying the methods used in a field and the theories or principles behind them, to develop an approach that matches the research project's objectives of the research project. A good methodology chapter should include the type of research done, the research design, the population or sample, the data collection and analysis methods, and the ethical considerations. Methodology In general, is a structured procedure for bringing about a certain goal, like acquiring knowledge or verifying knowledge claims. It is a body of methods, rules, and postulates employed by a discipline. The goal of following the steps of a method is to bring about the result promised by it. The methodology can also refer to specific procedures used to arrive at new knowledge or to techniques of verifying and falsifying pre-existing knowledge claims.

Methodology refers to the systematic approach or set of principles and procedures that are used to conduct research, solve problems, or achieve specific goals in various fields such as science, social sciences, business, and more. It outlines the strategies and techniques that guide the process of collecting, analysing, and interpreting data or information to draw meaningful conclusions or make informed decisions.

However, Nuclear energy project consider as the critical infrastructure of the country. It is crucial to collect the data in appropriate manner without breaking any law. This research focused on the critical academic review and empirical evidence taken from the literature review. This is performed by the following component which will give the sense of this research like how this research performed.



Source: Wilson et al. (2014)
Figure 2. Structure of research methodology.

Research Philosophy

Ontology focuses on the social factor. It is more inclined toward the nature and reality. It considers the external world whereas epistemology relies on knowledge such as how much knowledge can be taken from the social factor. This research is focused on epistemology rather than interpretivism. Interpretivism is based on participation. However, this research does not involve any participant. That is why, this research is considered positive because interpretivism tries to enter the external world and conceive the facts (Wilson et al., 2014).

Research Design and Approach:

Research design is a draft and layout of the research which will explain the procedure fo the research. Research is designed in a way that it consists of the objective, aim and scope of the project. However, it is crucial to differentiate the research design and research method separately because research design is mainly focus on the framework on the collection of the data and research method is a technique to collect the data. Both are slightly different to each other (Sanchez et al., 2020). This research will focus on the archival design which is based on the qualitative data. This secondary data is already present in the form of government audit report, company's documents, and academic research papers. It will give a holistic view regarding the cause of delaying the nuclear energy project. It will consider the scope of the research which defines the boundary of the research. The brief introduction of the research will give the holistic view of the causal factor of delay of nuclear energy project. The literature review of this research is deeply and critically analysed the academic paper related to Hinkley Point C. Research will help to find out the loophole and cause of delaying in the nuclear energy project.

It is crucial to describe the approach of the research. it is divided in two way Inductive and deductive approach. Inductive emphasis on creating a new theory from the experimental observation. However, deductive focuses on the existing theory rather than developing a new theory. This research relied on the existing theory and research that took place on the HPC project (Flyvbjerg et al., 2003).

Data Collection: Data collection is one of the crucial tasks which will provide the empirical evidence of this research. Data is one of the main pillars of this dissertation. It is vital to give evidence to analyse the literature review. There is a dilemma between the nature of the data collection either it should be qualitative method or quantitative method. Quantitative method on is related with quantity and primary data whereas qualitative method is based on the quality and secondary data (Ralston, 2021). Primary data is a collection of interviews, queries, survey and sampling. On other side, secondary data generally relay on the existing data which are available in academic papers, research, reports. This research is relay on the existing data of Hinkley Point C nuclear energy project which are available in academic literature papers, government audit reports, company's documentation, and journal articles. This secondary data known as qualitative date will help to find out cause of delay in nuclear project specially for Hinkley point C.

In this dissertation research, the qualitative method would be used to access the data instead of quantitative method. This research deals with the nuclear energy project which consider as critical project so that it is not possible to take interview of those people who are stakeholders of Hinkley Point C which require the material resources.

There is certain reason behind to use qualitative method and use of secondary data for this research.

1) **Economic:** Quantitative method would require a personal interview, survey, and face to face meeting. It is hard to invest the money under this economic distress to conduct the personal interview. That is why, qualitative method would be used to access the data to analyse the literature review for this research.
2) **Political:** The Hinkley project is very controversial nuclear energy project in UK. It is hard to conduct the personal interview with CEO of those company which are linked with Hinkley point c project. It has already become the hot topic in political domain.
3) **Limitation of time:** quantitative method requires an enough time. It is hard to the complete the research within three months by quantitative. That is why, qualitative method would be used to this research.
4) **Realistically:** In the contrast to primarily data. Secondary data is more straightforward to collect. One of the unique qualities of secondary data is that it allows to do crosssectional comparison which enable to reduce the confined research. This confine research based on its primary data which considered as the limitation of primary data. On the other side, secondary data will give provide the broad and holistic view on this research.

Finding

Data collection and data analysis are the two side of same coin. It is essential to briefly analyse the data so that information can be processed. This research will use the causal loop, bar chart, pie chart themes and pattern to analyse the data where there is a requirement. However, there is no specific approach to analyse the qualitative data. Holistic analyse is one of the approaches in that manner so case of this research would be analysed and considered as the unit and mainly focus on the aim of the research.

Discussion

The research discussion is broadly focus on the summarise the whole aspect of the research. This research discussion will provide the precautionary element which will help to execute the project smooth especially big project. It will highlight of the proactive approach It will open the future aspect of the research on the issue and challenges in the nuclear energy project.

Ethics

Ethical aspect is crucial for any research. Ethics aspect deal with the consent, truth, duplicity, transparency, non-discrimination, honesty, and integrity. However, this research does not deal with any interview. There is no involvement of human, but it is crucial to uncover the ethical aspect of this research and its dimensions.

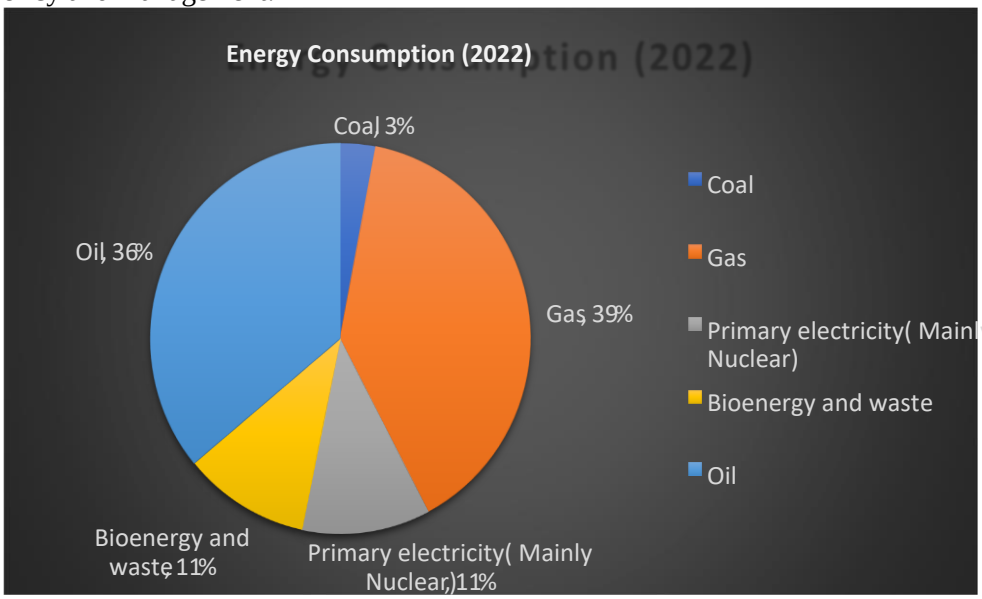
Conclusion

It will give the outcome of this research which will help to future project. This research will elucidate causal factors of delaying the nuclear energy project. The case studies of Hinley Point C will give the clear picture related with its delay factors and increment in the budget. However, every research has its some limitation. In this section, there will be some explanation related with its research confinement or limitation. It will give the idea to create the new idea and research for further research.

Chapter 4. Finding and Discussion

4.1 Finding

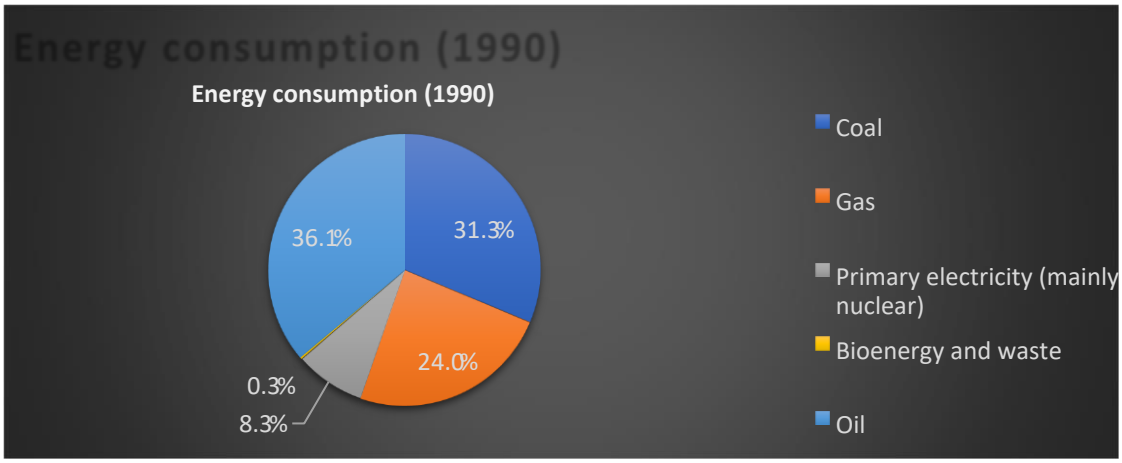
It is crucial analyse the cause of delay with the help of data so that main cause can come out on surface which can prevail to delay in future nuclear energy project. HPC is a critical infrastructure project which is facing trouble due to its ineffective policy and management.



Source: Department for business Energy and Industry Strategy (2022)

Figure 3. Energy consumption in UK in 2022

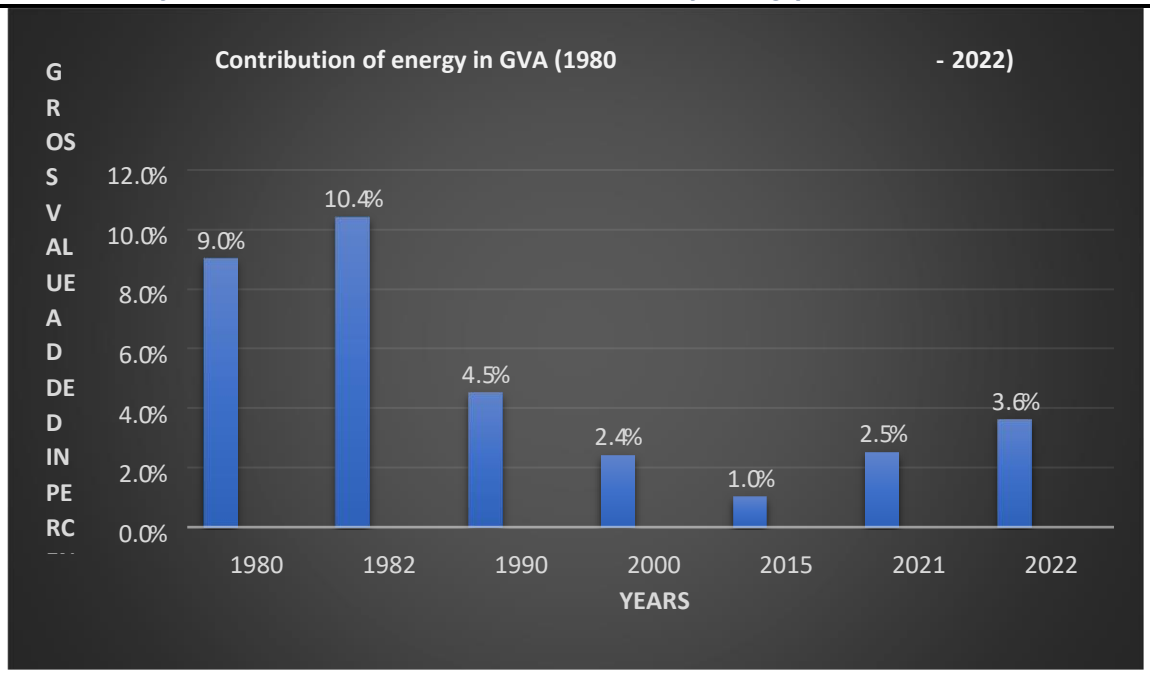
The energy consumption in the UK is mainly filled from gas (36%) and oil (39%) which consist of 75% of total energy consumption in 2022. It is not good for net zero carbon ambition by 2050. it is the need of the hour to reduce the energy dependency on gas and oil simultaneously it is also crucial to find the right fuel or substitute for oil and gas. It can only be possible by increasing the energy production by nuclear because the capacity of wind and bioenergy is not as much which can complete the demand of energy consumption.



Source: Department for business Energy and Industry Strategy (2022)

Figure 4. Energy consumption in UK by different types of fuel

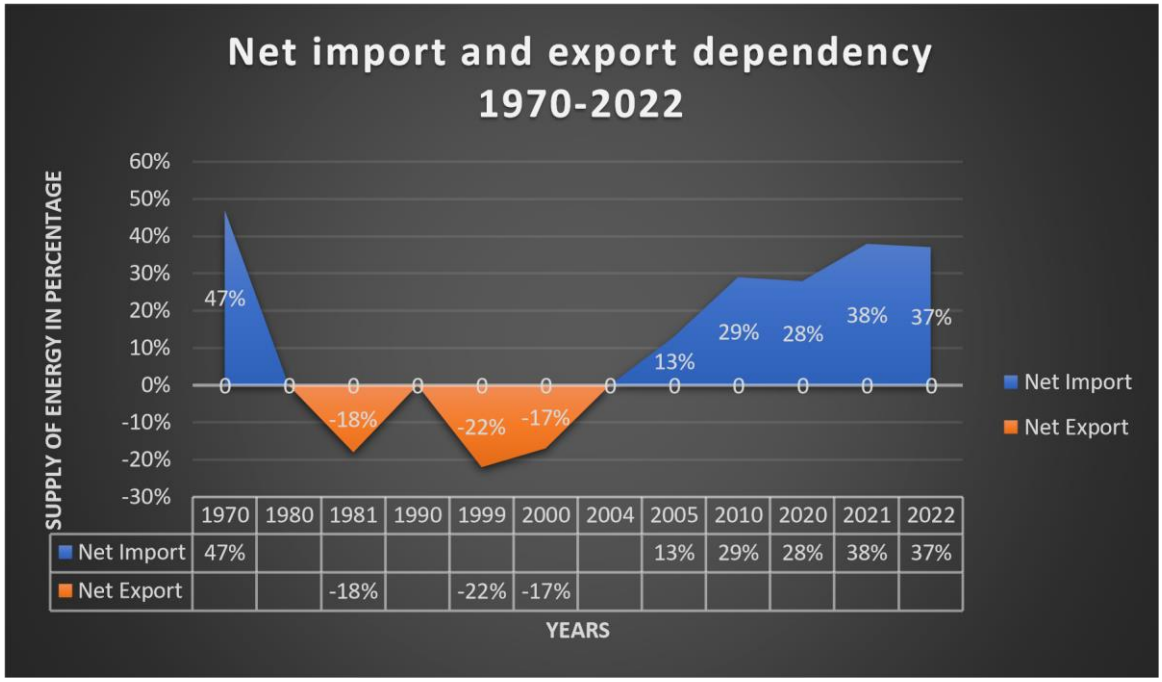
In 1990, coal was the second most fuel to provide energy in the UK. It reduced drastically up to 3 % in 2022. It is a good indication from a climate and energy perspective but there is no policy shift from fossil fuel to renewable and non-fossil fuel energy sources. The reduction of coal production was compensated by oil and gas even gas consumption in 1990 increased from 24 % to 39 % in 2022. There is not much increment in the nuclear energy. Policy intervention and wrong choice of wrong policy is the main cause of outages of nuclear reactors.



Source: Department for energy security and net zero (UK) (2023b)

Figure 5. Contribution of energy in GVA

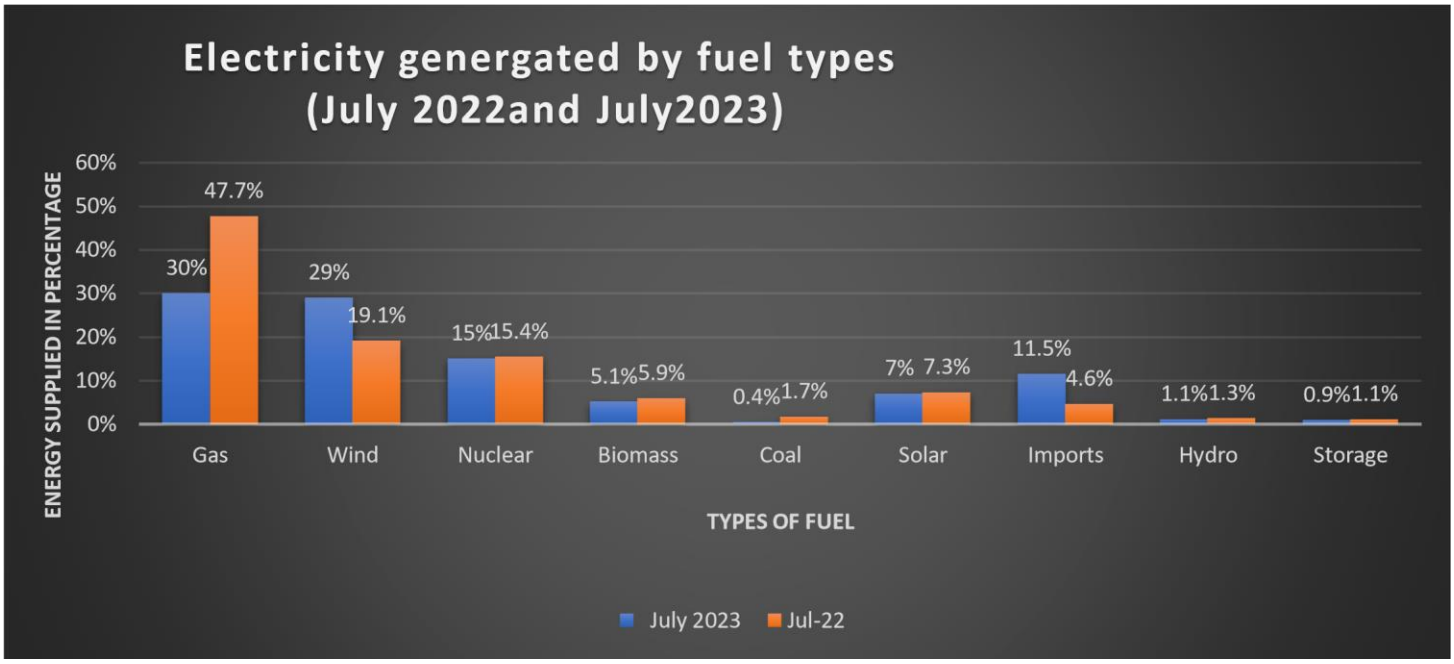
Energy is the main pillar of the economics of any country which contributes to the growth of the country in the form of GDP (Gross- domestic product) and GVA (Gross- value added product). The contribution of energy in GVA in the UK economy plays a major role in driving its economy. However, these energy-driven factors reduced drastically. During the time of 1982, the contribution of energy in GVA was at its peak which was 10.4 % out of total GVA. After 1990, the Volume of energy was reduced due to financial crisis in 1990. However, it is still in the struggling phase even 1990 financial crisis has been over. In 2022, it was 3.6 % just got a 1% increment from 2.5% in 2021. It is due to the outage of the nuclear plant.



Source: Department for energy security and net zero (UK) (2023a)

Figure 6. Net import and export dependency

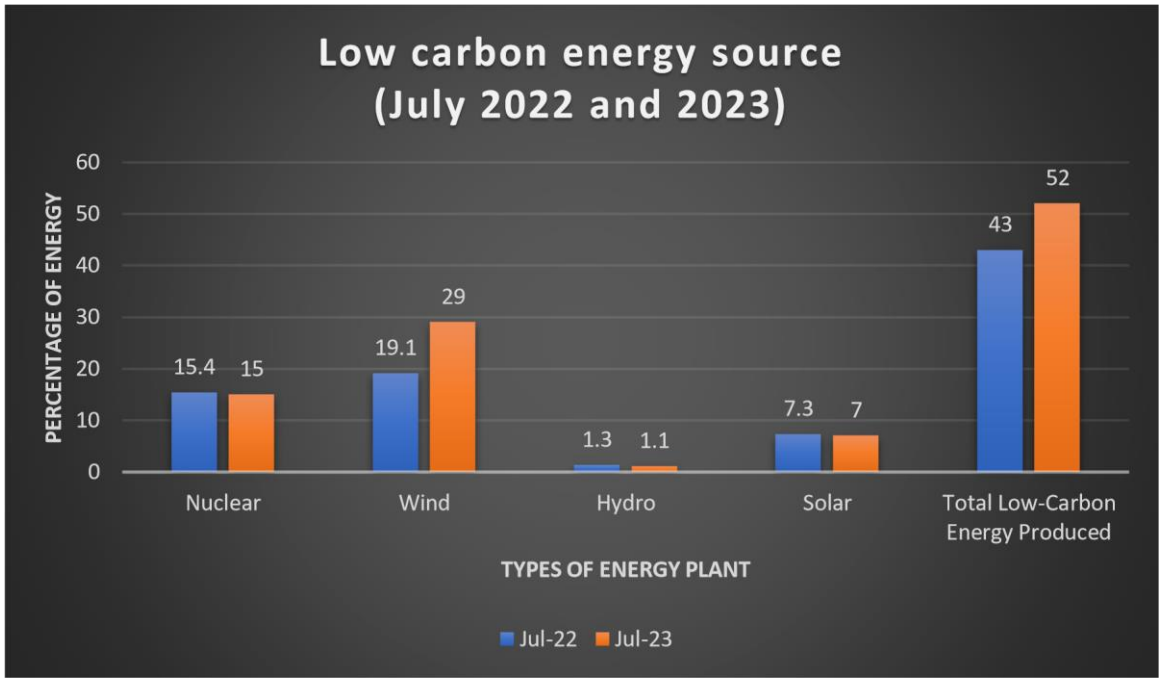
The country which gave the industrial revolution to the world. Now, that country itself is under a shortage of energy. In 1970, the UK was the net importer in the energy sector and 47% of energy was imported from outside the country. It was almost half of the total demand but after 1980, the UK tasted success in the energy sector and became an energy exporter in 1981. One of the factors was coal production behind it. It continued up to the 2005. After 2005, imports in the energy sector increased to meet the energy demand. It has reached up to 37% which is almost near to levels of 1970. It is critical for the nation's energy security perspective. Now, the UK is an energy importer country which imports nearly 37% to 38% from outside the country so that it can meet its energy needs.



Source: His Majesty's Government (HM Government) (2022)

Figure 6. Production of energy by different fuel type 2022-2023

The generation of energy from nuclear was 15% in 2023 which reduce from its last years. The reduction was mainly due to the retirements of old nuclear plants in 2019 especially Hinkley Point B. The major shift was seen in gas and import. It increased drastically. These facts show that energy production mainly comes from carbon sources such as gas and oil However, the volume of gas decreased from 47.7% to 30% because of the sanction on Russia and UkraineRussia conflict. That is why, the HPC nuclear plant plays a major role in the UK's energy security perspective. It is critical to complete the HPC on its new deadline which is in 2027. It will help for future nuclear projects.



Source: Edward de la Billiere (2016a)

Figure 7. Energy supplied from low carbon source.

The percentage of low-carbon energy sources has increased from 43% in 2022 to 52% in 2023 even the percentage of nuclear energy reduced from 15.4 to 15% in 2023 from its last year. It is the hurdle of the path to achieving net zero carbon emission. The target is to achieve the generation of 24 Gigawatt of electricity by nuclear plants by 2050. The contribution of the HPC nuclear plant is 3.2 Gig watt which is not as much but this research on cost and management challenges in HPC will give the idea and solution to further projects because HPC has been delayed for the past decade.

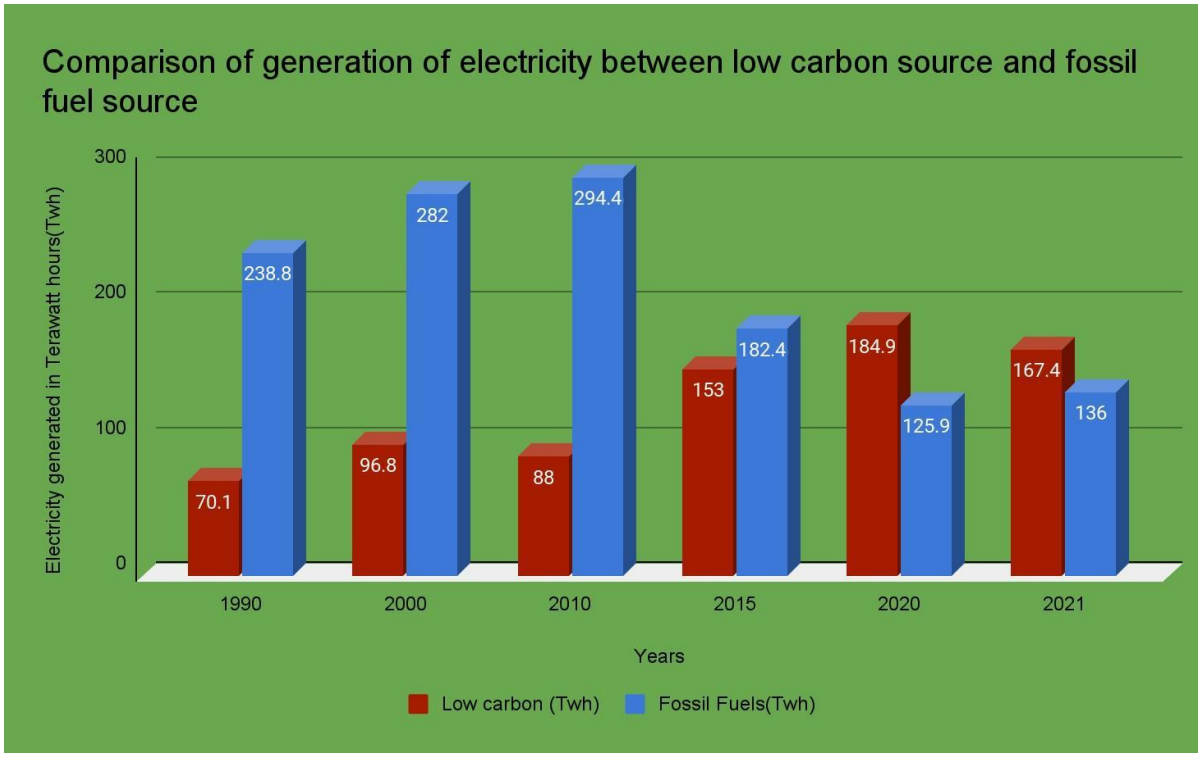
Key measures	End 2022 ambition	2023 ambition	2024 ambition	2025 ambition	2030 ambition	2050 ambitio
– Up to 8 reactors progressed across the next series of projects – Reaching up to 24GW by 2050 (up to 25% of demand) – Starting scoping out the Great British Nuclear Development Vehicle next month	– Great British Nuclear (GBN) Vehicle scoped and being set up – Future Nuclear Enabling Fund funding awarded	– Initiate the selection process for further nuclear projects	– By 2024, FID on one nuclear project (this parliament)	–	– Up to 8 new reactors progressed	– Up to 24GW nuclear installec (up to 25% of total GE demand

Source: Chris Matthew (2022)
Figure 8 Net zero target of UK government

Power Station	Opening Date	Closure Date	Installed Capacity (MW)	Current Status	Reactor Type
Calder Hall	1956	2003	220	Closed	Magnox
Chapelcross	1959	2004	196	Closed	Magnox
Berkeley	1962	1989	276	Closed	Magnox
Bradwell	1962	2002	242	Closed	Magnox
Hunterston A	1964	1989	180	Closed	Magnox
Dungeness A	1965	2006	450	Closed	Magnox
Trawsfynydd	1965	1991	470	Closed	Magnox
Hinkley Point A	1965	2000	500	Closed	Magnox
Sizewell A	1966	2006	420	Closed	Magnox
Oldbury	1967	2012	434	Closed	Magnox
Wylfa	1971	2015	980	Closed	Magnox
Hinkley Point B	1976	2023	1061	Operational	AGR
Hunterston B	1976	2023	1074	Operational	AGR
Hartlepool	1983	2024	1207	Operational	AGR
Heysham I	1983	2024	1179	Operational	AGR
Dungeness B	1983	2028	1120	Operational	AGR
Heysham II	1988	2030	1254	Operational	AGR
Torness	1988	2030	1250	Operational	AGR
Sizewell B	1995	2035[2]	1216	Operational	PWR
Hinkley Point C 1	2025	2086	1630	In construction	EPR
Hinkley Point C 2	2026	2087	1630	In construction	EPR
Sizewell C	*2030 - 2035*	*2090 - 2095*	*3340*	Proposed	Hualong One
Bradwell B	*2030 - 2035*	*2090 - 2095*	*2300*	Proposed	Hualong One

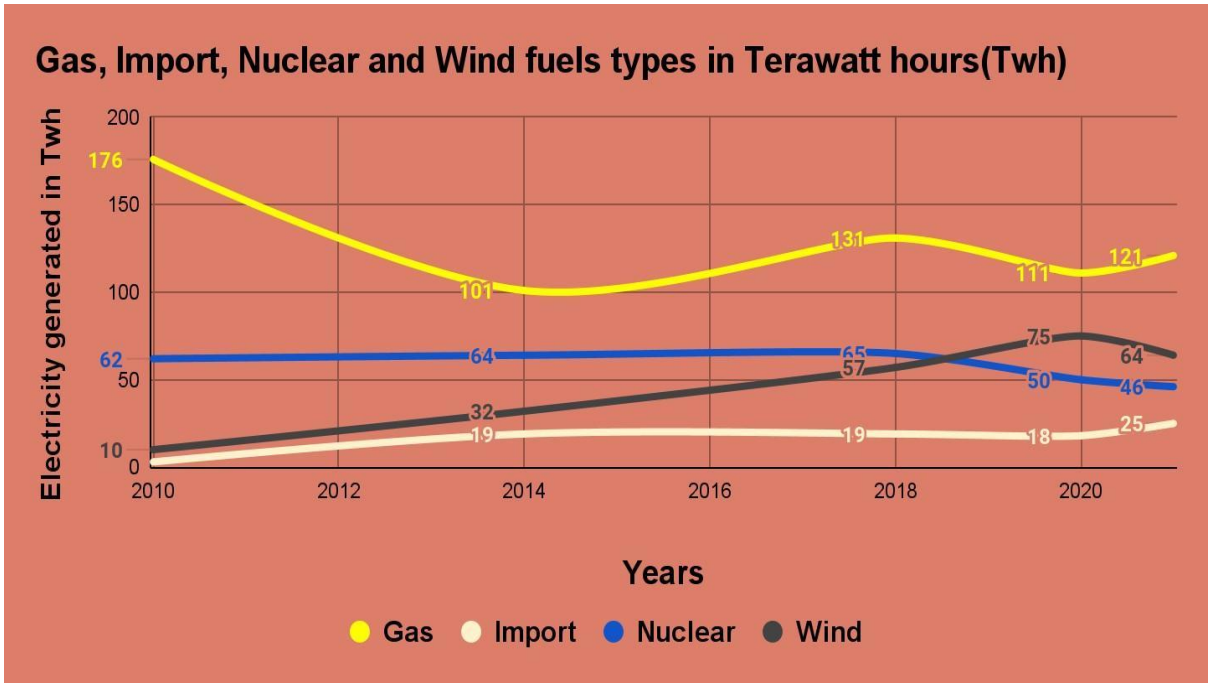
Source: Forrest Crellin (2022)
Figure 9. Outages of Nuclear plant and status of operational plant

The outage and decommissioning of the nuclear plant made the HPC more important in terms of energy security. The first nuclear plant was operational in 1956 on magnox-based nuclear reactor technology. Now, the above data shows that most of the nuclear energy plant has been closed due to its outages. There are only eight nuclear plants which are operational. However, four out of eight nuclear plants will close in the next two years. Hinkley Point B and Hunterston will be closed in 2023 with a capacity of 1061 Megawatt and 1074 mega-watt respectively. The other two Hartlepool and Heysham will also close in 2024 generating a capacity of 1207 megawatt and 1179 megawatt respectively. The total reduction would be 4521 megawatts of electricity production in the next two years. This is a huge reduction in the production of electricity by nuclear plants. This energy might be compensated by importing the energy of oil and gas. Recently, the UK government has given the licence to drilling near the north of England so that oil could be discovered. It is not enough because the rest of the four will also close before 2035. It means HPC will be only the operational nuclear plant. However, still it is under construction, delayed and under construction. There are lot of uncertainty regarding the new deadline of HPC which is expected in 2027.



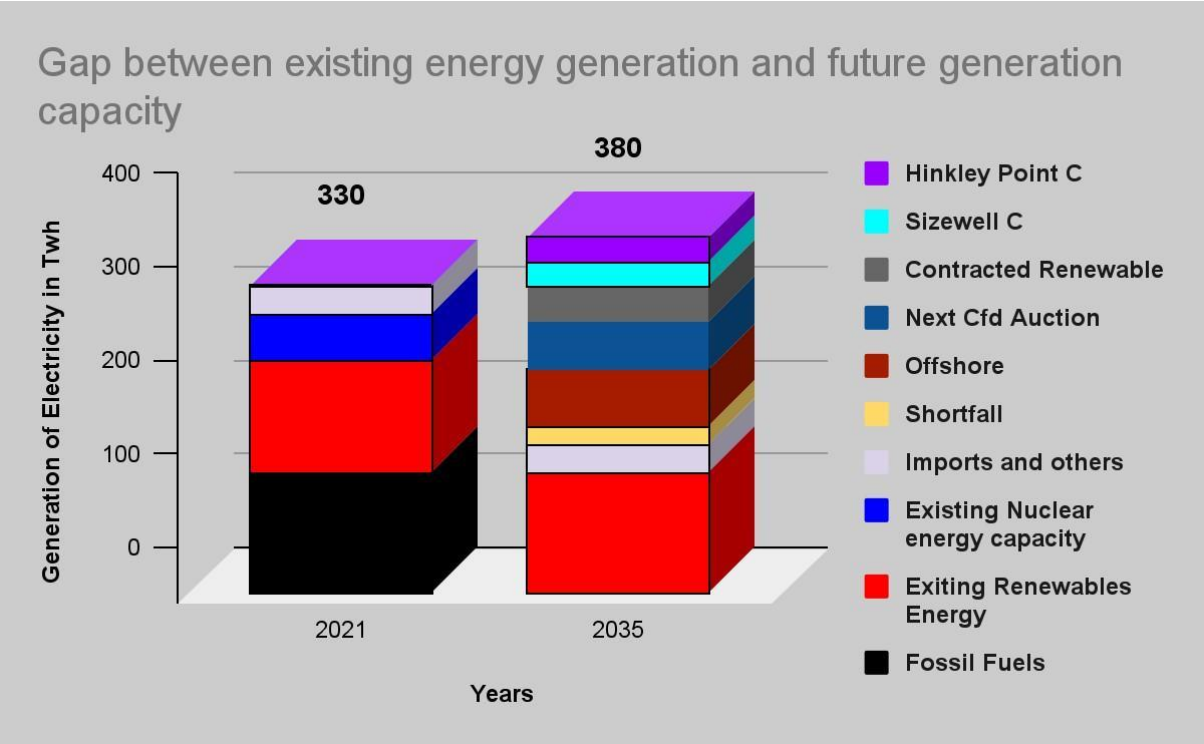
Source: The Nuclear Institute (2021)
Figure 10. Comparison between low carbon and fossil fuel source generation

Low carbon source is the main pillar to achieve net zero carbon emissions. In 2015 has increased to 153-terawatt hours from 70.1-terawatt hours in 2000. However, the speed of this trend reduced in 2020 and 2021. One of the main factors is outage of the nuclear plant. There is no substitute for nuclear energy in terms of its capacity generation in low-carbon energy sources. It shows that nuclear energy plant was not a priority for the UK's government which was crucial for the nation's energy security. Most of the energy was imported. Now, the UK is at a critical point in terms of its energy production.



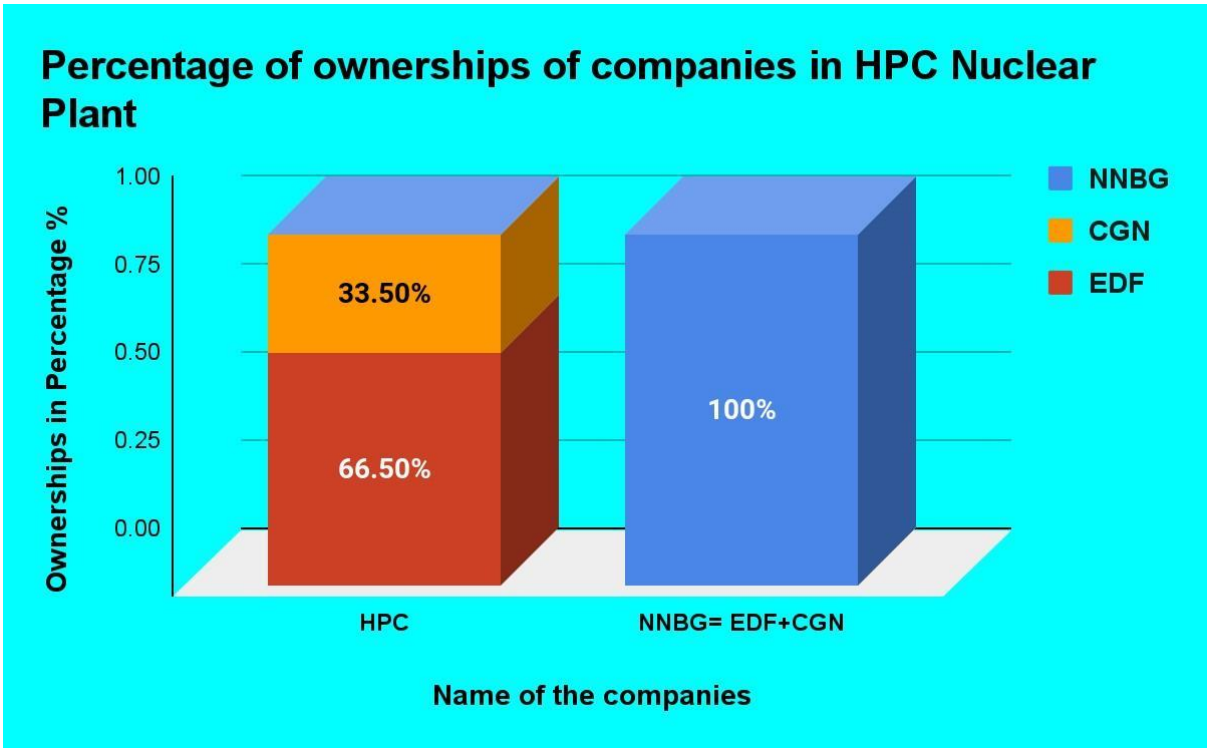
Source. Evans (2022)
Figure 11. Fall in nuclear output due to outage

The trend line shows which fuels are used to compensate for the reduction in the production of electricity by outages of nuclear plants and delaying of HPC nuclear plants. The blue line shows that the production of electricity from nuclear is almost constant from 2010 to 2018 and there is not much increment in its production. Nuclear production declined drastically up to 46terawatt hours in 2020 from 65-terawatt hours in 2018. This reduction compensates for importing energy from outside the country and by increasing the production of gas. This trend is not good for climate change to achieve the net zero target and economy of the country because it will increase the debt of the country for importing energy.



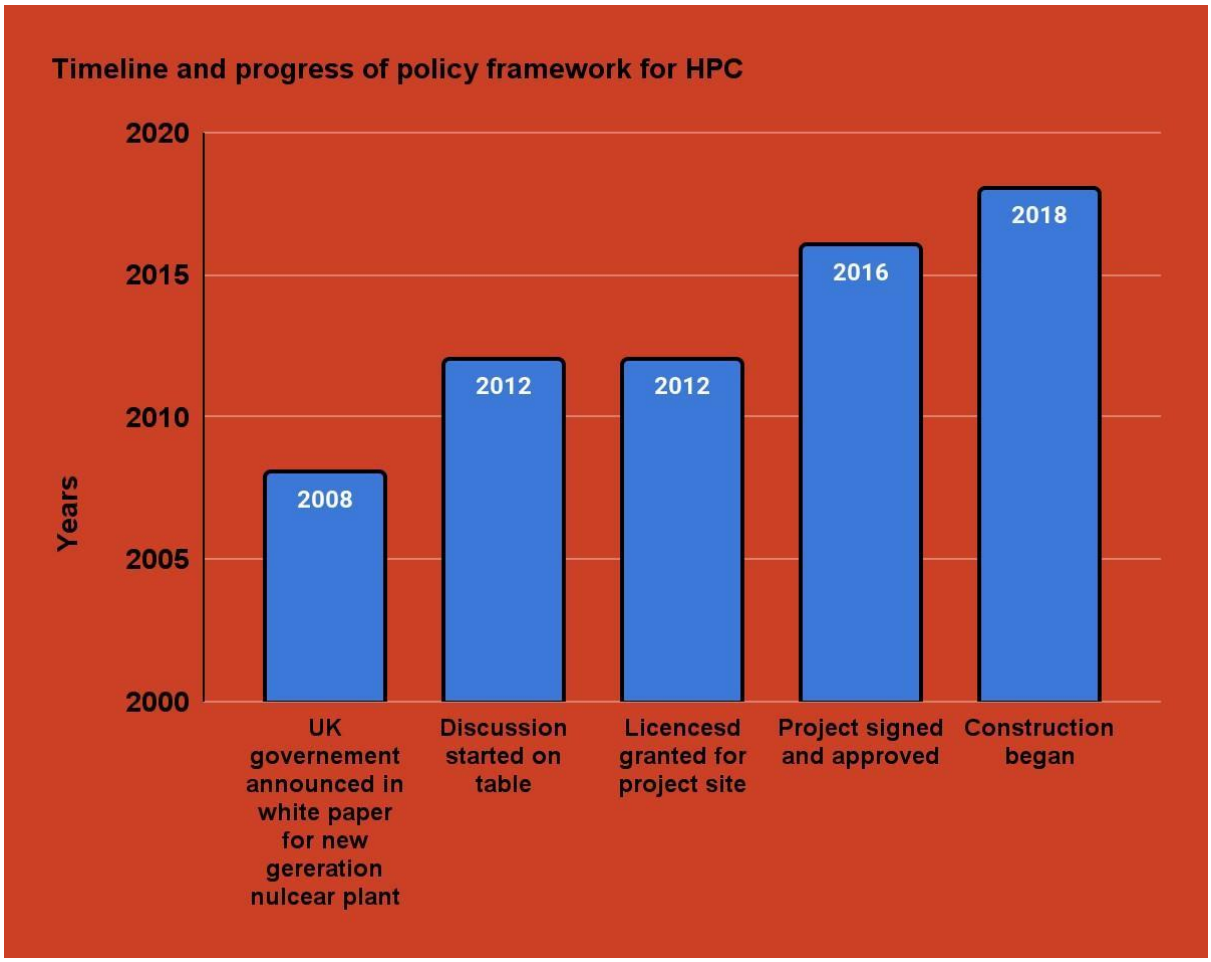
Source: The Conversation (2015), Government of UK Audit Reprot (2023), (Simon Levey, 2016)
Figure 12. Gap between current and future electricity capacity

The gap of decline in nuclear energy filling by gas and import. Hinkley Point C has become a major player in becoming a fully decarbonised country. However, the Current speed to decarbonise the energy is not enough. The current capacity of energy generation is enough to achieve the net zero target by 2050 which is around 330 terawatt-hours British power-up policy is to generate 24 Giga watt electricity by nuclear energy plants. It would require electricity generation of 380 terawatt hours by 2035 to achieve the net zero target. It is essential to achieve because the UK is legally binding for net-zero targets. The big part of fossil fuel will be replaced by the Hinkley Point C, Sizewell nuclear plant and renewable energy. However, still there is a shortfall of 50 TWh with the current capacity. The current nuclear capacity is 5.5-gigawatt hours which is 15% of total generation. It will fall drastically in 2028 because of the outage of nuclear plants also.

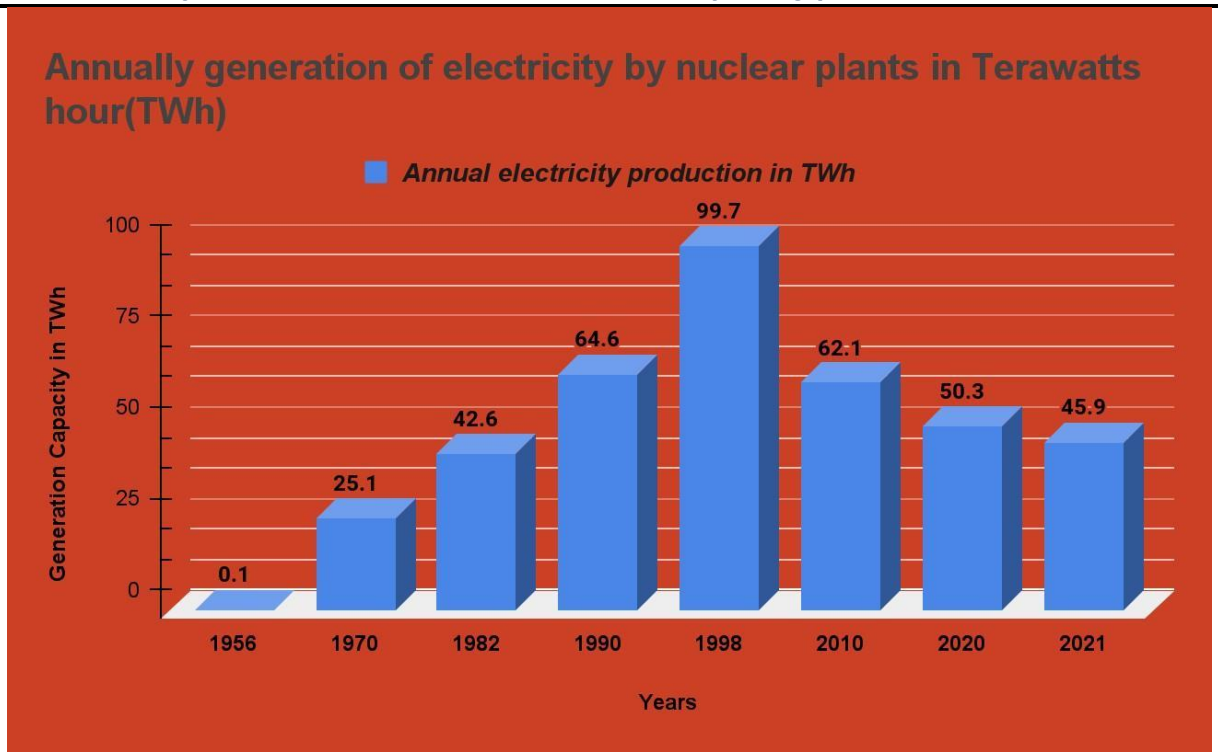


Source: Department for energy security and net zero (UK) (2023b)
Figure 13. Stakeholders in HPC plant

Location of two nuclear reactors at Hinkley Point C (HPC) in Somerset, in southwest England. The above data show that energy security is at a critical stage. There is the involvement of foreign stakeholders and countries. It is critical in terms of cyber-attack on the nuclear plant. The involvement of the Chinese government is directly in the form of CGN (China General Nuclear Power Group) which is the main concern and consists of 33.5%.
Another company is EDF which consists of 66.5%. There is no UK stakeholder in the HPC.
EDF made another company which is called NNBG (Nuclear New Build Generation Company), especially for HPC. It delayed the project also due its uncertainties in the budget because of the approval of the investment from the foreign country.

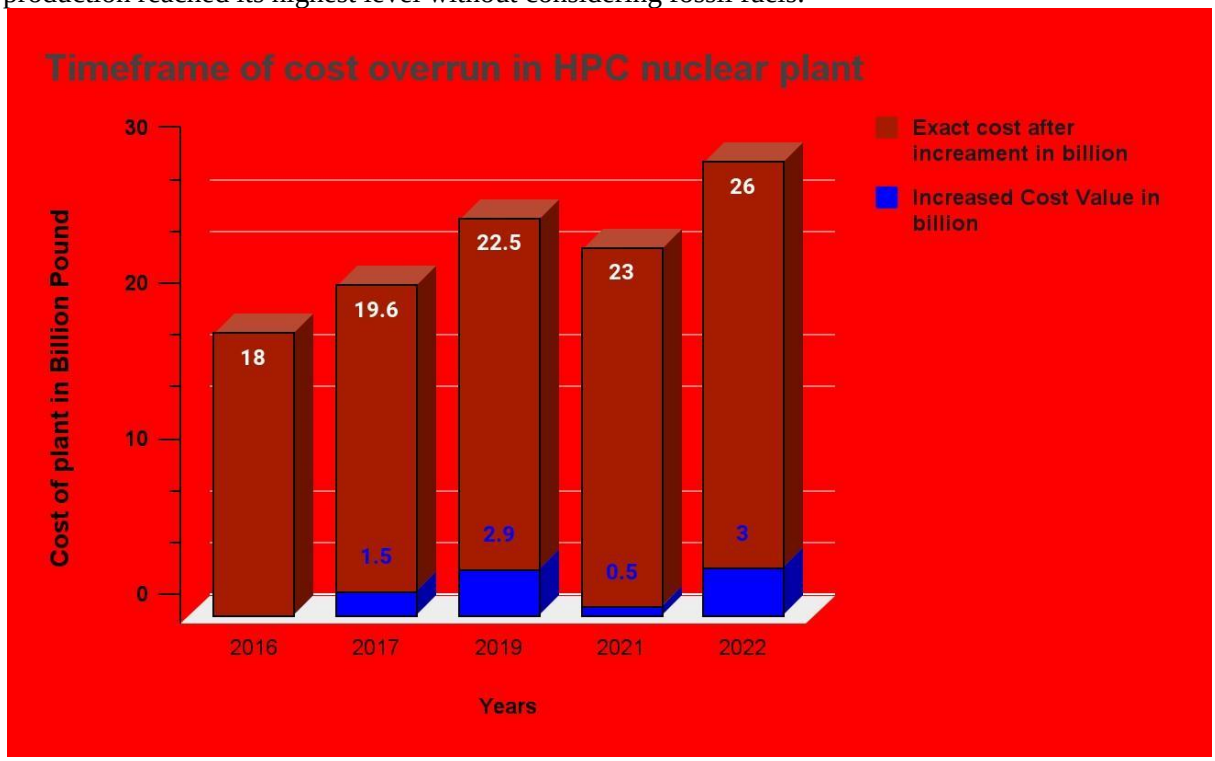


Source: Department for energy security and net zero (UK) (2023b)
Figure 14. Schedule and policy timeline of HPC plant
It is clearly reflected in the data that it took more than a decade to approve the project. This was a significant delay for the HPC project. It delayed its scheduled deadline because of ineffective planning. The main concern was the approval of the design of the HPC project because of its environmental impact, especially on aquatic species. Another concern was the financial. The first time the HPC project was highlighted in a British government white paper in 2008 and construction began in 2018. It is really a disaster for any project. It showed that HPC is not the priority of the government in terms of good governance. In 2016, a project was signed between the British government and EDF including the CGN event though it took another two years to start the construction. This data highlights the ineffective policy and lack of governance behind for delaying of HPC approval of the project.



Source: Department for business Energy and Industry Strategy (2022)
Figure 15. Annually generation of electricity by nuclear plant

The generation of electricity by nuclear reactor in 1998 was at peak which was almost 100 terawatt-hours of energy. However, this production did not sustain for at least the next two years, and it slipped down to 62.1 terawatt hours. This decline is still in the declining phase and has now up to 45.9 terawatt hours annually. This was due to the policy shift from nuclear to oil and gas energy. Another crucial factor is the outages of the nuclear plant. These outages can be seen more in 2010 and 2021. During the period of 1990 and 2010, this was the best time for nuclear generation. Energy production reached its highest level without considering fossil fuels.



Source: Kenzie Consulting Group (2020)
Figure 16. timeframe of cost over of HPC

The delay of the HPC project impacted the budget of the project also. This impact transfer might be to the consumer in the form of a high electricity bill. In 2016, the Project was signed at 18 billion pounds of its original cost then project. It was strange to know that within a oneyear project, cost increased up to 19.6 billion pounds which was 1.5 more than its original cost. This cost increased due to ineffective planning and execution of the project. In 2019, EDF increased the 2.9 billion pounds due to the change in its design. The design was changed due to the change in ground conditions for drilling. The extra drilling increased the cost of the budget. It seems that there was no proper scientific study on the ground position before the project. It was the highest increment in the price of the budget. It has now reached up to 26 billion pounds from its original cost. It has increased total cost by up to 8 billion pounds which is almost a 40%

increment. This financial burden might come on consumer payers in the form of bills and taxes. It was not enough but this time the COVID19 pandemic increased the cost of the project without any explanation. It took more time and money to evaluate the exact price and money of the project due to following COVID-19 norms.

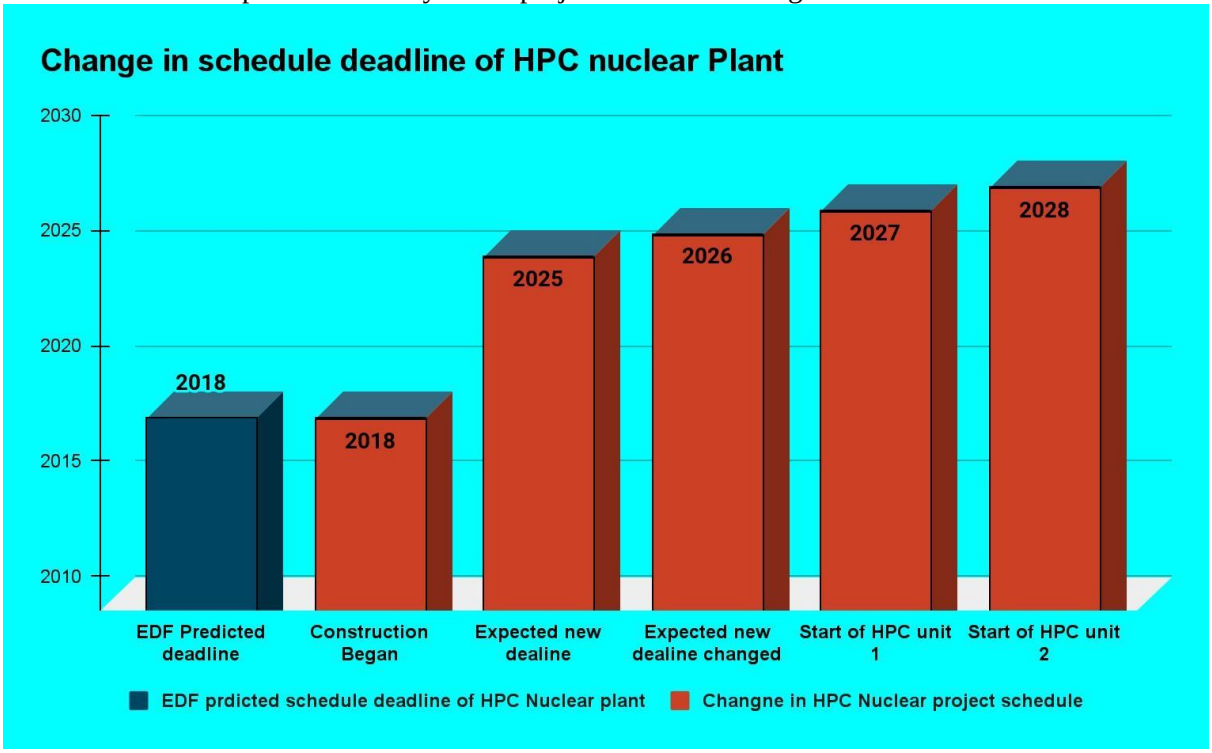
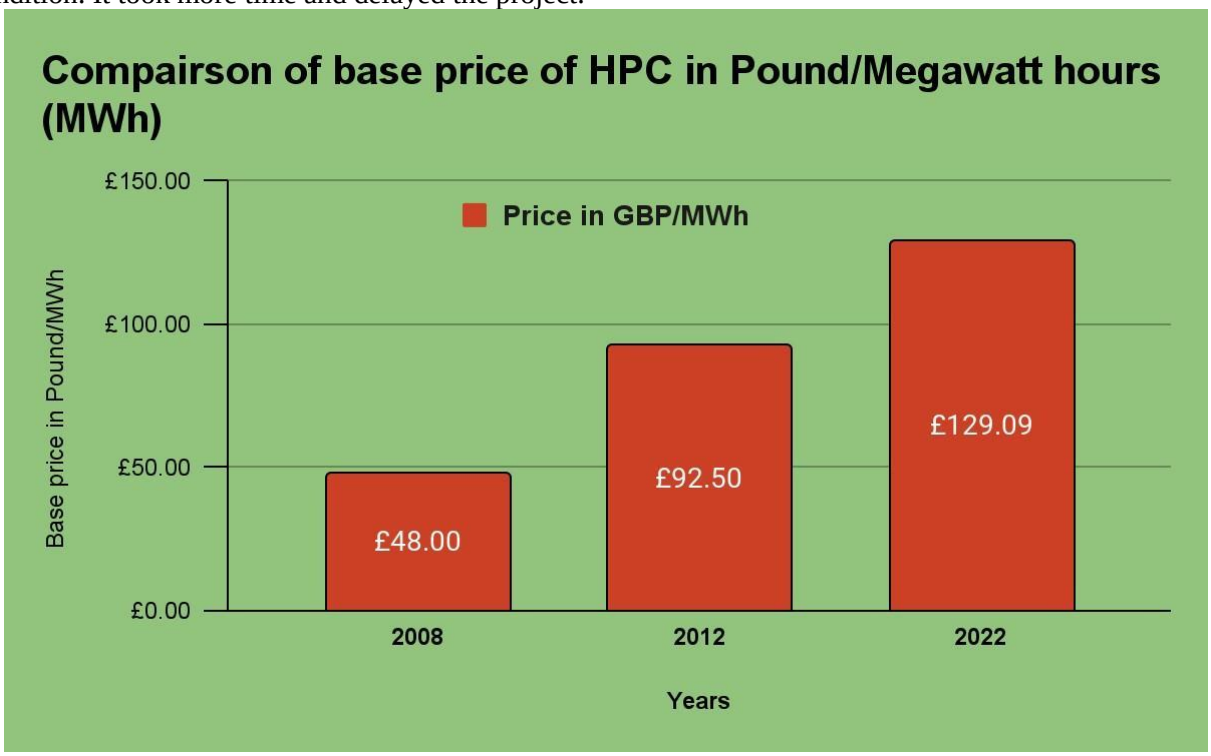


Figure 17.

Source: (Edward de la Billiere, 2016b)

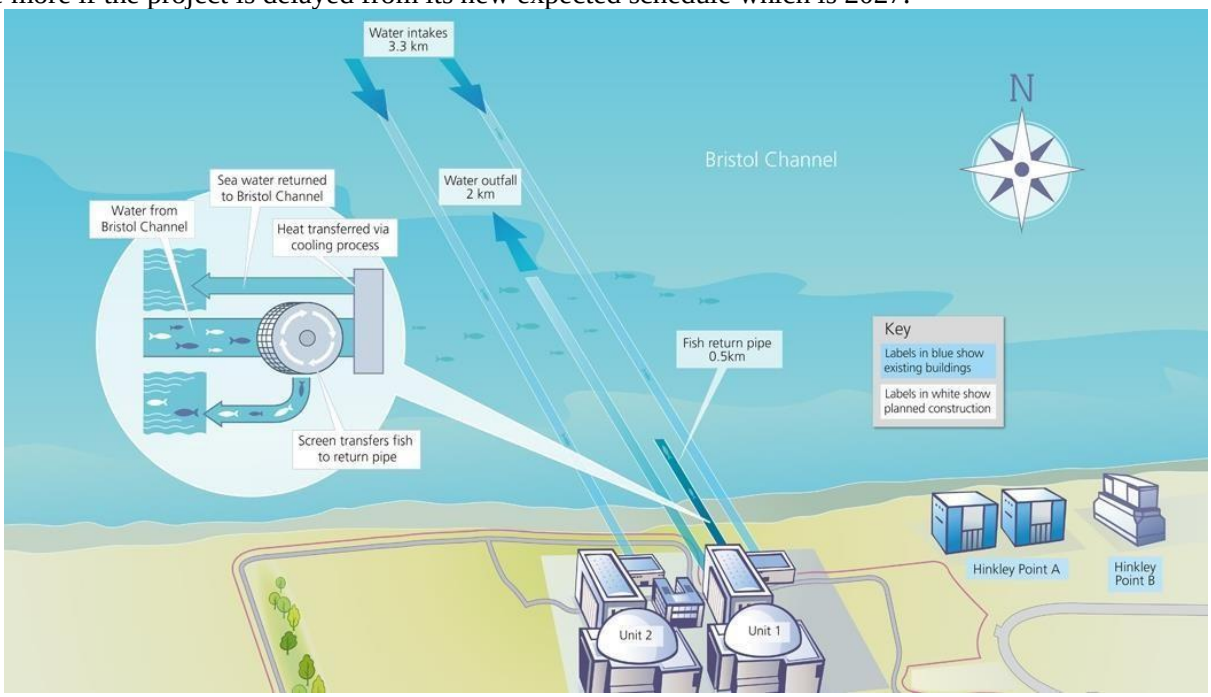
EDF predicted that the deadline for completion of the HPC project would be in 2018. However, the reality is that construction began in 2018 due to a lack of governance. EDF got the project approval in 2016. It took more than 5 years to approve the project on the UK's government side such as negotiation on the project budget and safety concerns. It showed that there is a huge difference between the paper knowledge and on groundwork. This difference impacted the project's schedule. However, construction started in 2018 and the deadline was 2025. This was due to the change in the earth rock condition. EDF did not expect that much of a difference between its study about the soil and rock condition. It took more time and delayed the project.



Source: House of Commons Committee of Public Accounts UK Parliament (2017)

Figure 18. Base price in different years

This is the first time that the base price concept used to support project financing from the government. It boosted the confidence of the stakeholders regarding the uncertainty of the project, but it raised the cost of the project. British Government was planning to give the contract on a base price of 48 pounds per megawatt hour generation of electricity. Unfortunately, the project was delayed for four years due to its bidding and planning of the project. Finally, the project was tabled in 2012 for 92.50 pounds per megawatt of electricity but it has reached up to 129 pounds per megawatt including inflation. The base price has been increased in this chart due to changes in design, ground condition, policy delay and lack of governance. Till now, it has increased by about 38 pounds per megawatt of generation. It might be possible this cost will be bored on the consumer's shoulders, but the British government is claiming that consumers will not face any financial stress due to project delay. However, data showed, that it might increase more if the project is delayed from its new expected schedule which is 2027.



Source: Beyond Nuclear International BNI (2023)

Figure 19. Environment and aquatic concern

The HPC nuclear reactor needs cooling water so that the reactor can cool, and extra heat can compensate effectively. The cooling water will come Bristol channel then it will go toward the cooling plant. However, during this phase, aquatic species such as fishes, dolphins and protected species will also come with water in the cooling plant. There is a huge suction motor which inlets the water and then pumps it towards reactors. This would be a huge loss for marine and aquatic species. However, EDF claimed that they will install the system which will create vibration in the Bristol channel. this vibration will keep aside aquatic and species fishes from the Bristol channel so that fishes will not go into the cooling pipes. it will ensure and reduce the mortality rate of fish. however, recently EDF have changed the design. it means it can harm the fish. that is why, there may be a chance that the project could be delayed again if environmental concerns are not resolved.

4.2 Discussion

Nowadays, energy has become the engine of economic growth for any country. The production of energy from different fuel types is directly connected with our climate change so it is critical to generate energy from low or zero-carbon sources. Climate change plays a crucial role which impacts countries' economic, social, and technological development. The UK is one of the countries that signed the legally binding documents to achieve net zero carbon emissions by 2050 (David Whitehouse Chief Executive Officer Offshore Energies UK, 2023). However, there is no clear enforcement policy and plan for how it will be enforced in the UK and what will be consequent if the UK does not achieve the net zero target however, its impacts on the political and economic image of the country affect more. The current progress to generate electricity by low carbon is not in the favour of UK's energy production. Even though the UK have good experience in the construction of nuclear energy plant (World Nuclear News (WNN), 2022). The UK was the first country to split uranium atoms to generate electricity from nuclear energy in 1956. The UK constructed the world's first nuclear energy plant at Calder Hall in Cumbria in 1956 (Beyond Nuclear International BNI, 2023). . Now, the country itself is struggling to construct the nuclear energy plant which has been famously under construction for a long time and known as Hinkley Point C (HPC) is behind its scheduled time and become over budget. HPC is a game changer to fulfil the demand for energy in the UK because five out of six nuclear plants will outage in the next decades. Therefore, HPC is the need of the hour for low-carbon energy sources (Chris Matthew, 2022). However, there are enormous reasons such as mismanagement, lack of planning, policy framework, governance, and budget mismanagement (Wilson et al., 2014). There have been significant time and money overruns in new nuclear development all throughout the world, but especially in Europe and North America. Large energy infrastructure projects frequently underestimate costs, but nuclear projects have seen some of the highest percentage cost increases, with projects between 1969 and 2005 going 117 per cent over budget, on average. The international

elements influencing cost reductions in exceptional circumstances include project management and repeatability, as well as lower labour costs and a lesser reliance on labourintensive safety features (Whiteaker, 2022). Costs may be reduced by having a nuclear strategy to build numerous, identical reactors. However, it has shown that poor project management and design revisions can result in cost increases for nuclear programmes. New nuclear facilities are intended to operate for 60 years and could produce electricity after capital repayment over a 25 to 30-year period, even though costs have almost always exceeded predictions. Extending a nuclear licence can supply electricity at a lower cost than a new build if predicted revenue exceeds maintenance costs, although power plants have also been shut down early for financial and safety concerns (David Whitehouse Chief Executive Officer Offshore Energies UK, 2023).

4.2.1Reason for delay of HPC project

Incompetence and inconsistency in governance

The lack of governance took the time to give the approval for the construction of HPC. The government of Britain has been discussing and negotiating with EDF and CGN for the HPC project since 2012. The construction started in 2018. It took 6 years to initiate the project on the ground (The Nuclear Institute, 2021). There is a policy conflict also. According to the energy security report, Britain set a target to generate electricity from nuclear energy up to 24 gigawatts by 2050. It will cover 25% of total energy demand (World Nuclear Association (WNA), 2023). However, as per the British Energy Security Strategy 2022 mentioned that the net zero target will be a smooth transition from fossil fuel to low-carbon sources (Department for business Energy and Industry Strategy, 2022). There will not be an immediate shutdown of oil and gas energy. Now, the government of Britain has given approval for drilling offshore so that oil and gas could be discovered. It means the government have two views regarding energy policy which delayed the approval of HPC. In 2008, the British government's white paper announced that there would be a 30 to 35 giga-watt demand of electricity required by 2030 so it is important to construct a new generation nuclear plant to meet that demand. Policy and plan to make an HPC took 4 years for discussion on tabel from papers (The Conversation, 2015). It means, one decade was taken just to make policy and approval of HPC nuclear project. The Office for Nuclear Regulation granted a Nuclear Site Licence for Hinkley Point C in November 2012, the first such licence granted for a new power station site in the UK in 25 years. NNB Generation Company is the new nuclear build subsidiary of EDF Energy. The independent nuclear regulator for the UK has acknowledged that the new build organisation has created the necessary management structure, plans, and processes for the construction, commissioning, and operation of the proposed new nuclear power station in Somerset by issuing the site licence (Department for energy security and net zero (UK), 2023a).

There are eight sites have been designated for nuclear energy plants in the UK.

Hinkley	Sizewell	Heysham	Hartlepool	Bradwell	Wylfa	Oldbury	Moorside

There is no long-term policy plan. Even design of the future proposed nuclear plant has a replica of HPC at Bradwell and Sizewell.

Inefficient financial policy

There is no doubt, the construction of nuclear energy needs a huge investment, risk, and uncertainties. The British government made a special financial policy to support the nuclear project so that the confidence of the inverter could be boosted. Generally, three basic funding models are working in energy sectors (Department of Finance, 2022).

1) Contract for differences (CFD): The CFD concept works on the base price. It is the difference between the current market price or base price and the future base. If the base price of electricity (Pound/MWh) decreases, then the decreased cost will be compensated including inflation by the British government. The procedure will reverse if the base price increases, then the remaining amount will return to the British government including inflation. EDF will receive money from the British government for 35 years if the market price reduces which has expected that market price may fall.
2) Regulated Asset base: it is good for investors and stakeholders. It mitigates the financial risk for stakeholders and investors, but it transfers the financial risk to the consumer and taxpayers in the form of increased cost overrun and construction cost.
3) Government equity: It is the direct involvement of the government in the project. The government invested their money in the project. It supports the project when financial risk is greater. However, the direct involvement of the government will take more time for approval.

Out of the three-funding model. The CFD funding model selected for HPC which is called Contract for differences. HPC operation might start in 2027 as per the new scheduled date. It means, that before the operation starts, EDF will get monetary support from the British government even before completing the project for 35 years. This compensating payment would be around 30 billion pounds for 35 years. There is no doubt that the consumer will not get hurt at the initial time but later this compensating amount will be recovered from the consumer bill or taxpayers (Edward de la Billiere, 2016b).

In the United Kingdom, every nuclear power plant that has ever been in operation was built using taxpayer money and is listed on the public sector balance sheet. Other civil nuclear states throughout the world have mostly followed this model. The currently under-construction Hinkley Point C is distinctive in that it is being financed off the financial sheet of the UK Government by the Chinese CGN and French government owned EDF. However, it has proven impossible to reproduce this funding strategy—a Contract for Difference (CFD)—for more nuclear reactors. Due to this, the government is thinking about adopting an alternative strategy in which construction risk is accepted onto the public balance sheet using a Regulatory Asset Base (RAB) model. Governments across the world have attempted to combine public finance with private sector building and operation in several methods, including this one. Additional funding methods utilised globally that combine various public and private funding sources. While a CFD model that shields the taxpayer from construction risk is probably not repeatable, the proposed RAB model itself has some significant flaws, the most significant of which is not fully appreciating the value of construction risk that taxpayers or billpayers would take on. According to the Nuclear Futures Institute (NFI), this strategy is "not very successful" because of the risks and the amount of capital, which necessitate more expensive financing or may be difficult to get (Forrest Crellin, 2022).

If the market price reduces from its base price including inflation, then EDF will also receive top-up money. This complex subsidy structure made policy more complicated and ineffective for HPC.

Covid-19 also reduced the pace of the HPC construction due to following the norms of Covid19. However, to maintain the integrity of this project, the project's construction did not stop and the supply chain was maintained throughout the process. Another major hurdle was inflation. Inflation also became the villain of the HPC project. The cost of labour increased due to the increment in cost-of-living prices. The concrete of nuclear energy plants requires a highquality material. Inflation increased material costs also.

Fund mismanagement and choice of wrong stakeholders:

Most of the funds involved in HPC came from EDF and CGN. CGN is a China state-owned company. The cost of HPC increased from 21.5 22.5 billion pounds to 22 23 billion pounds in 2021 due to COVID-19. EDF was ready to arrange the fund as per its proportional and voluntary support to the HPC project, but CGN has refused to invest more money in HPC because the British government is planning to overcome the involvement of the Chinese government in the further critical infrastructure project even British government took the decision that CGN will not get a contract for construction of Bradwell B nuclear project after HPC. it was not enough, and another was a British issue with Beijing on Hong Long sparked the fire. That is why, CGN is not willing to more investment in HPC. Now, budget management in HPC has been shaken and created uncertainty because CGN has been pulling out from further investment in HPC. (New exact price) It showed the huge risk associated with HPC because of ineffective risk management.

The track record of the EDF is not good in the completion of nuclear projects on their scheduled date and within the desired budget. EDF tried to buy the four nuclear plants in Finland, France China. The cost of all four projects increased, over budget and delayed even though it took more than a decade to start an operation. The design of these plants was the same as HPC. These nuclear projects used EPR technology. This EPR nuclear technology will also be used in the HPC nuclear project. Now, it has increased the uncertainty whether the project will compete or not on time because of the bad track record EDF and CGN. Hinkley Point C was scheduled to start producing power in 2025 at a cost of £18 billion when it received final clearance in 2016. It will employ EPR technology developed in the UK that was modified from EDF's EPR already in use. The construction and deployment of the EPR design had issues in the past, according to critics of this reactor design, with delays at Flamanville 3 in France, Taishan in China, and Olkiluoto 3 in Finland leading to large cost overruns.

Compromise with nation's security and energy risk.

Direct involvement of foreign governments especially the Chinese government is sitting on a time bomb. On one side the British government emphasis on power up Britain. It means power made in Britain, for Britain and making energy independent but other side there is direct involvement of foreign countries in the nation's critical infrastructure project (Electricité de France (EDF), 2023). The involvement of foreign stakeholder makes country as dependent on others such as France and China. It is an indication of the cyber risk involved in the HPC nuclear project. The Chinese government have a record of stealing data, cyber-attack and using it without any consent (Ralston, 2021).

Improper planning and blame game

The lack of research about the soil quality created the confusion on the ground. When the EDF increased the cost by 1.9 to 2.9 billion pounds due to unfavourable ground conditions. EDF stated that earthworks have become more expensive because of more challenges in excavating soil on the site of HPC. EDF Blamed the UK nuclear regulator for changing the design it was the major reason behind this unfavourable ground condition because it took digging of 2.3 million metric cube more rock and more marine work which increased the cost of the HPC project. Either the EDF or UK nuclear regulator is ready to take responsibility for this increased cost overrun. It showed the lack of planning and differences between paperwork and laptop exercise and exact work on the ground (Electricity System Operator (ESO), 2023).

Lack of advance technology

HPC: 3200 MW (Megawatt electricity) consist of two reactors. HPC nuclear energy plant used the European pressurised (water) reactor (EPR). EPR nuclear technology is not cost-effective as compared to fourth generation SMR and AMR technology. These are the fourth-generation reactors technology for nuclear energy plants. A small modular reactor (SMR) is small in size and can be built in a factory or other place then installed and transported to the desired site. Construction of the SMR nuclear plant takes less time. SMR is easy to run so operation and running cost is less. HPC use the EPR technology in its reactor. Construction of EPR is costly and not efficient for running because of high running costs. HPC reactors do not use generation fourth reactors technology which is more efficient than EPR. Although AMR technology is under developing stage, but SMR has been already developed. It means SMR can use in HPC rather than EPR. The quality of SMR is its cost which is the cheapest as compared to traditional nuclear plants (Government of UK Audit Reprot, 2023).

HPC nuclear energy plant is not construction under future consideration because the nuclear energy plant generates steam which consists of more the two hundred degrees Celsius. It takes time to cool at a certain temperature before striking the turbine blade which turns the armature and then produces the electricity. It means a huge amount of steam waste during the cooling process. However, this steam can be used to produce hydrogen. New advanced energy needs to work on hydrogen so that climate does not impact. HPC nuclear plant does not connect with the hydrogen-producing mechanism by using the waste steam even this steam and heat can be used in other industries also. Although, reactors are now used to generate electricity, but the heat they produce might be used to create a variety of goods, including industrial heat, desalination, and hydrogen. This process of co-generation is useful to increase the efficiency of the nuclear plants. Since, 65% of generation of steam energy by reactor lost as waste heat, co-generation can increase thermal efficiency (His Majesty's Government (HM Government), 2022).

It can increase the efficiency of the whole plant and save money. It is called the combination of nuclear and hydrogen plants. This mechanism is good for future consideration. A strategy must be developed to reach the 24 GW nuclear target for 2050, and it must be clear which organisations will carry it out. It is good to see that the Government has introduced amendments to the Energy Bill 2022–2023 to incorporate this legislation after requesting the Department to be more specific about what legislation will be necessary to ensure that Great

British Nuclear can operate as envisaged. However, there are still several areas where Great British Nuclear plan (GBN) remain unclear. It is not enough, there are also uncertainties remain on how Great British Nuclear will operate and what tasks it will perform in addition to hosting a competition for small modular reactors. We anticipated more information to be provided when the government launched GBN in July 2023, but the announcement only contained information on the SMR competition and the funding distribution that had already been made public (HORGAN, 2019).

Gap in nuclear skills in employers

The UK nuclear workforce is comparatively aged, which is not surprising considering the fleet of outdated nuclear sites outside of Hinkley Point C. In 2021, 39 per cent of the nuclear workforce and 32 per cent of the working population overall were over the age of 50. To prepare for the start of construction at Hinkley Point C, EDF informed us that it was necessary to recruit to the sector and that it had already done so (House of Commons Committee of Public Accounts UK Parliament, 2017). A conventional nuclear power plant has a capacity of one to three GW. An alternate method of generating nuclear power is using small modular reactors. At 300 to 500 MW, SMRs are only about half as large, but at this capacity, they are equivalent to a gas production plant. Several competing designs may provide these, yet none are currently in use (Breese et al., 2020).

Their exact position will be determined by several variables, including the availability of land, the distance from an adequate water supply, environmental and socioeconomic considerations, and the talents and capacities of the local population. Greater flexibility may also be possible when several SMRs are used because of their capacity to close some units or follow loads. The bigger concern is whether the cost hikes and potential delays will lessen the likelihood of building any further power plants, whatever their causes may be. Even if rivals' projects at Moorside and Wylfa have been put on hold, EDF still intends to develop Sizewell C, the next power plant after Hinkley, while its joint venture partner China General Nuclear is slated to build Bradwell B. There will be no impact on bill payers due to Hinkley's increased construction costs under the agreement EDF reached with the UK government in 2013, which guaranteed it would receive £92.50 per MWh - index linked - for power for 35 years. But at twice the going wholesale rates, this kind of offer is generally viewed as being too expensive to replicate. Nuclear generation capacity increased by just 1% in 2017, whereas solar and wind generation capacity increased by 35% and 17%, respectively, in 2017. In the previous ten years, everything has changed, according to Dorfman. Nuclear investment is not profitable. Any cost increases in this climate make it difficult and harder to implement viable nuclear plans. However, proponents of nuclear power contend that because it offers low carbon "firm" generating capacity, it is more valuable than intermittent renewables (House of Commons Science, 2022). Baseload or solid power continues to be the core of the energy network. Our fleet of nuclear power plants needs to be replaced because they are all set to shut down. Following the sector's privatisation, during the "dash for gas," there was a significant increase in new gas-fired power plants, which resulted in a substantial decline in wholesale prices in the UK. Nuclear power plants were particularly susceptible to this change in market prices due to their high fixed costs, and by 2002 British Energy was

unable to pay its obligations. After years of reorganisation and a government rescue, British Energy's assets were eventually sold to EDF in France (House of Commons Committee of Public Accounts UK Parliament, 2017).

Even while Hinkley made headway, the controversy surrounding its engagement with the Chinese business CNG as an investor only served to heighten political concerns about Chinese foreign direct investment during the ensuing ten years. The Fukushima tragedy in 2011 caused many nations, including Germany, to completely abandon nuclear power, which negatively impacted public view of nuclear power during this time (Joey Gardiner, 2019). At a time when nuclear power in general was already unpopular, the government was saddled with one pricey, unpopular nuclear power project. For the better part of a decade, no considerable progress was made on any other new reactors as Hinkley Point C's construction continued. Stone of the Nuclear Industry Association said, "It was what we referred to as 'facilitative actions'." "Effectively preparing the cricket pitch so that businesses may participate in the match and compete. By 2025, a goal of 16 GW was set, and it was feasible at the time, but it is not possible without effective project management (Keyte, 2022).

4.2.2 Ethical Concern

Ethical concern is important to deal with research. it includes empathy, consent privacy etc. It is crucial to consider the consent of a person. Nowadays, data biases can influence the research and objective. It means ethical views play a major role in following the path of ethics. However, this research does not involve any human participation and interviews. There is no concern about data biases, privacy, data misuse and data leaking without consent from the responsible authority.

Chapter 5. Conclusion

However, the Generation of electricity by nuclear energy plants is considered as two sides of the same coin. On one side it works as a low-carbon source and acts on climate change. On the other hand, it produces a huge amount of electricity. However, it is not easy to construct a nuclear energy plant within the desired budget and schedule time without effective planning and management. The track record shows most of the nuclear energy plant was delayed because of ineffective planning and policy. Hinkley Point C (HPC) is one of the nuclear plants which is still under construction for more than decades (Loughran, 2021). The cost of HPC was 18 billion pounds during the initial phase but it increased to 26 billion pounds because these are based on traditional nuclear plant technology which is based on the AGR (Advanced Gas-cooled Reactor) and EPR (European pressurised water Reactor) reactors. These technologies occupy huge space and have more construction costs, advanced skills labour, and operation costs. Instead of implementing AGR and EPR technology, the UK government should work on small modulator reactors (SMR) and advanced modular reactors (AGR) which can be built in factories, transported at location sites, less costly and more effective than traditional reactors. SMR technology has been successfully tested and the USA has constructed an SMR nuclear reactor. However, the AGR reactor is still under process (NS Energy, 2019). However, SMR is ready to use, and the UK should work and execute on SMR reactors in future nuclear plants. One of the complex situations is the implementation of policy and approval of the project. There is a huge risk involved in nuclear energy plants in the form of its complex design, the impact on health by radioactive material like uranium and the involvement of big financial risk. Due to this, every authority wants to analyse the risk in more depth. Authority takes time to give approval to the project by the environment department. It was the most common issue faced in the HPC nuclear plant even though the HPC design was a replica of the old one. There should be timeframe work for those plants which are using the plant and reactors designed old because of design has been already executed in another place. It is not important to construct the new nuclear plant on traditional technology rather than we can extend the outage time of the existing plant by investing less money in its repair and can work on SMR and AGR nuclear plants. Funding for a project is a challenge specially to convince the stakeholders for a project (Nuclear Engineering International, 2023). The CFD funding model has used in HPC which is not good for the consumer side because before completing the construction and grid connection, stakeholders will get a return on it even by 2029. Ultimately, these funds will be arranged from the public balance sheet. It is best to use a regulated asset base model, in which increased cost will not be arranged from public money and it will be the responsibility of stakeholders and contractors to arrange the increased money including any uncertainties. However, government support is necessary to eye watch these projects because of the huge involvement of risk and public money. It is the need of the hour for our climate and future generation to build more nuclear reactors on SMR and AGR technology so that electricity generation can take place at less cost because future transport will also work on electricity (Nulcear AMRC, 2023).

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