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The UK's Net Zero Policy through the Lens of Project Management

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Abstract

Climate change is one of the biggest challenges that human civilization is facing. The good news is that the scientific community has proposed many solutions to fight the climate crisis. One promising solution is to achieve net zero by mid-century. However, the goal and the means to achieve net zero present huge economic, technical, and societal challenges at the national levels. In 2015, the world community signed an agreement to limit the global temperature increase to 1.5°C above pre-industrial levels, significantly reducing the impacts of climate change. The agreement is commonly known as the Paris Agreement. Almost 8 years after signing the treaty, we see the world leading economies still struggle to meet their net-zero targets, but comparatively, the UK shows promising progress towards achieving its targets. Therefore, this thesis presents a case study of the UK's approach to net zero. The two fields that have the potential to deal with a challenge as big as net-zero are public policy and project management. Creating synergies between these two fields can produce greater benefits and better results. The UK has published several detailed documents about its net-zero policies in the last few years. This thesis aims to find how public policy and project management fields communicate and coordinate with each other in the UK to better understand some of the success factors. In this report, we aim to analyse the structure of the UK's net-zero policy in terms of its principles, goals, and objectives and how these goals and objectives are aligned with the landscape of projects and programs in the UK by analysing the different types of projects and programs. Furthermore, to stress the idea that projects can play an important role in policy implementation toward achieving the net-zero targets, we evaluate the success dimensions of the projects that have been completed in the UK. The key implications of the findings of this report are that there is a stronger need for coordination between the two fields. By allowing public policy goals and objectives to guide projects and vice versa, the countries will have a better chance of achieving their net-zero targets.

Abstract in lingua italiana

Il cambiamento climatico è una delle maggiori sfide che la civiltà umana sta affrontando. La buona notizia è che la comunità scientifica ha proposto molte soluzioni per combattere la crisi climatica. Una soluzione promettente è quella di raggiungere l'azzeramento delle emissioni entro la metà del secolo. Tuttavia, gli obbiettivi e i mezzi per raggiungere il "*net zero*" presentano enormi sfide economiche, tecniche e sociali a livello nazionale. Nel 2015, la comunità mondiale ha firmato un accordo per limitare l'aumento della temperatura globale a 1,5°C rispetto ai livelli preindustriali, riducendo in modo significativo gli impatti dei cambiamenti climatici. L'accordo è comunemente noto come Accordo di Parigi. A quasi 8 anni dalla firma del trattato, vediamo che le principali economie mondiali faticano ancora nel raggiungere i loro obiettivi di net zero, ma in confronto, il Regno Unito mostra progressi promettenti verso il raggiungimento dei suoi obiettivi. Pertanto, questa tesi presenta un caso studio dell'approccio del Regno Unito al net zero. I due campi che hanno il potenziale per affrontare una sfida così grande come il net zero sono le politiche pubbliche e il project management. La creazione di sinergie tra questi due campi può produrre maggiori benefici e risultati migliori. Negli ultimi anni il Regno Unito ha pubblicato diversi documenti dettagliati sulle sue politiche net zero. Questa tesi mira a scoprire come le politiche pubbliche e il project management comunichino e vengono coordininate tra loro nel Regno Unito per comprendere meglio alcuni dei fattori di successo. In questa ricerca, ci proponiamo di analizzare la struttura della politica net zero del Regno Unito in termini di principi, obiettivi e target e come questi siano allineati con il panorama dei progetti e dei programmi nel Regno Unito, analizzando i diversi tipi di questi ultimi. Inoltre, per sottolineare l'idea che i progetti possono svolgere un ruolo importante nell'attuazione della politica verso il raggiungimento degli obbiettivi net zero, valutiamo il successo dei progetti che sono stati completati nel Regno Unito. Le implicazioni principali dei risultati di questo rapporto sono la necessità di un maggiore coordinamento tra i due ambiti. Consentendo agli obiettivi della politica pubblica di

guidare i progetti e viceversa, i paesi avranno maggiori possibilità di raggiungere i loro obiettivi di net zero.

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List of abbreviations

UK:	United Kingdom
HM:	Her Majesty
COP:	Conference of the Parties
GHG:	Greenhouse Gas
NDC:	Nationally Determined Contribution
BECCS:	Bioenergy with Carbon Capture and Storage
CCUS:	Carbon Capture, Utilisation and Storage
PV:	Photovoltaic
R&D:	Research and Development
CHP:	Combined Heat and Power
EPC:	Engineering, Procurement, and Construction
EIA:	Environmental Impact Assessment
LCOE:	Levelized Cost of Electricity
O&M:	Operations and Maintenance
ETS:	Emissions Trading System
TWh:	Terawatt-hour
PPA:	Power Purchase Agreement
RES:	Renewable Energy Source
LCA:	Life Cycle Assessment
GtCO2:	Gigatonnes of Carbon Dioxide
CB:	Carbon Budget
MtCO2e:	Metric Tons of Carbon Dioxide Equivalent
P&P:	Projects and programs
IPCC:	Intergovernmental Panel on Climate Change
LCOE:	Levelized cost of electricity
LFSCOE:	Levelized Full System Costs of Electricity
SCC:	Social Cost of Carbon

UNFCC:	United Nations Framework Convention on Climate Change
IEA:	International Energy Agency
RTFO:	Renewable Transport Fuel Obligation
CORSIA:	Carbon Offsetting and Reduction Scheme for International Aviation
SAF:	Sustainable Aviation Fuel
CEER:	Council of European Energy Regulators
CFD:	Contracts for Differences
CTS:	Commerce, Trade and Service
DSM:	Demand Side Management
REG:	Renewable Energy Act
EKF:	Energy and Climate Fund
Entso-e:	European Association for the Cooperation of Transmission System
GDP:	Gross Domestic Product
ICAO:	Civil Aviation Organisation
ICAP:	International Carbon Action Partnership
BEIS:	Department for Business, Energy & Industrial Strategy
WEF:	World Economic Forum
HMG:	Her Majesty's Government
EWP:	Energy White Paper
TDP:	Transport Decarbonization Plan
DfT:	Department for Transports
IAS:	International Aviation and Shipping
HGVs:	Heavy Goods Vehicles
EVs:	Electric Vehicles
DECC:	Department of Energy and Climate Change
UKRI:	United Kingdom Research & Innovaton

Introduction

The Pyramid of Giza, a true wonder of the world, has baffled humanity for many millennia. On one hand, it holds many secrets but on the other it tells us a profound story. The scale and precision of its architecture shows that human ingenuity has no limits. It reassures us of our capabilities and gives us courage to undertake and complete mega projects which seem impossible to ordinary minds. The Pyramid of Giza is an amazing example of what humans can achieve with collaboration. Yet the same monument warns us of what can possibly await us in the coming future. It tells a fascinating story of a civilization with immense knowledge and technology that existed in antiquity but is no more. It is not important to discuss here the causes of the fall of the great Egyptian Civilization. Important here is to understand that the existence and the prosperity of our modern civilization is not to be taken for granted.

There are many challenges that threaten the existence of our civilization on this planet. Climate change and global warming is the biggest of them all. Human activities are estimated to have caused approximately 1.0°C increase in global mean surface temperature above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate (IPCC, 2018a). Greenhouse gas (GHG) emissions are the primary driver of climate change (Millar & Allen, 2017). From heating our homes to filling up our cars, burning fossil fuels releases the greenhouse gases that increase global temperatures. In the past few years, we have already started to observe an increase in the cases and intensity of floods, wildfires, melting of glaciers, sea level rise and other climatic calamities. Concentration of CO2 in earth's atmosphere is higher than it has ever been for at least the past 2 million years. The alarming report of IPCC on the Impacts of Global Warming, published in 2018, clearly states that if we fail to limit global warming to 1.5°C above pre industrial level, we will lose control of our climate for good (Rogelj et al., 2018).

UN secretary general Antonio Guterres called the IPCC's sixth review on the impact of global warming as "Code red for humanity". By the middle of this century, we need to control the rise in global temperatures well within the limit of 1.5°C above pre industrial level. On 12 December 2015, 196 parties adopted a legally binding international treaty on climate change which is commonly known as the Paris Agreement. The goal of the treaty is to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels (UNFCC, 2015). Climate change related actions agreed at the 26th Conference of the Parties of the UNFCC (COP26) can be divided into three main categories: 1- Mitigation: All actions related to limiting GHGs emissions and limiting climate change, 2- Adaptation: Helping people, economies and the environment adapt and prepare for the impacts of climate change, 3- Loss and Damage: Actions to control the loss and damage associated with the climate change impacts (UNFCC, 2021).

Human activities release 55 gigatonnes of GHGs into the atmosphere every year. To stop global warming, we have to reduce our GHGs emissions down to zero (IPCC, 2018a). It is impossible for our present day global economy to suddenly stop emitting GHGs, instead we can use an approach called Net Zero. Which means that for every molecule of GHG we put into the air, we also take one out, making our net emissions of GHGs zero (IEA, 2021). On paper, the solution may seem simple, but the action plan towards Net Zero poses the biggest challenges for the global economy. It requires disruptive innovation and cooperation between different sectors and fields at a level never done before in order to move away from the traditional fossil fuel dependent economy into a greener and clean economy (Martiskainen & Kivimaa, 2018). We also have to develop new technologies to capture GHGs and to store them permanently. This is a humongous challenge but it is our best chance for a sustainable future. In the current scenario, the higher responsibility lies on the countries with bigger and flourishing economies to lead the way, present solutions and produce a practical framework which can be adopted by the developing countries for smooth and timely transition towards a sustainable future.

When we talk about handling a challenge as massive and as serious as climate change, the two main fields that have the potential to tackle the issue are public policy and project management. Public policy provides us with institutionalised proposals and a set of elements such as regulations, guidelines and actions to solve a real world problem that affects the society at a mass level. On the other hand, P&Ps are the vectors of change. They provide us with a mechanism and frameworks for smooth transition into a projected future. Currently we see a gap in the literature regarding creating the synergies between the two fields. There is a greater need to develop coordination and the two fields should communicate with each other cohesively in order to be able to tackle the challenge of climate change quickly and more efficiently. Unfortunately we do not see a lot of progress in the current academic field to develop coordination between the two fields.

In this report, we aim to highlight the importance of coordination between the two fields and key topics which require deeper attention in order to obtain synergies between the two fields. We propose a theory that the countries which align their public policy with the landscape of projects and programs and vice versa are better positioned to achieve net zero. A relevant example of one such leading economy is that of the United Kingdom. In 2018, the UK became the first major economy to adopt a legally binding target to

bring greenhouse gas emissions to net zero by 2050 (UK Gov, 2021). The UK makes an interesting case study because despite facing many challenges like Brexit, Covid-19, Ukraine Conflict and global inflation, the progress reports published every year by the UK's climate change committee (CCC) cast a rather promising picture of the UK's progress towards its net zero targets.

For this report, we have three main objectives. First is to understand the structure of the UK's net zero policy. Second objective is to study the connection between the UK's net zero policy and the projects and how it is impacting the landscape of P&Ps in the country and the third is to understand the role of P&Ps in the successful

implementation of the UK's net zero policy. In order to achieve the objectives of this research following three research questions have been proposed:

1. What are the actual principles, goals and objectives of the UK's Net Zero Policy?
2. What types of projects have been completed in the UK to achieve net zero?
3. How successful are those projects in achieving net zero?

The structure of this report is focused on these three research questions. First we will discuss the relevant topics for each of the research questions in the literature review. Then we will explain the methodology which will be adopted to find answers to each of our research questions. Then we will present our analysis for each of the research questions and we will also pay attention in building logical connections between the three questions for better synchronisation of our findings to provide a cohesive conclusion to the objectives of our research.

1. Literature review

This section explores the definitions, explanations, frameworks and concepts in order to better understand the topics that will be under discussion in this report. The basis of this report is to analyse the above mentioned research questions regarding UK's net zero policy in the light of most relevant scientific methods and frameworks which are well established and accepted in the literature and scientific community.

Topics like public policy and project management are complex in nature which require understanding of multi-dimensional and cross functional subjects. For example, talking about net zero policy, existing literature lists different types of public policies and mentions different areas or point of views from which a public policy can be studied. Similarly, project management is also a diverse field. Different sectors have different classifications of projects and programs and the ways they manage projects are inherently different from one another. A relevant example can be a comparison

between the nuclear power sector and ICT sector. The principles of agile project management which are widely used in the ICT sector are rarely applicable in the nuclear power sector.

The literature review consists of three distinct parts. Each part is dedicated to one of the research questions. In each part, we explore the concerned topic starting from basic definitions, classifications and taxonomies. Then we study different frameworks which are available and finally by doing option analysis, we will try to choose a framework which is the most relevant for us in the context of this report.

In the first part, we will focus on the field of public policy to understand: what is the definition of public policy, why policies are made, different areas to study public policy and its objectives. In the second part, the focus will be on the topics of: projects and programs as the vector for change and different frameworks to classify projects and programs particularly in the context of net zero transitions. Finally the third part focuses on the different ideas of project success and finding the most relevant frameworks or indicators to evaluate project success in achieving net zero targets.

1.1 Introduction to public policy

In recent times, as the world is becoming more aware of climate change and its impact, we are seeing the governments taking different approaches to tackle the issue. For example Saudi Arabia has announced the construction of a linear city called "The Line" to move towards a sustainable future (Neom, 2022). The government of Pakistan has decided to plant 10 billion trees in an effort to capture GHGs (MOCC GOP, 2018). This is a very confusing situation because the problem is the same yet the actions taken by the world governments are very different from each other.

What, how and why do the governments decide to do one thing and choose not to do the other? What factors control these decisions and determine the direction towards the solution? All these questions come under the domain of the public policy process. A public policy may refer to what the government intends to do to achieve certain goals. This definition makes public policy look like a mere decision. But it is wrong to

say that mere declaration of intentions, wishes, principles, or expression of desires can be called public policy (Anyebe, 2018). There are many different definitions of public policy proposed by different scholars. In academic studies of policy, scholars offer definitions of public policy to understand the shape of the field they seek to study. For many people, defining public policy helps them define their own role in policy making, as well as that of the organisation they work for (Birkland, 2011). It is, therefore, very important to understand different definitions and the common attributes of a public policy.

1.1.1. Definitions and types of public policy

In academics, many researchers have tried to summarise the concept and the scope of public policy. Here are some of the definitions of public policy proposed by prominent academic researchers in this field.

- "The term public policy always refers to the actions of government and the intentions that determine those actions." (Carr et al., 2008)
- "Whatever governments choose to do or not to do." (Dye, 1992)
- "Public policy consists of political decisions for implementing programs to achieve societal goals." (Cochran & Malone, 2005)
- "Stated most simply, public policy is the sum of government activities, whether acting directly or through agents, as it has an influence on the life of citizens." (Peters, 2015)

Owing to the complexity and the implications of a public policy, the researchers and scholars may never agree upon one single definition but in order to better understand the concept, Thomas A. Birkland in his book (An Introduction to Policy Process) argues that by analysing different definitions of public policy, we can discern some key attributes of a public policy (Birkland, 2011):

- Policy is made in response to some sort of problem that requires attention.
- Policy is made on the "public's" behalf.

- Policy is oriented toward a goal or desired state, such as the solution of a problem
- Policy is ultimately made by governments, even if the ideas come from outside government or through the interaction of government and nongovernmental actors.
- Policy is interpreted and implemented by public and private actors who have different interpretations of problems, solutions, and their own motivations.
- Policy is what the government chooses to do or not to do.

A public policy is devised in response to a problem that affects the public. The governments around the world are responsible for thousands of policies. Each policy is different in terms of its implementation and outcomes. Classifying public policies into different types helps us to discuss them more clearly (Sabatier, 2007). Public policies influence societies in many different ways. They shape the political debate, the economy and the lifestyle of the people. Therefore, classification of public policies allows us to study which features of public policy have more influence in what way on society (Peters & Pierre, 2006). No single classification is suitable for all purposes and a single policy can have elements of more than one type of policy (Sabatier, 2007). Public policies can be classified according to many different schemes. One scheme classifies policies based on the purpose they are made to serve. For example the main purpose for the governments can be to provide security, membership (who and who is not part of the society), prosperity and needs (Anderson, 2003). A second scheme of classification emerges when political scientists try to determine whether certain kinds of policies affect the types of political activity involved in policy making. This influential classification divides policies into regulatory, self-regulatory, distributive and redistributive (Peters, 2015).

- **Regulatory Policies:** These policies are about specifying the behaviour of individuals and groups that are allowed. These policies give conditions and constraints for individuals and collective behaviour. For example, in some

countries you are only allowed to drink alcohol from the age of 18 (Peters, 2015,).

- **Distributive Policies:** Under these policies, the government decides to allocate some resources or benefits from its own pockets to certain segments of the society. For example the government decides to spend its money on free education (Peters, 2015).
- **Redistributive Policies:** These policies concern changing the existing income distribution. For example the government decides to put higher taxes on people with higher income and spending that money on the lower income population (Peters, 2015).
- **Self-regulatory Policies:** These policies are similar to regulatory, except that the persons or groups regulated possess considerable authority and discretion to formulate and police the regulations governing them. For example physicians and doctors develop their own code of ethics and help to administer and enforce discipline (Peters, 2015).

The table below summarises different classification schemes of public policy and their types:

Table 1 Classification of Policy

Purposes	Types	Goods
Security	Distributive	Collective
Membership	Regulatory	Private
Prosperity	Self-Regulatory	
Needs	Redistributive	

Table 1 Classification of Policy, Intergovernmental Perspective, Vol 18, No. 4 (Fall 1992): 8

1.1.2. Areas to study public policy

Public policy is a multidisciplinary subject that encompasses a broad range of studies. Public policies are not created and implemented in a vacuum. It is not only shaped by socio-political norms and ideologies but its implementation also changes the socio-

political and economic landscape of the country (Dunn, 2017). It affects political debate, the way governments are run, the lifestyle of the people and decides the future of a population. Therefore, the studies of public policy are not only relevant for political scientists and researchers. Researchers from other professions and walks of life are equally interested in studying public policy (Dolowitz & Marsh, 1996). Of course the approach and the reasons to study public policy for researchers from different professions corresponds to their area of interest (Rhodes & Marsh, 1992).

There are two main reasons why students and researchers study public policy. The first reason is Theoretical or Scientific reason. Public policies have a significant impact on society, and understanding how policies are formulated and implemented is crucial for evaluating their effectiveness and improving them. Public policies can shape many aspects of society, such as the economy, social welfare, health, education, and the environment. By studying public policy, scholars can identify patterns and trends, analyse the factors that influence policy-making, and evaluate the outcomes of policy decisions (Birkland, 2011).

The second reason to study public policy is the Practical one. This reason is also the basis of this report. For this reason, people study public policy in order to solve practical problems in policy making and how to improve them (Birkland, 2011). As discussed earlier, public policy is not made in a vacuum. It seeks agreement and satisfaction from a variety of stakeholders. So the people interested to study public policy for practical reasons are more interested to know the causes of obstacles which are inherent to the policy making system and how to make systems to facilitate the process. Some authors mention a third reason which is the political reason but they also debate that it is closely linked with the second reason (Peters, 2015). This reason is for the people who are interested in making a counter narrative against public policies and highlights the choices that people are compelled to make in response to a policy.

In public policy morphology, there are four different variants of research (Birkland, 2011):

- **Public Policy Processes:** The study of public policy processes typically focuses on the development and execution of policies. Scholars who investigate this area of research draw on the framework of politics, exploring themes such as the emergence of public issues, the construction of cultural understandings around policy concerns, the creation of policies, their feasibility in the political realm, and the subsequent implementation of those policies (Birkland, 2011).
- **Comparative public policy:** It involves applying comparative analysis to various policy issues, in order to better understand and compare their substance. Recently, there has been a focus on cross-national comparisons in this area of research. In addition, there is a growing body of literature on comparative policy research within the United States, with a particular focus on comparing policies across different American states. However, it is important to note that much of this research is descriptive in nature, rather than offering theoretical explanations (Birkland, 2011).
- **Public Policy Analysis:** This approach draws extensively from economic theory, using a "rational" analytical perspective to identify problems, generate policy alternatives, and evaluate policies. Various techniques are utilised in this process, including quantitative methods, economic analysis, welfare economics, and qualitative assessments. Many academic programs in public policy offer two-year master's degrees, which focus on this type of training (Birkland, 2011).
- **Public Policy Research:** Policy research is an application of social science research that aims to document policy problems and assess interventions. Its defining characteristic is a focus on addressing specific problems. This means that the methods and disciplinary perspectives employed can vary widely, depending on the nature of the problem at hand (Birkland, 2011).

According to the topic and scope of this report, we will be working within the domain of public policy process. The purpose is to bridge a connection between public policy process and project management. In the next section, we will explore more in detail

the public policy process and see where we can apply the principles and frameworks of project management to find answers for our research questions.

1.1.3. Public policy making process

The policy process can be represented by an input-output model, where the inputs include various issues, pressures, and information that drive the actions of the actors within the system. The outputs of this model are public policy decisions, which can be either to take action or to refrain from doing so (Easton, 1965). However, some critics of Easton's systems model argue that it treats the political system as a "black box" - an opaque entity whose internal workings are not explained (Leslie, 1972).

Figure 1 A systems Model of Politics and Policy

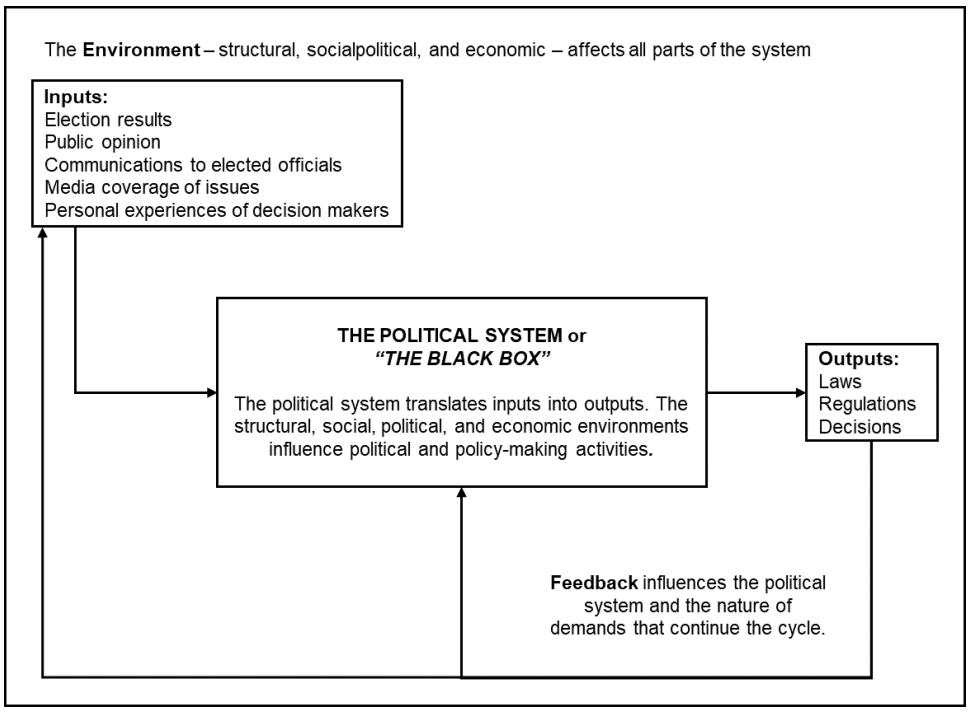

Figure 1: A systems Model of Politics and Policy, An introduction to the policy process: Theories, concepts, and models of public policy making

In contrast, the stages model of the policy process aims to shed light on the workings of the political system by breaking down the process into its constituent stages and analysing each one in detail. By doing so, it seeks to provide a more thorough

understanding of how policy decisions are made and implemented (Fischer et al., 2007).

The public policy process refers to the series of steps and activities that are undertaken by governments, interest groups, and other stakeholders to identify, develop, implement, and evaluate policies and programs aimed at addressing societal problems and achieving public goals. The public policy process typically involves the following stages (Birkland, 2011):

1. **Issue emergence:** The phase in which a problem or concern gains attention and becomes part of the public policy agenda. In this stage policymakers identify and prioritize the problems that need to be addressed.
2. **Agenda setting:** This stage of the policy process involves identifying and prioritising issues that require attention and action from policymakers. This may involve public debate, media coverage, and advocacy efforts from interest groups.
3. **Alternative selection:** In this stage, policy proposals are developed by policymakers, analysts, and stakeholders. This may involve research, consultations, and negotiations to identify the most effective and feasible policy options.
4. **Adoption/ Enactment:** Once policy proposals are formulated, they must be adopted by the appropriate legislative body, executive agency, or other decision-making authority.
5. **Implementation:** The implementation stage involves the practical application of policy decisions. This may involve the allocation of resources, the creation of regulations and guidelines, and the establishment of new programs or initiatives.
6. **Evaluation:** The final stage of the policy process involves assessing the effectiveness and impact of policies and programs. This may involve monitoring and measuring outcomes, analysing feedback, and making recommendations for improvement.

Throughout each stage of the policy process, there may be opportunities for public input, debate, and revision. The process is often iterative and subject to political, economic, and social factors that can influence outcomes (Carr et al., 2008).

Figure 2 The stages Model of the Policy Process

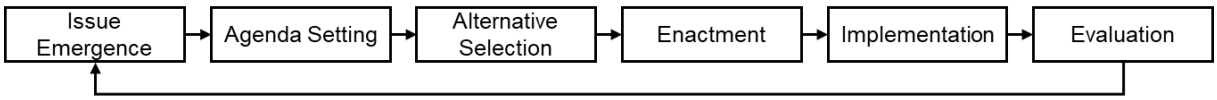

Figure 2: The stages Model of the Policy Process, An introduction to the policy process: Theories, concepts, and models of public policy making

1.1.4. Principles, goals and objectives of a policy

Public policy without principles, goals, and objectives would lack a clear framework for decision-making, direction, and focus. Without principles, policymakers may make decisions that are inconsistent or unethical, leading to a lack of public trust and potential negative consequences (Cairney, 2011). Without goals and objectives, policymakers may not have a clear vision of the outcomes they hope to achieve, and their decisions may lack purpose and direction (GradesFixer, 2022).

Usually people confuse the terms principles, goals and objectives with one another and sometimes even use them interchangeably (Brewer & DeLeon, 1983). Therefore, before we discuss what is the role of principles, goals and objectives in policy making and implementations, it is important to define and distinguish these concepts:

- **Principles** refer to the fundamental values or guidelines that underpin a policy or decision-making process. In public policy, principles can include accountability, transparency, participation, equity, efficiency, sustainability, and evidence-based decision-making (Kraft & Furlong, 2020).
- **Goals** are the broad outcomes or results that policymakers hope to achieve through a policy or decision-making process. Goals do not provide specific details on how to achieve them but rather describe what the end result should be (Weimer & Vining, 2017).

- **Objectives** are specific, measurable targets that must be met in order to achieve the broader goals of a policy or decision-making process. Objectives help to ensure that policymakers are able to measure progress towards their broader goals and make adjustments to their strategies as needed (Weimer & Vining, 2017).

Goals and objectives are important components of public policy because they provide direction and focus for policy development and implementation (Weimer & Vining, 2017). However, goals and objectives must be grounded in a set of principles that provide a framework for decision-making and ensure that policies are developed and implemented in a responsible and ethical way. Some common principles in public policy include accountability, transparency, participation, equity, efficiency, sustainability, and evidence-based decision-making (Kraft & Furlong, 2020).

These principles are shaped by a range of factors, including ideology, public opinion, evidence, international norms and standards, and resource constraints. Ideology refers to a set of beliefs or values that guide political decision-making, while public opinion can play a significant role in shaping the principles of a policy (Peters & Pierre, 2006). Evidence from research, data, and analysis can help to shape the principles that underpin a policy, while international norms and standards can also shape the principles of a policy. Resource constraints, such as budget limitations or capacity constraints, can also shape the principles of a policy (Sabatier & Mazmanian, 1989).

By adhering to these principles, policymakers can ensure that policies are developed and implemented in a way that is fair, just, and sustainable, and that they serve the best interests of the public. In this way, goals and objectives that are grounded in principles can help to ensure that public policy is effective, ethical, and responsive to the needs and interests of society (Goodin et al., 2014). Goals and objectives are key components of public policy, as they provide specific direction and focus for policy development and implementation. Researchers have formulated key reasons to emphasise on the importance of goals and objectives in public policy. Here are some of the reasons (Vedung, 1997):

- **Provide clarity and focus:** Goals and objectives help policymakers to identify and articulate what they want to achieve through a policy. By setting specific and measurable targets, policymakers can focus their efforts and resources on achieving those outcomes.
- **Help prioritize policy actions:** By setting goals and objectives, policymakers can prioritize different policy actions and determine which ones are most likely to achieve their desired outcomes. This can help to ensure that resources are allocated effectively and efficiently.
- **Enable accountability:** Goals and objectives provide a clear benchmark against which policymakers can measure their progress and evaluate the effectiveness of their policies. This can help to hold policymakers accountable for their actions and decisions.
- **Facilitate stakeholder engagement:** Goals and objectives can help to facilitate engagement and collaboration with stakeholders, such as community groups, non-governmental organisations, and businesses. By involving stakeholders in the development of goals and objectives, policymakers can ensure that policies reflect the needs and interests of a diverse range of stakeholders.
- **Promote transparency:** By setting goals and objectives, policymakers can be transparent about what they hope to achieve through a policy, and how they plan to achieve those outcomes. This can help to build trust and legitimacy with the public.

1.1.5. Net zero as a public policy, objectives and challenges

Governments across the world have adopted the concept of "net zero" as a central objective of their public policy in order to limit and control GHG emissions in recent years, as the world grapples with the challenge of climate change. The scientific community has provided unequivocal evidence that human activities and industrialization, such as burning fossil fuels, have resulted in a substantial increase in greenhouse gas emissions. These emissions are causing the planet to warm up,

leading to rising sea levels, more frequent and intense extreme weather events, and a host of other adverse impacts (IPCC, 2018a). To limit global warming and avoid the worst effects of climate change, public policies have been developed with the aim of transitioning to a net zero emissions economy.

Net zero goal is a mammoth task. Never before in history, humanity has undertaken a collective challenge such as transforming a whole planet. Although seen from a different angle, it was human activities that caused the planet to warm up (IPCC, 2018a). Objectively speaking, we have already transformed our planet. This is something that we have done over centuries especially after the great industrialization period (Steffen et al., 2015). Industrialization refers to the process of the introduction of large-scale manufacturing, advanced technology, and mechanisation of production processes (Hobsbawm, 1999). This has been a significant driver of economic growth and development in many countries around the world. Industrialization is commonly thought to be the source of a substantial increase in GHGs in our atmosphere but there are several advantages associated with it as well. We must look at both sides of the picture to find a balanced solution and save our planet from the disaster of global warming. (Acemoglu & Robinson, 2013):

Pros:

- **Economic growth:** Industrialization has been a major driver of economic growth and development in many countries. It has created new industries, provided employment opportunities, and increased production output, leading to higher economic growth rates.
- **Increased productivity:** Industrialization has enabled manufacturers to produce goods at a much faster rate than before. This has led to increased productivity, which has, in turn, helped reduce the cost of goods.
- **Improved standard of living:** The increased production of goods and services resulting from industrialization has led to an improvement in the standard of

living of people. The availability of affordable products has made life easier and more comfortable for people.

- **Technological advancements:** Industrialization has resulted in the development of new technologies, which have improved production processes, increased efficiency, and lowered costs.

Cons:

- **Environmental pollution:** Industrialization has led to an increase in pollution levels due to the release of toxic chemicals and gases into the environment. This has had a negative impact on the health of people and the environment.
- **Social inequality:** Industrialization has created significant disparities in wealth and income distribution. Some people have benefited significantly from industrialization, while others have been left behind, leading to social inequality.
- **Exploitation of workers:** Industrialization has often led to the exploitation of workers, who are forced to work long hours under poor working conditions for low wages.
- **Resource depletion:** The large-scale use of natural resources in the production process has led to resource depletion and environmental degradation.

Net zero refers to the point at which greenhouse gas emissions are balanced by removing an equivalent amount of greenhouse gases from the atmosphere. This means that the amount of greenhouse gases being emitted into the atmosphere is offset by the amount of greenhouse gases being removed, resulting in a net zero balance. The most commonly referenced greenhouse gas is carbon dioxide, which is produced by burning fossil fuels (IPCC, 2021).

The primary objective of net zero is to limit global warming to well below 2°C above pre-industrial levels, as set out in the Paris Agreement (IPCC, 2021). The Paris Agreement, adopted in 2015, is an international treaty that aims to limit global warming to well below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels (UNFCC, 2015). To achieve

this objective, the agreement calls for global greenhouse gas emissions to reach net zero by the middle of the century.

The IPCC, in its most recent report, has warned that the planet is on track to warm by more than 1.5°C above pre-industrial levels, and that this will have severe consequences for the planet (IPCC, 2021). To avoid the worst impacts of climate change, it is therefore imperative that we transition to a net zero emissions economy as soon as possible (IEA, 2021).

While the objective of net zero is clear, achieving it presents significant challenges. One of the biggest challenges is the scale of the transition required (IPCC, 2021). To achieve net zero, we will need to transform our energy systems, transportation systems, and land use practices. This will require significant investments in new infrastructure, such as renewable energy, electric vehicles, and public transportation (IPCC, 2018a).

In addition to the scale of the transition, there are also technical challenges that must be overcome. For example, while renewable energy sources such as wind and solar are now cost competitive with fossil fuels, they are intermittent and require storage solutions to ensure a reliable supply of energy. Battery storage technology has improved significantly in recent years, but it is still not cost competitive with fossil fuel alternatives in all cases (IRENA, 2022).

Another challenge is the need to scale up carbon capture and storage (CCS) technology. CCS involves capturing carbon dioxide emissions from industrial processes and storing them underground. This technology is seen as an important tool for achieving net zero, but it is still in the early stages of development and has not yet been deployed at scale (IRENA Carbon Capture, 2022).

Finally, there are political and social challenges that must be overcome. For example, transitioning to a net zero economy will require significant changes to our lifestyles and economic systems. This could create winners and losers, and there may be resistance to these changes from some groups (IRENA Partnerships, 2022).

In the light of the above mentioned argument, humanity has come a long way from the horrors and hardships of primitive human life yet the challenge to create a balance

in the world is not over. We are aware of the negative effects of our activities on our planet yet we cannot simply press a reverse button and undo all the effects of our centuries old activities. This requires a significant shift away from the current reliance on fossil fuels towards low-carbon energy sources and technologies. A brief overview of the complexity of achieving net zero goal is mentioned blow (IPCC, 2021):

- **The scale of the challenge:** The transition to net-zero is a significant challenge, requiring a complete overhaul of the energy systems that currently underpin modern economies. It requires the transformation of the power, transportation, buildings, and industrial sectors, which are all major emitters of greenhouse gasses.
- **Technological innovation:** Achieving net-zero emissions requires the development and deployment of new technologies, such as renewable energy sources, energy-efficient buildings, and carbon capture and storage (CCS) technologies. These technologies are still relatively new and require significant investment and development to become cost-effective and scalable.
- **Cost implications:** The transition to net-zero emissions requires significant investment in low-carbon technologies and infrastructure. This can be a challenge for many countries and businesses, as it may require significant upfront costs. However, there is also evidence that the cost of renewable energy sources and other low-carbon technologies is falling, making it increasingly cost-effective to switch to low-carbon energy.
- **Policy frameworks:** Achieving net-zero emissions requires effective policy frameworks that incentivize low-carbon investment and discourage high-emission activities. This can include policies such as carbon pricing, regulation, and subsidies for low-carbon technologies. However, the political will to implement such policies may be a barrier in some countries.
- **International cooperation:** Climate change is a global problem, and achieving net-zero emissions requires international cooperation. This includes cooperation on issues such as finance, technology transfer, and capacity

building. However, there may be challenges in achieving international cooperation on these issues due to geopolitical tensions and differing national priorities.

1.2. Introduction to projects and programs

A project is a temporary effort that is undertaken to deliver a unique outcome, such as a product, service, or result. Projects have specific objectives to be achieved within a defined timeframe, with defined resources and constraints (PMBOK, 2017). They require careful planning, execution, monitoring, and control to ensure successful delivery (Kerzner, 2017).

On the other hand, a program is a collection of related projects that are managed together to achieve a specific strategic objective or set of objectives. Programs typically have a longer duration than individual projects, and may involve multiple projects running concurrently (Crawford et al., 2006). They require a high level of coordination, communication, and integration to ensure that the individual projects are aligned with the overall program goals and objectives (PMI, 2017).

Projects and programs are critical components of effective project management, with projects being the building blocks of a program, and programs providing the framework for managing multiple projects to achieve strategic objectives (Ireland & Cleland, 2006).

1.2.1. Projects and programs as vector of change

Projects and programs are critical vectors for change that enable individuals, organisations, and societies to achieve their desired future (Huemann & Silvius, 2017). Both projects and programs have the potential to catalyse change by creating new opportunities, improving organisational efficiency, and addressing complex societal problems (Turner & Müller, 2003).

The significance of projects and programs as vectors for change is well documented in the literature. A study conducted by the Project Management Institute (PMI) found that organisations with effective project management practices are more likely to achieve their strategic goals and have a higher success rate in implementing new initiatives (PMI, 2017). Another study by the Boston Consulting Group (BCG) found that companies that excel at managing their project portfolios achieve a higher return on investment (ROI) and have better growth prospects than those with poor project management capabilities (Dreischmeier et al., 2015).

Projects and programs are essential for achieving a desired future by providing a structured approach to managing change (Huemann & Silvius, 2017). They help organisations to clarify their vision and strategy, identify key success factors, and create a roadmap for achieving their goals (Kerzner, 2017). Projects and programs also enable organisations to manage risks, allocate resources effectively, and measure progress towards their objectives which also helps them to make more precise projections about the future.

Projects and programs also play a critical role in addressing complex societal problems, such as climate change, poverty, and inequality (Schaltegger et al., 2012). The United Nations Sustainable Development Goals (SDGs) are a prime example of a programmatic approach to addressing complex global challenges. The SDGs are a collection of 17 goals and 169 targets that provide a comprehensive framework for sustainable development (UN DESA, 2016). The SDGs require a coordinated effort by governments, businesses, civil society, and individuals to achieve their objectives, highlighting the importance of programs in addressing complex societal problems.

Projects and programs can also create new opportunities by fostering innovation and entrepreneurship. For example, the European Union's Horizon 2020 program is a research and innovation program that provides funding and support for innovative projects in areas such as health, energy, and the environment (European Commission, 2020). The program has helped to support the development of new technologies and businesses, creating new opportunities for economic growth and job creation.

1.2.2. Characteristics and types of projects and programs

There are various types of projects and programs, each with its unique characteristics, objectives, and methods of implementation. These different types of projects and programs are designed to address a wide range of social, economic, and environmental challenges. This classification helps project managers to adopt practices that are vital for the success of a certain project (Müller & Turner, 2007). Projects and programs have multiple characteristics on which they can be classified. As projects have multiple characteristics, therefore; one classification cannot satisfy all the characteristics. A project can be classified based on its size, complexity, duration, industry or purpose. Some types of projects based on industry or organisation in which they are implemented and which are relevant for the scope of this report are mentioned below:

- **Infrastructure or Construction Projects:** These projects involve the design, planning, and execution of physical structures, such as buildings, roads, bridges, and dams. These projects require significant investment in terms of resources, time, and money, and involve multiple stakeholders, including architects, engineers, contractors, and government agencies (Hendrickson et al., 1989). Construction projects are typically complex and require careful management to ensure that they are completed on time, within budget, and to the required quality standards. Examples of construction projects include the Burj Khalifa in Dubai, the Panama Canal, and the High-Speed Rail project in California.
- **Information Technology (IT) Projects:** IT projects involve the development, deployment, and maintenance of software, hardware, and network systems. These projects are critical for businesses and organisations, as they enable them to streamline their operations, improve efficiency, and enhance their competitiveness (Project Manager, 2023). IT projects can vary in scope and complexity, from simple website development to the implementation of large-scale enterprise resource planning (ERP) systems. Examples of IT projects

include the development of the iPhone by Apple, the implementation of the SAP ERP system by Nestle, and the deployment of the Google Fiber network.

- **Research and Development (R&D) Projects:** R&D projects involve the creation and testing of new products, processes, or technologies. These projects are critical for innovation and progress, as they enable organisations to develop new solutions to existing problems or to create new opportunities (Brennan et al., 2020). R&D projects require significant investment in terms of resources and time, as well as a high degree of risk-taking, as the outcomes are often uncertain. Examples of R&D projects include the development of the first polio vaccine by Jonas Salk, the creation of the first electric car by Tesla, and the development of the first 3D printer by Chuck Hull.
- **Intangible Projects:** Intangible projects involve the implementation of initiatives to address social or environmental problems, such as poverty, inequality, or climate change. These projects are critical for improving the quality of life and well-being of individuals and communities and require collaboration and partnership among multiple stakeholders, including governments, NGOs, and civil society organisations . Intangible projects can take various forms, such as education programs, community development projects, or environmental conservation initiatives.

1.2.3. Public policy process through the lens of project management

In 2015, Graham M. Winch and Joe Sanderson published an article in the international journal of project management called "Call for Papers - Public policy and projects". In this article the authors call on academics and practitioners to contribute papers on the intersection of public policy and projects. The authors argue that there is a need for more research and discussion on the relationship between these two areas, as public policy can have a significant impact on project outcomes, and projects can also be used to implement public policy (Winch & Sanderson, 2015).

Continuing their argument that there is a need for more integration and alignment between these two areas in order to achieve better outcomes for society, they published another article in 2017. In this paper, they discuss the challenges of implementing policy through projects and look at ways to improve this process, such as involving policymakers in project planning. The paper emphasises the importance of collaboration and communication between public policy and project management professionals to achieve successful outcomes (Sanderson & Winch, 2017).

We have already explored the policy making process in section 2.1.3. Before we talk about the similarities and common stages between policy making and project management, it is important to review the key aspects and stages of project management. According to PMBOK guide, project management process involves the following steps (PMBOK, 2017):

1. **Initiation:** This involves defining the project scope, objectives, and stakeholders, as well as identifying the resources required to complete the project.
2. **Planning:** In this stage, the project plan is developed, including defining tasks, timelines, and resource allocation. A risk management plan is also developed to identify potential problems and their solutions.
3. **Execution:** This involves implementing the project plan, including coordinating tasks and resources, and monitoring progress.
4. **Monitoring and Controlling:** This stage involves tracking the project's progress, identifying potential problems and taking corrective actions as needed to stay on track.
5. **Closure:** This stage involves concluding the project and delivering the results to stakeholders. This includes assessing the project's success, documenting lessons learned, and archiving project records.

Figure 3 Project Management Lifecycle

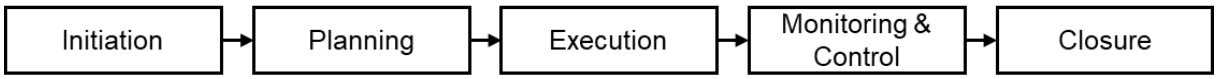

Figure 3: Project Management Lifecycle, A guide to the project management body of knowledge

Comparing the two processes, we can see some striking similarities and some contrasts. Both the processes involve the identification of objectives, the allocation of resources, the coordination of activities, and the management of risk. In fact, if we overlap the two processes they strengthen each other and overcome the weaknesses. Public policy tends to rely on more qualitative methods, such as expert opinions and stakeholder engagement, while project management relies more heavily on quantitative methods, such as budgeting and project scheduling (Owen et al., 2012). Below are the commonalities between the two processes in which they can explore synergies:

- **Identifying objectives:** Both processes involve identifying the objectives and goals that need to be achieved. In the public policy process, this includes defining the policy problem and the desired outcome (Owen et al., 2012). In the project management process, this includes defining the project scope and objectives (PMBOK, 2017).
- **Allocating resources:** Both processes involve allocating resources, such as time, money, and personnel, to achieve the desired outcomes. In the public policy process, this includes identifying and allocating financial resources, personnel, and other necessary resources to support the policy's implementation (Bardach, 2012). In the project management process, this includes creating a resource plan to ensure that the project has the necessary resources to achieve its goals. (Ralf Müller & Judgev, 2012)
- **Coordinating activities:** Both processes require coordination and collaboration between multiple stakeholders to achieve the desired outcome. In the public policy process, this includes coordinating activities between different government agencies, interest groups, and other stakeholders (Jenkins-smith &

Sabatier, 1993). In the project management process, this includes coordinating activities between different project team members and stakeholders (Larson & Gray, 2017).

- **Managing risks:** Both processes require risk management to ensure that potential problems are identified and addressed in a timely manner. In the public policy process, this includes identifying potential risks and developing strategies to mitigate them (Lindblom, 1959). In the project management process, this includes identifying potential risks and developing a risk management plan to mitigate or avoid them (Chapman & Ward, 2013).
- **Evaluating outcomes:** Both processes require evaluation of outcomes to determine whether the objectives have been achieved. In the public policy process, this includes evaluating the effectiveness of the policy and its impact on the intended beneficiaries (Weiss & Weiss, 1972). In the project management process, this includes evaluating the project's deliverables to ensure that they meet the project's objectives (Mishra, 2017).

1.2.4. Role of projects and programs in public policy implementation

In recent years, the use of project and program management techniques in the public sector has gained significant attention as a way to improve the effectiveness of public policy implementation (Sanderson & Winch, 2017). Project and program management approaches offer a structured and systematic approach to planning, executing, and monitoring complex initiatives (Owen et al., 2012). In this section we will explore the role of projects and programs in the public policy process and how project management can contribute to achieving policy objectives based on established research.

The public policy process can be complex and challenging, with numerous stakeholders, varying interests, and limited resources (Winch & Sanderson, 2015). Effective policy implementation requires a well-designed plan, effective execution,

and continuous monitoring and evaluation (Birkland, 2011). This is where project and program management can play a significant role. Project management provides a structured approach to managing complex initiatives, from the identification of goals and objectives to the monitoring and evaluation of outcomes (Sanderson & Winch, 2017).

One of the primary roles of project and program management in public policy is to enhance the effectiveness of policy implementation (Žurga, 201). By applying project management principles, public organisations can ensure that policies are implemented in a structured, timely, and efficient manner. This can help to reduce waste, increase efficiency, and improve the quality of services provided to citizens (Crawford & Helm, 2009).

In addition to enhancing the effectiveness of policy implementation, project and program management can also help to achieve policy objectives. Projects and programs are designed to achieve specific goals and objectives, and the application of project management principles can help to ensure that these objectives are met (Gasik, 2022). This can be particularly important in complex policy areas where there are numerous stakeholders, and competing interests must be balanced.

Another significant role of project and program management in public policy is to improve accountability and transparency. By using project management tools and techniques, public organisations can ensure that policies are implemented in a transparent and accountable manner (PMI, 2015). This can help to build trust and credibility with citizens, leading to increased public satisfaction with government services.

Furthermore, project and program management can help to build capacity within public organisations. By applying project management principles, public organisations can develop a culture of continuous improvement, ensuring that policies are implemented in a consistent and effective manner (Gasik, 2022). This can lead to improved employee skills and knowledge, increased productivity, and more efficient

use of resources. Applying project management practices, public organisations can also build following synergies:

Stakeholder engagement is critical in public policy implementation, as it ensures that the interests of all relevant stakeholders are considered (Anderson, 2003), (Cairney, 2011), (Birkland, 2011). Project management provides a structured approach to stakeholder engagement, which involves identifying stakeholders, understanding their needs and expectations, and involving them in decision-making processes (Davis, 2017). By engaging stakeholders effectively, public policy projects and programs can gain the support and buy-in needed for successful implementation.

Risk management is also essential in public policy implementation, as it helps to identify and manage potential risks and uncertainties that may affect project outcomes (Anderson, 2003). Project management provides a systematic approach to risk management, which involves identifying risks, assessing their impact and likelihood, and developing mitigation strategies (Chapman & Ward, 2013). By managing risks effectively, public policy projects and programs can avoid or minimise potential disruptions and delays.

Performance measurement is critical in evaluating the effectiveness of public policy projects and programs (Bardach, 2012). Project management provides a structured approach to performance measurement, which involves setting measurable objectives, developing performance indicators, and tracking progress against targets (Pinto et al., 2022). By measuring performance effectively, public policy projects and programs can identify areas for improvement and adjust their approach to achieve better outcomes.

Finally, project and program management can help to promote innovation and creativity in public policy. By using project management principles, public organisations can identify new and innovative approaches to policy implementation (Sanderson & Winch, 2017). This can help to identify new solutions to complex policy problems, leading to improved outcomes for citizens.

In conclusion, project and program management can play a significant role in the public policy process, enhancing the effectiveness of policy implementation, achieving

policy objectives, improving accountability and transparency, building capacity within public organisations, and promoting innovation and creativity (Winch & Sanderson, 2015). By applying project management principles to public policy, public organisations can ensure that policies are implemented in a structured, timely, and efficient manner, leading to improved outcomes for citizens (Owen et al., 2012).

1.2.5. Projects and programs as a way for net zero transition

The transition to a net zero carbon future is a complex and daunting task that requires coordinated efforts and investments from all sectors of society. This view is evident in the report "Net Zero by 2050: A Roadmap for the Global Energy Sector" published by the International Energy Agency) (IEA, 2021). In order to achieve this goal, we need to shift our focus from traditional business-as-usual practices to a more holistic approach that emphasises innovation, collaboration, and long-term planning (Meena et al., 2022). This is where projects and programs come into play, serving as the backbone of the net zero transition which will require significant changes in energy systems, transportation, buildings, and other areas of our economy. Projects and programs provide a framework for organising and managing these changes in a systematic and efficient manner. (Heede, 2021).

According to a recent article "Projects to create the future: Managing projects meets sustainable development" published in the International Journal of Project Management, projects and programs are critical components of the transition to a net zero carbon future. The authors discuss the two concepts of sustainability linked with the projects and programs; "Sustainability of the project" and "Sustainability by the project" (Huemann & Silvius, 2017). Let's dig deeper into these two concepts because they are essential to understand the role of projects and programs in net zero transition.

"Sustainability by the project" refers to the impact that a project has on the environment, economy, and society. The authors argue that project managers have a responsibility to ensure that their projects contribute to sustainable development and

do not harm the environment or society. On the other hand, "sustainability of the project" refers to the ability of a project to be economically, socially, and environmentally sustainable throughout its lifecycle. The authors argue that project managers need to consider the sustainability of a project from its inception to its completion and beyond. This can be achieved by incorporating sustainable practices into project design, planning, execution, and monitoring and evaluation (Huemann & Silvius, 2017).

The concept of sustainability of the project has its own importance and there is a significant amount of research being done in this area to incorporate sustainability in project management practices. However, for the sake of scope of this report we will be focusing more on the concept of sustainability by the project. Mentioned below are just a few examples related to this concept to grasp the broad field and scope covered by projects and programs in net zero transition.

One example of a project that is contributing to the net zero transition is the Deep Geothermal Energy Project in Cornwall, UK. This project involves drilling deep underground to access geothermal energy, which can then be used to provide heat and electricity to homes and businesses. The project is expected to produce 3 MW of electricity and 12 MW of heat, and will avoid the emission of 12,000 tonnes of CO2 per year (Richter, 2021).

Another example of a project that is contributing to the net zero transition is the Solar Settlement in Freiburg, Germany. This project involves the construction of 59 homes that are designed to be energy self-sufficient, using a combination of solar panels, heat pumps, and other renewable energy sources (Pieper & Kasper, 2022).

Low Carbon London program, is another example of a program aimed to transition towards net zero (UK Power Networks, 2014). This program involves the installation of smart metres, electric vehicle charging points, and other technologies that enable consumers to better manage their energy use and reduce their carbon footprint. The program is being implemented in collaboration with local authorities, businesses, and

community groups, and is expected to reduce carbon emissions by 60,000 tonnes per year.

The above mentioned examples of projects and programs have the same goal of transitioning into a net zero future yet they are different in their objectives and deliverables. They require different technology, resources and implementation methodology. Although the traditional classification of P&P mentioned in section 2.2.2. can be applied on these projects yet the topic of P&P in net zero transition requires a better understanding and classification for scientists, researchers and professionals to study and examine the P&Ps in net zero context. The findings suggest that the study of this subject in academic literature is still relatively new, but there is an increasing interest among scholars, which is paving the way for novel avenues of research (Armenia et al., 2019).

Marco Terenzi in his article "Projects as vectors of change: a transition toward a net-zero asset portfolio" argues that based on the types of deliverables, we can classify net zero transition P&Ps into four main types (Terenzi, 2023). This classification is very relevant in the context of this report particularly during the analysis of the second research question, so based on Marco's classification, these four types are defined more in detail below:

- **New Asset:** This type includes P&Ps that facilitate the decarbonisation of asset portfolios by introducing new assets or replacing existing ones, such as the installation of a wind farm in a fossil-fuel-based portfolio to decrease the average carbon intensity. This type of P&Ps is commonly discussed in the literature, with a particular emphasis on net-zero P&Ps in the energy and transport sector (Terenzi, 2023).
- **Upgrade Asset:** These types of P&Ps aim to transition assets to net-zero by decarbonising their portfolio through upgrading or improving existing assets, such as enhancing the insulation of a building through retrofitting. The literature contains numerous examples of net-zero transition P&Ps for upgrade

assets, particularly in the realm of building heating/ cooling systems and industrial processes (Terenzi, 2023).

- **Intangible:** This type of P&Ps encompasses deliverables that are not physical in nature, such as awareness campaigns. These types of Net-zero transition P&Ps induce changes in how asset portfolios are utilised, and they can decrease GHG emissions in two ways: by altering intensity (e.g., P&Ps aimed at persuading individuals to use less carbon-intensive modes of transportation, such as trains instead of cars) and quantity (e.g., P&Ps aimed at reducing the number of miles travelled, such as substituting videoconferencing for in-person meetings). However, discussions of intangible Net-zero transition P&Ps are uncommon in the literature, with only a few instances found in transportation and food consumption (Terenzi, 2023).
- **R&D:** Research and development encompass P&Ps that strive to generate knowledge that has the potential to decarbonize systems. For example, R&D projects related to fusion energy could potentially decarbonize power plants. It can be challenging to identify R&D Net-zero transition P&Ps since several of them do not aim to create technologies or practices that directly decarbonize a specific asset portfolio, or they may not be initially developed for decarbonization purposes (Terenzi, 2023).

1.3. Success and evaluation of projects and programs

There is a very thin line between the ideas of project evaluation and project success. While doing the literature review and getting into the depth of this topic, we found multiple perspectives about project success and project evaluation. For some people, project success and evaluation have the same meaning and the terms can be used interchangeably, however this idea is not very well supported in the literature (Maylor, 2011). For some, the act of measuring project success is called project evaluation (Ika, 2009) (Judgev & Müller, 2005). In the past, most of the research on project evaluation has largely focused on project success and assessments conducted

after project completion (Haass & Guzman, 2020). These evaluations often use the classical iron triangle, which assesses time, cost, and quality and compares the results to the plan (Lenfle, 2012). However, there has been a growing emphasis on assessing long-term project effects in addition to achieving short-term goals (Atkinson, 1991) (Shenhar et al., 2001). In the next paragraphs, these concepts (evaluation & success) are explored more in detail.

Project evaluation is the systematic and objective assessment of a project's effectiveness, efficiency, and impact. The purpose of evaluation is to determine whether the objectives of the project have been achieved, and to identify strengths and weaknesses so that improvements can be made (Rode et al., 2022). Evaluation involves collecting and analysing data about the project, and using that information to make judgments about the project's performance and impact (Haass & Guzman, 2020).

On the other hand, project success refers to the degree to which a project has achieved its objectives, goals, and deliverables. Project success can be measured by factors such as meeting the project schedule, budget, and scope requirements, as well as the level of stakeholder satisfaction with the project outcomes (Bannerman, 2008).

While project success and project evaluation are related, they are not the same thing. Project success is focused on achieving specific goals and outcomes, while project evaluation is focused on understanding the effectiveness and impact of the project as a whole. Project success is typically measured against predetermined criteria, while project evaluation involves a more comprehensive analysis of the project's performance and outcomes (Rode et al., 2022).

This distinction is useful to decide our direction of research keeping in view the context and scope of this report. Project evaluation is a complete subject on its own and a lot of research is being done in improving project effectiveness and efficiency. However, in the context of this report we are more interested to understand to what degree the projects and programs initiated in the UK are able to achieve the goal of transitioning towards net zero. This view essentially takes us in more depth on the topic of project success. Before we can talk about the ways to evaluate project success particularly in

terms of net zero goals and objectives, there is another important distinction that needs to be understood. This distinction is between project success and project management success which is discussed in the next section.

1.3.1. Project success vs project management success

In the field of project management, the concepts of project management success and project success are often discussed. While they are related, they are not the same thing. Project management success is about meeting project goals within the constraints of time, cost, and quality, while project success is about achieving broader strategic objectives (Shenhar et al., 1997). This idea has proved to be very useful in gaining deeper insight in the subject of project management.

According to Terry C. Davies, project management success is essential for achieving project success. In his article, he identifies several "real" success factors that contribute to project management success, including leadership, clear objectives, effective communication, and a focus on delivering value. These factors help project managers to meet project goals within the constraints of time, cost, and quality. However, he notes that project management success is not sufficient on its own. In order to achieve project success, it is also necessary to meet broader strategic objectives, such as improving organisational performance or meeting stakeholder needs (Davies, 2002).

Going deeper into the subject, Geraldi, Maylor, and Williams discuss the complexities of projects and how they impact project management success and project success. The authors argue that project management success is necessary but not sufficient for achieving project success, particularly in complex projects. They identify several factors that contribute to project complexity, including uncertainty, ambiguity, and stakeholder diversity. These factors make it difficult to achieve project success, as they can impact project goals, stakeholder satisfaction, and organisational performance. The authors note that project managers must be aware of these complexities and be able to adapt their approach to meet project goals and achieve project success (Geraldi et al., 2011).

In summary, project management success and project success are two related but distinct concepts in project management. Project management success is focused on meeting project goals within the constraints of time, cost, and quality, while project success is focused on achieving broader strategic objectives. While project management success is necessary for achieving project success, particularly in complex projects, it is not sufficient on its own. The factors that are responsible for project management success are highly dependent on the organisational capabilities, knowledge and expertise (Davies, 2002).

For the scope of this report, we will be analysing projects initiated to meet the UK's net zero goals and objectives. These projects have different stakeholders (owners, suppliers and clients, etc,). These stakeholders must also belong to different professions and walks of life, hence; they will have varying levels of project management skills. Their methodology of implementing project management will also vary depending on which framework they use, whether waterfall or agile project management. Therefore; talking about the project management success in context of this report will lead us away from the intended scope. In this report we are more interested to analyse project success of the net zero transition P&Ps in the UK.

1.3.2. Different theories of project success

Despite the evolution of sophisticated practices and frameworks of project management, projects often face challenges such as time and cost overruns, stakeholder disappointments, and sustainability shortfalls (Gill & Pinto, 2018). Adding to the problem, stakeholders often hold different or conflicting views of success that also change overtime (Davis, 2017).

A range of theories and frameworks have been developed to conceptualise project success, each with its own unique perspective and criteria for evaluation. Table 1, borrowed from (Ika & Pinto, 2022) shows the evolution of success dimension over time. In this section, we will review some of the most prominent theories and frameworks of project success as identified in scientific literature.

Table 2 Measuring Success across Time

	Period 1 **1960s – 1980s**	**Period 2** **1980s – 2000s**	**Period 3** **21st Century**
Success criteria	Iron triangle (time, cost, quality)	Iron triangle Business case benefits Benefits to key internal stakeholders (clients/ funder, owner, end-users, project team, organizational employees)	Iron triangle Business case benefits Value of the investment for the funding/ owner, the delivery and supply (or other partnering) organizations Benefits to internal stakeholders Benefits to external stakeholders Symbolic and rhetoric evaluation and attributes of success by diverse stakeholders Community, environmental, societal impacts or sustainability
Results Chain	Outputs	Outcomes	Impacts
Time Horizon	Short-term	Medium-term	Long-term
Emphasis	Project plan success	Business case success	Green efficacy

Table 2:Measuring Success across Time, Project success as a topic in project management journals. Project Management Journal, 40(4), 6-19

One of the earliest theories of project success is the "Iron Triangle" model, which was introduced in the 1960s by Dr. Martin Barnes. This model defines project success based on three factors: time, cost, and scope (Shenhar et al., 2001). According to this model, a project is successful if it is completed within its allotted time and budget while meeting its predetermined scope requirements. While this model has been widely adopted in project management practice, it has been criticised for oversimplifying project success and neglecting the impact of other important factors, such as stakeholder satisfaction and project quality (Judgev & Müller, 2005).

In response to this critique, several other frameworks have been proposed that offer a more holistic approach to project success. One such framework is the "Project Success Wheel" developed by Aaron Shenhar and Dov Dvir. This framework identifies eight dimensions of project success: project efficiency, impact on the customer, business success, preparation for the future, stakeholder satisfaction, team satisfaction, team growth, and societal success. According to this model, project success requires a

balance of these eight dimensions, with no single dimension being more important than the others (Dvir & Shenhar, 2007).

Another prominent theory of project success is the "Resource-Based View" (RBV), which emphasises the importance of project resources in achieving success. According to this theory, project success is determined by the ability of the project team to leverage its unique resources and capabilities to create value for the organisation (Grant, 1991). In this view, project success is not just about meeting time, cost, and scope requirements, but also about creating a sustainable competitive advantage for the organisation through the project outcomes.

In December 2019, the OECD updated and revised its evaluation criteria to better align with the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015. The revised evaluation criteria aim to promote a more holistic approach to development assistance that addresses the interconnected challenges faced by developing countries. These criteria were also adopted by Ika for his success model for international development projects (Ika & Donnelly, 2017). These six revised criteria are as follows (OECD, 2019):

1. **Relevance:** The relevance principle focuses on whether aid programs are aligned with the priorities and needs of the partner country. The revised criteria emphasise the importance of country ownership and participation in the design and implementation of aid programs. The criteria also stress the need for aid programs to address the root causes of poverty and inequality, such as gender disparities and climate change.
2. **Coherence:** This principle focuses on the idea of ensuring policy coherence across different areas of governance, such as economic, social, and environmental policies. Coherence is important to avoid conflicting policies, and to maximise the benefits of policies across different sectors. The framework outlines several criteria for policy coherence, including the identification of common objectives across different policy areas, the alignment of policies with

these objectives, the assessment of policy impacts, and the involvement of stakeholders in the policy-making process.

3. **Effectiveness:** The effectiveness principle focuses on whether aid programs are achieving their intended outcomes. The revised criteria emphasise the need for aid programs to be evidence-based, adaptive, and results-oriented. The criteria also highlight the importance of monitoring and evaluation to track progress and identify areas for improvement.
4. **Efficiency:** The efficiency principle focuses on whether aid programs are using resources effectively and efficiently. The revised criteria stress the need for aid programs to be cost-effective, to use local resources and capacities where possible, and to minimise transaction costs.
5. **Sustainability:** The sustainability principle focuses on whether aid programs are promoting sustainable development. The revised criteria emphasise the importance of environmental sustainability, social sustainability, and economic sustainability. The criteria also stress the need for aid programs to promote inclusive growth, build resilience, and strengthen institutions.
6. **Impact:** The impact principle focuses on whether aid programs are making a positive difference in the lives of people in the partner country. The revised criteria emphasise the importance of measuring the long-term impact of aid programs, including their contribution to the achievement of the SDGs. The criteria also stress the need for aid programs to be transparent and accountable, and to involve stakeholders in decision-making processes.

Figure 4 OECD Evaluation Criteria

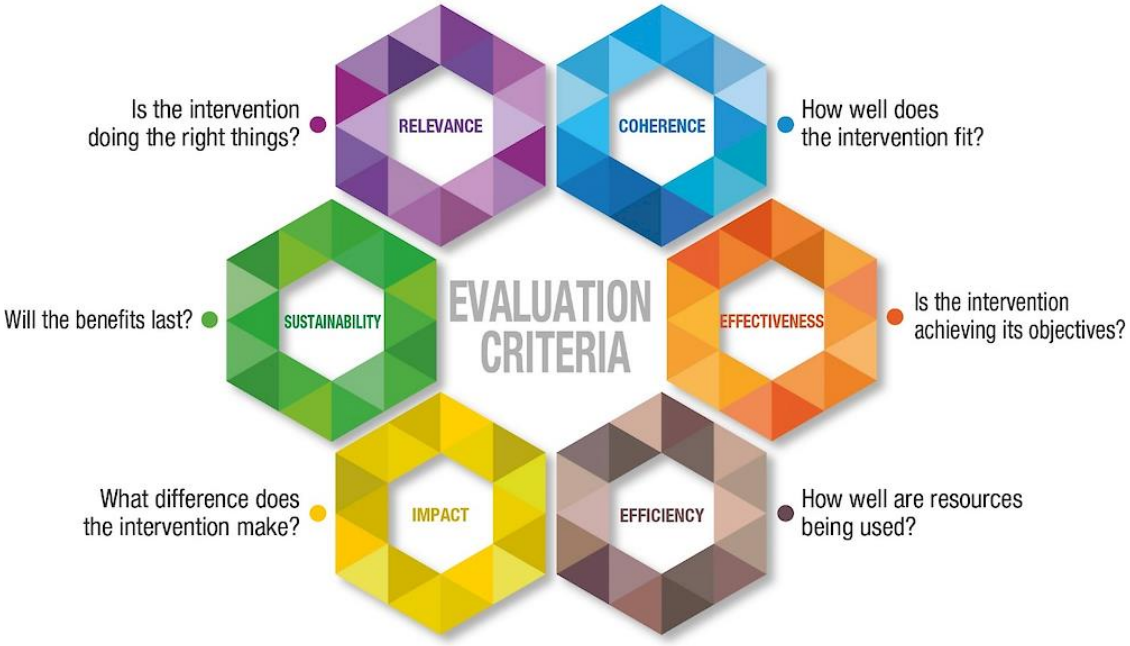

Figure 4: OECD Evaluation Criteria, The six criteria: Their purpose and role within evaluation

Despite the differences among these theories and frameworks, they all share the common goal of defining and measuring project success. However, the criteria for project success can vary depending on the context and the stakeholders involved in the project. Table 2, borrowed again from (Ika & Pinto, 2022) does a great job in summarising key existing models of success in the project management literature. One issue with all the models mentioned in the table is that none of these models provide a holistic view of project success. Most of the models lack the green success factor which is one of the important dimensions to measure the success of net zero transition P&Ps. Although Maltzman and Shirley feature green success prominently in their work, they do not account for stakeholder expectations in their model (Maltzman & Shirley, 2015).

Table 3 Eight Models of Success

Barnes (1969)	Pinto & Slevin (1988)	Atkinson (1999)	Delone & McLean (2003)	Shenhar & Dvir (2007)	Maltzman & Shirley (2015)	Ika (2018)	Zwikael & Meredith (2021)
			IS	New product development	Generic	International development projects	Generic
Generic	Generic						
		IS					
Time, cost & quality (Iron triangle)	Time, cost & performance	Iron triangle (Time, cost, quality)	Information quality	Efficiency	Project management success	Project management success (Efficiency/ time & cost; effectiveness/ objectives)	Project management success (Time, budget, scope, no undesirable impacts by project manager)
	Perceived quality	The IS	System quality	Impact on customer	Project success	Deliverable success (Relevance country, relevance for beneficiaries, institutional impact, sustainability)	Project ownership success (Target benefits; business case realized)
		Maintainability, reliability, validity, information quality use					
	Client satisfaction		Service quality	Impact on team	Green success		Project investment success (satisfactory results, investment again by funder, overall success)
		Benefits to organization (Improved efficiency, effectiveness; increased profits, strategic goals, organizational learning, reduced cost)	Intention to use	Business and direct success			
		Benefits to stakeholder	Use	Preparation for future			
		Community (Satisfied users, social and environmental impact, personnel development, professional learning, contractors' profits, capital suppliers, content project team, economic impact to surrounding community)					
			User satisfaction				
			Net benefits				

Table 3: Eight Models of Success, The "re-meaning" of project success: Updating and recalibrating for a modern project management. International Journal of Project Management, 40(7), 835-848

In order to solve this issue of a holistic view of project management success, Ika and Pinto suggested a four dimensional tesseract model of success in which they try to account for all the major dimensions of project success including the green efficacy (Ika & Pinto, 2022).

Figure 5 A Four-dimensional (Tesseract) Model of Project Success

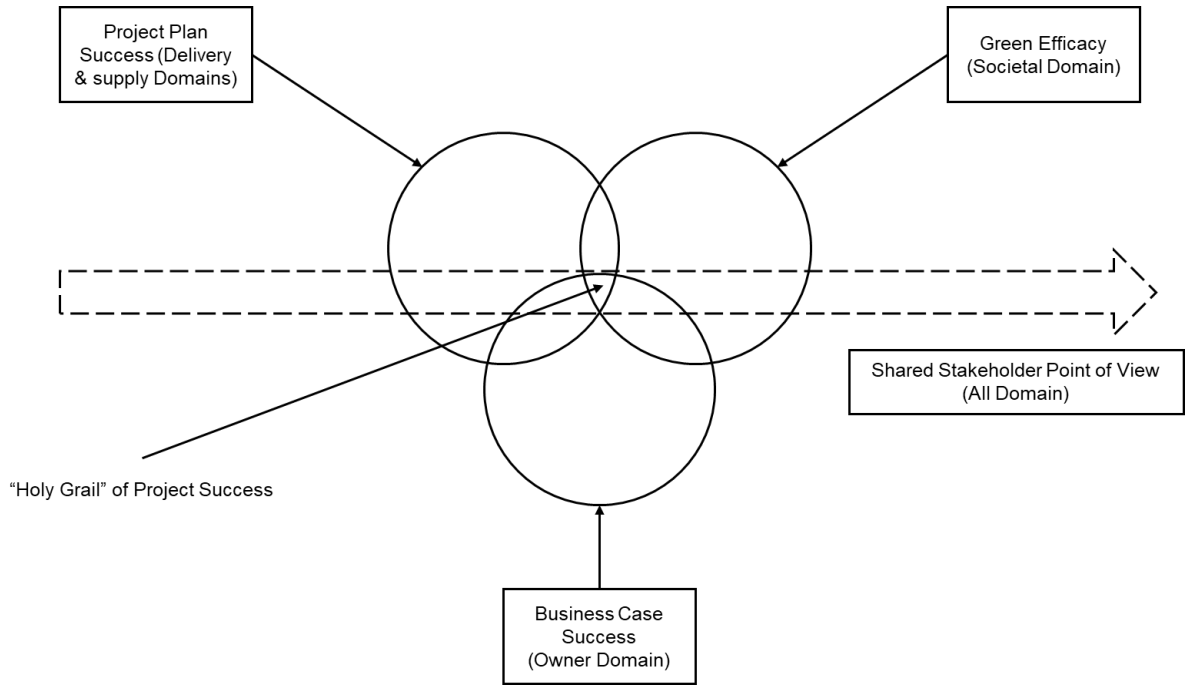

Figure 5:A Four-dimensional (Tesseract) Model of Project Success, The "re-meaning" of project success: Updating and recalibrating for a modern project management. International Journal of Project Management, 40(7), 835-848

1.3.3. Tesseract model of project success

This model was proposed in a research paper published in the international journal of project management, called "The "re-meaning" of project success: Updating and recalibrating for a modern project management" written by IKA and Pinto in 2022. The tesseract model has four dimensions. Three of the four dimensions correspond to a specific domain of project success criteria. For example project plan success corresponds to delivery and supply domain and project success will be measured in terms of time and quality. This dimension measures project success in the short-term. Business case success dimension corresponds to the owner's domain and project success will be measured in terms of cost benefit, success of product lifecycle and profit margins. This dimension measures project success in the medium-term. The third dimension is the green efficacy, which corresponds to the society's domain and project success will be measured in terms of environmental impact and sustainability. This dimension measures project success in the long-term. The fourth dimension is the stakeholder dimension which overlaps in all the above mentioned three dimensions.

The stakeholders which correspond in the other three dimensions will behave differently and thus, different domains, along with different key stakeholders, contribute differently to key dimensions of success and thus carry different weights. Table 3, borrowed from (Ika & Pinto, 2022) summarises the four dimensions of this model, their corresponding domains and timeframes.

Table 4 Matching the Tesseract model, the OECF evaluation criteria, domains of organizing and timeframes

Tesseract success dimensions	Project domains of organizing	Key stakeholders: 1) who evaluates?, 2) who is evaluated?	Timeframes	OECD criteria
Project plan success	Delivery & supply	1) Who evaluates?: Senior executives 2) Who is evaluated?: Project manager, team members, suppliers	Short-term (e.g., soon after completion)	Efficiency and effectiveness
Business case success	Owner	1) Who evaluates?: Project funder, public at large 2) Who is evaluated?: Project owner, senior executives	Medium-term (e.g., years after completion when all benefits are realized)	Relevance, coherence, and impact
Green efficacy	Society	1) Who evaluates?: Regulators, NGOs, environmental pressure groups, public at large 2) Who is evaluated?: Senior executives, project managers	Long-term (e.g., decades after the benfits are achieved)	Sustainability
Shared view of stakeholders	All domains	All stakeholders	All timeframes	Stakeholder inputs

Table 4:Matching the Tesseract model, the OECF evaluation criteria, domains of organizing and timeframes, The "re-meaning" of project success: Updating and recalibrating for a modern project management. International Journal of Project Management, 40(7), 835-848

Initial analysis of this model, considering the traditional three dimensions (Project plan success, business case success and green efficacy) reveals that there are a total of nine possible combinations to assess the success of the project over time:

1. These are projects that are universally regarded as successful - commonly referred to as "the holy grail". Such projects are completed on time, within budget, deliver benefits that meet or exceed expectations, and successfully achieve their sustainability targets. Essentially, they are successes across the board - from the project plan and business case to their green efficacy.
2. These are projects that can be classified as complete failures - not only in terms of the project plan, business case, and sustainability targets, but also due to exceeding the projected costs and/or timeline, failing to deliver benefits as anticipated, and having a negative impact on sustainability.

3. These are projects that succeed in terms of the project plan and business case, but fail in terms of green efficacy by causing harm to sustainability.
4. These are projects that fail in both the project plan and business case aspects but succeed in green efficacy, resulting in a net positive impact on sustainability.
5. These are projects that succeed in the project plan and green efficacy aspect but fail in terms of the business case.
6. These are projects that fail in the project plan aspect, but succeed in terms of the business case and green efficacy.
7. These are projects that are successful in project plan dimension but fail in business case and green efficacy dimensions.
8. These are projects that fail in project plan and green efficacy dimension but are successful in business case dimension.
9. These are projects that are failures in project plan and business case but succeed in green efficacy.

Now by adding the fourth dimension of stakeholder point of view, this model manages to give a holistic view of project success and at the same time allow the stakeholders to focus and interpret the meaning of project success in their respectives domains. If all the stakeholders in their respective domain will take care of the project success, only then the synergies can be explored and the project can reap benefits for all the stakeholders. Otherwise the problem of different interpretation project success for different stakeholders will always remain.

2. Research methodologies

This section is dedicated to the explanation of research methodologies selected for this report. The approach to defining our research methodology is inspired by the book called "Business Research Methods" by Alan Bryman and Emma Bell. The book provides a very elaborate step by step guide for carrying out business research. First

we will briefly discuss the ontological and epistemological considerations for this research and then we will explain the selected research strategy and design respectively.

The first philosophical consideration is the ontological position. There are four different types of ontological positions (realism, internal realism, relativism and nominalism) (Thorpe et al., 2015). Both the fields under study have inherent complexities in them. There are many stakeholders involved in the process hence there are many truths and the facts are dependent on the viewpoint of the observer. The approach to public policy and project management varies greatly in the context of the countries and the organisations. Thus, there is no single reality that can somehow be discovered, but there are many perspectives on the issue. Therefore, we are closer to the relativistic position of ontology for this report. The next philosophical consideration for this research is the epistemological approach. The two main epistemologies are positivism and social constructionism (Thorpe et al., 2015). We will follow the social constructionism approach because human interests are the main drivers in both the fields of public policy and project management. Our aim is to increase the general understanding of the situation in which the two fields under discussion can create synergies to achieve a common goal. In this report we will gather rich data from which we can induce the idea that public policy should be aligned with project management and vice versa to enable countries to fight the climate crisis. In social constructionism, the unit of analysis includes complexity of the whole situation and it should incorporate stakeholders' perspective. The two main topics of this report (public policy and project management) have inherent complexities due to multiple stakeholders involved and hence cannot be discussed objectively without considering the viewpoint of multiple stakeholders.

The focus of this research is to study public policy through the lens of project management. The objective will be to find commonalities between the two fields and how one field can leverage the strengths and methodologies of the other field and vice versa. The three questions chosen for the research in this report as mentioned in the

introduction section have an inductive orientation. In the first research question, the objective is to understand the structure of the UK's net zero policy in terms of its guiding principles, goals and objectives. In the second research question, the objective is to understand whether or not the public policy goals and objectives have any impact on the types of projects a particular society inclines towards following a certain public policy. In the third research question, the objective is whether any specific type of project is more successful than the other types in achieving the policy goals.

All these questions have a deductive orientation. It means that using the existing knowledge in the fields of project management and public policy, we will be more inclined to generate a theory that public policy can be better implemented by adopting the project management practices or vice versa. In the light of the above mentioned argument, our research strategy will be qualitative. The next step to decide for this research is what is the research design chosen for this report. This report is a single case study about the UK's net zero policy. We chose a single case study rather than other methodologies because we want to leverage on the progress that the UK has already achieved in this field. The UK is the world's first major economy to adopt, in 2018, a legally binding target of achieving net zero by 2050. According to 2019 statistics, the UK is the third largest emitter of GHGs in Europe after Russia and Germany and the fifth largest in the world (Armstrong, 2019). In recent years, besides climate change and COVID-19, the UK faced other challenges as well, like brexit. Having been facing all these challenges, the UK still managed to develop an elaborate net zero policy to fight climate change and all the progress report of the UK's carbon budgets up to date shows a very promising picture that all the targets have been achieved efficiently. Where the other major economies of the world struggle to meet their net zero target, the UK's progress projects that it is likely to be the world's first country to achieve net zero.

Being one of the biggest economies of the world and also a technologically advance, this case study is also chosen keeping in mind the potential that the UK has in leading innovative projects that can be adopted by other countries of the world. Another factor

in choosing the UK is the transparency and availability of data. All the documents regarding net zero policy, the past and existing situation of average temperatures and GHG emission as well as the future plans are all made public. The UK's climate change committee has maintained a detailed and up-to-date database of all the carbon budgets and the progress report.

2.1. Adopted frameworks

As mentioned earlier, we will adopt an interpretivism position for this research and we will adopt well established frameworks proposed by renowned writers and scholars in their respective field. In this section, we will explain the frameworks adopted for each of the research questions.

The first research question concerns the interpretation of the UK's net zero policy. The objective was to understand what are the components and structure of the UK's net zero policy. In his book titled "An introduction to public policy: Theories, concepts and models of public policy making" the author, Thomas A. Birkland explains that principles, goals and objectives are the pillars of any public policy (Birkland, 2011). Therefore, we will use his narrative and deconstruct the UK's net zero policy documents to understand its structure in terms of its key guiding principles, goals and objectives. Since the framework is universally very well accepted therefore, we decided to simplify the first research question by stating "What are the actual principles, goals and objectives of the UK's net zero policy?"

The second research question concerns the different types of projects and programs under the UK's net zero policy. To find answers and to have a common ground for the discussion of findings of the second research question, we have adopted the framework of Marco Terenzi's classification of net zero transition projects and programs in his research article titled "Projects as vectors of change: a transition toward net-zero asset portfolio". In this article, the author establishes that there are four types of net zero transition P&P: upgrade asset, new asset, intangible and R&D.

Using this framework, we will analyse the projects and programs which are being done in the UK to achieve its net zero policy.

The third research question is about evaluating the success of different types of net zero transition projects and programs. The success of a project is a very subjective topic. It changes its meaning for different stakeholders involved. The framework chosen for this question is proposed in the article titled "The re-meaning of project success: Updating and recalibrating for a modern project management". In this article, the authors propose a tesseract model with four dimensions of project success. As reduction in GHGs is not the only factor of success for net zero transition projects and programs in the UK, the projects also need to meet the iron triangle criteria as well as deliver value to the stakeholders, therefore, the tesseract model is the most suitable framework to evaluate project success from a multi-dimensional point of view.

2.2. Data collection and analysis

As mentioned earlier, the research strategy adopted for this report is qualitative. About the UK's net zero policy goals, objectives and targets have been collected sourcing institutional websites of the Department for Business, Energy & Industrial Strategy (BEIS), the Department for Transport (DfT) an the Climate Change Committee (CCC) in which are collected all the documents that highlight the UK Net Zero strategy. In particular the principal document utilised are:

- *Net Zero Strategy: Build Back Greener* (BEIS)
- *The Ten Point Plan for a Green Industrial Revolution* (BEIS)
- *Energy White Paper: Powering our Net Zero Future* (BEIS)
- *Heat and Buildings Strategy* (BEIS)
- *Industrial Decarbonisation Strategy* (BEIS)
- *Sustainable Warmth: Protecting Vulnerable Households* (BEIS)
- *UK Hydrogen Strategy* (BEIS)
- *The Sixth Carbon Budget* (CCC)
- *Decarbonising Transport* (DfT)

- *Jet Zero Strategy* (DfT)

Also the data regarding transport projects undertaken in the public sector are collected from some of the documents listed above, as well as from the "*Major Projects Portfolio data"* found on the official website of the DfT.

Data about projects undertaken in the private sector is collected from independent sources, from the websites of the companies which own those projects. The data collected for all the research questions were collected from credible sources and no adjustments were made to the data as there was no third party data used in this report.

3. Findings: Answer to the first research question

This section has the purpose of answering the first research question: "What are the actual Goals, Principles and Objectives of UK Net Zero policy?"

The section is structured as follows: first will be introduced the fundamental principles that guide the UK Government in setting its Net Zero Policies, then will be analysed the general goals and objectives of the strategy as a whole. Finally, a detailed analysis of the goals and objectives of the strategy in each sector will be conducted.

3.1. Goals, Principles and Objectives

First, it is essential to distinguish between the meaning of the terms *Goals*, *Principles* and *Objectives*.

While these terms are often used interchangeably, there are subtle differences between them. Here is a brief explanation of each term:

- ***Goals*** describe a desired outcome. They are often used to communicate an overall vision or purpose. Goals do not provide specific details on how to achieve them but rather describe what the end result should be. While analysing

the Net Zero Strategy of the UK Government, we will refer to Goals describing the achievable output of a determined policy or action.

- ***Principles*** are beliefs or values that form the foundations that guide decision-making and behaviour. They describe the properties of the solution and point to the direction toward goals without specifying the goals or the means to achieve them.
- ***Objectives*** are specific, measurable, and time-bound targets used to achieve a goal. Objectives are concrete and specific and provide clear guidance on what needs to be accomplished. They often break down a goal into smaller, more manageable steps.

In summary, goals provide an overarching vision or purpose, principles provide a set of guiding values, and objectives provide specific, measurable targets for achieving a goal.

Cleared these definitions, we can analyse the UK Net Zero Strategy, starting with the principles that guide it.

3.2. Key Principles

In approaching the energy transition, the UK Government is committed to following four key principles (BEIS, 2021a):

1. Work with the grain of consumer choice.

This means understanding and accommodating consumers' preferences, needs, and behaviours in developing policies and solutions.

By working with the grain of consumer choice, environmental policies can be designed to make it easier and more attractive for individuals and businesses to make sustainable choices.

To make it simple, the Government does not want anybody to be forced to scrap their current car and buy a costly electric vehicle. Instead, consumers need to have access to the right technologies at an affordable price, understand their benefits, and have confidence that they will be protected if they use them (BEIS, 2021a).

To work in that direction, the Government is committed to incentivise sustainable choices to encourage individuals and businesses to make environmentally-friendly choices; increase information availability about the environmental impacts of different products and services, allowing consumers to make informed choices; support sustainable innovation by investing in R&D in order to lower the cost of green technologies and making them affordable for the vast majority of the population.

2. Ensure the biggest polluters pay the most *for the transition through fair carbon pricing.*

The rationalities of this principle lie between the externality theory: Pollution generated by the consumption or production of individuals and companies negatively affects the life of people and the environment in general. So the responsible for the emissions should bear the cost to solve the market failure.

The *"**polluters pay principle**"* was already introduced during the 1992 Rio Declaration stated during The United Nations Conference on Environment and Development (UNCED). Now the UK government applies this principle to greenhouse gas emitters through a **carbon price**: a fee charged for every tonne of carbon dioxide equivalent (CO2e) emissions produced.

The carbon price forces emitters to reduce their footprint or internalise the cost of pollution.

Moreover, the other aspect of this key principle lies in the *"**Carbon Inequality**"* concept:

According to a report by the CDP (Carbon Disclosure Project), just 100 companies are responsible for more than 70% of the world's greenhouse gas emissions since 1988. The term *"**polluter elite**"* (Kenner, 2021) describes a small group of individuals and companies responsible for a disproportionately large share of greenhouse gas emissions.

The polluters pay principle is adopted by the UK Gov. in a way that is fair and does not disproportionately impact low-income households, placing economic justice at its heart.

3. Ensure that the most vulnerable are protected through Government support *in the form of energy bill discounts, energy efficiency upgrades, and more.*

According to the UK government's latest statistics, around 13.5 million people in the UK, 20% of the population, were estimated to be low-income households in the financial year 2020/21. This figure is based on a relative low-income measure, defined as household income below 60% of the median income (Department for Work and Pensions, 2022).

The Government plans to support vulnerable households by offering **energy bill discounts** to help them to pay their energy bills; provide support for **energy efficiency upgrades** to make homes more energy-efficient and reduce energy bills; provide **support to access low-carbon transport options**, such as electric vehicles, public transportation, and active travel (e.g. walking and cycling) (BEIS, 2021a).

4. Work with businesses *to continue delivering deep cost reductions in low-carbon tech through support for the latest state of the art kit to bring down costs for consumers and deliver benefits for businesses.*

The UK government recognises businesses' critical role in achieving the country's net zero emissions goal. To support businesses in driving the necessary changes, the Government will tailor its approach based on the size and sector of each business. Working collaboratively across different sectors and value chains will foster faster innovation, create more substantial incentives for investment in low-carbon alternatives, and ultimately lead to lower costs for these technologies to make them more affordable and accessible to consumers.

These principles stress the role of the Government as a leader in the green transition: Many businesses across the UK have said they want to tackle climate change but that they do not know where to start (BEIS, 2022b).

So the Government will be essential to design a path for approaching the green transition for SMEs and larger businesses, as well as providing funding and incentives for companies investing in low-carbon technologies.

Following these four principles, the UK Government continuously delivers meaningful policies to stay in line with the Paris Agreement.

Moreover, the principles point to the direction toward the goals that will be analysed in the next section.

3.3. Goals

The ultimate goal of the UK'Net Zero Strategy is to end the domestic contribution to man-made climate change by 2050 (BEIS, 2021a).

The UK's legal commitment to reducing its domestic contribution to climate change started in 2008 with the passing of the Climate Change Act. The act established a legally binding target to reduce the country's greenhouse gas emissions by at least 80% below 1990 levels by 2050.

Since 1990, the UK has delivered straightforward results compared to the rest of the G7 countries by reducing its GHG emission by 44% while growing its GDP by 78%.

Figure 6 UK vs Rest of G7 GDP and GHG Emissions

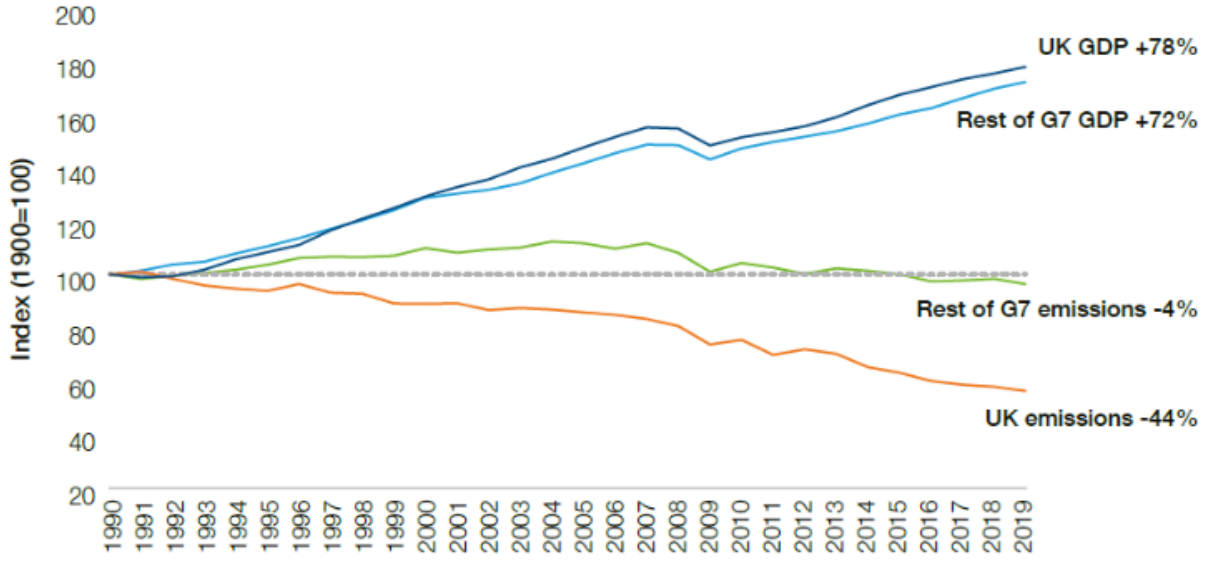

Figure 6: UK vs Rest of G7 GDP and GHG Emissions, Net Zero Strategy: Build Back Greener. Department for Business, Energy & Industrial Strategy (2021)

This figure is perfect for understanding the Goals of the UK gov: The green transition is not something that will entail just costs, differently it is a source of opportunities for the UK economy. While the world addresses the challenge of climate change, many new opportunities will arise for UK companies both in domestic and international markets: key net zero aligned sectors could contribute up to £60 billion of gross value added (GVA) annually by 2050 (BEIS, 2019a).

*"An immediate action to **reduce emissions** brings enormous economic opportunities to revitalise our economy and deliver on our priority **to level up the country**."* (BEIS, 2021a)

So, it is possible to summarise the general **Goals** of the UK'Net Zero Strategy as follows:

Goal n.1: End the domestic contribution to man-made climate change by 2050

Goal n.2: Level up the country

Goals n.2 can further be broken into:

- **Create new jobs** for UK citizens
- **Lead** the world in **green technologies**
- **Drive private investment** to maximise the impact of policies

The transition to a low-carbon economy will require a significant expansion and transformation in various sectors, ranging from renewable energy and energy-efficient buildings to sustainable transport and green finance. Such a transformation will create many new green jobs for UK citizens all across the country.

Moreover, the exact technology and energy mix in 2050 cannot be known now. Instead, it will be influenced by various factors.

For example, renewable energy solutions that utilise wind and solar power will be subject to resource availability and energy demand. Differently, in the case of nuclear power, it will play a critical role in public opinion and social acceptance.

Depending on the pace of innovation, the cost of deploying different technologies will be a crucial consideration in determining the most cost-effective and efficient energy mix.

Lastly, some sectors such as agriculture or aviation will be more difficult to decarbonise. To compensate for the residual emissions will be needed Greenhouse gas removal (GGR) solutions like Direct Air Capture (DAC).

In that scenario, the UK plans to position itself as a leader in exporting green technologies and solutions among the advanced countries.

Figure 7 *UK's world ranking in key renewable energy technologies*

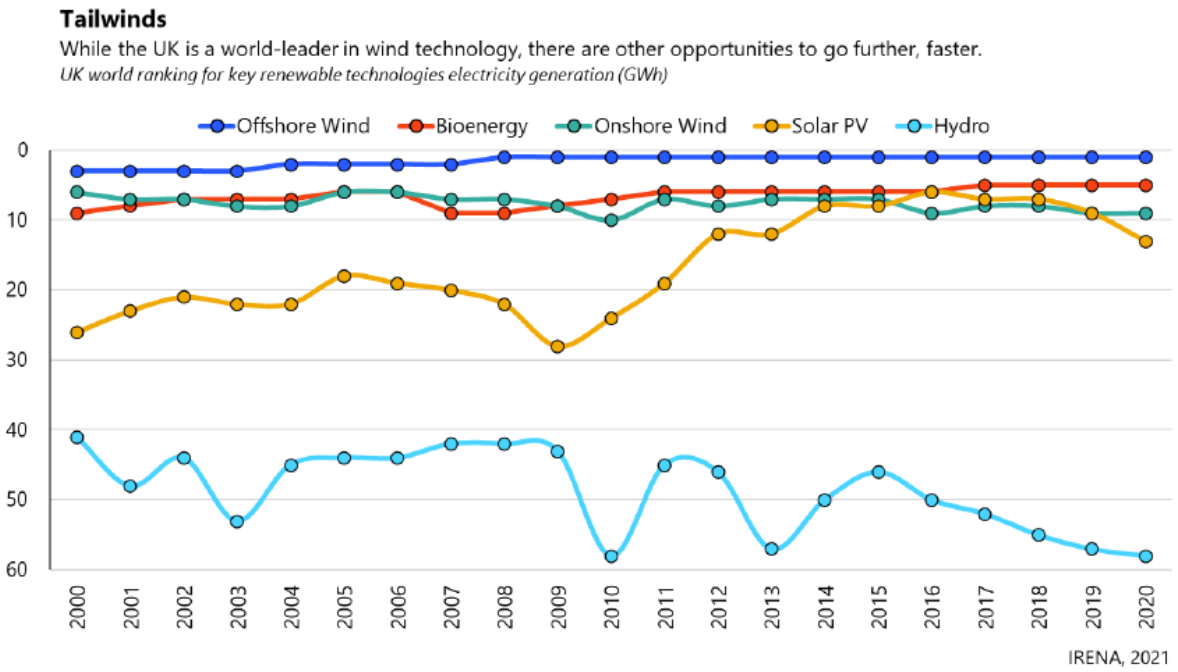

Figure 7: UK's world ranking in key renewable energy technologies: Independent Review of Net Zero: Mission Zero (2023)

The UK will require significant investment to maintain its leadership in sectors like Offshore wind and, at the same time, strengthen its positioning in other technology fields, creating many opportunities in green finance.

The City of London is long established as a leader in green finance. The city is home to many initiatives and financial institutions committed to climate change challenges. Examples are:

- The Green Finance Institute (GFI): the main forum of collaboration between the public and private sectors to deliver a coordinated Green Finance Strategy.

- Green Finance Taskforce: an independent initiative to accelerate the growth of green finance and the UK's low-carbon economy (Gov.UK, 2019).
- Green Investment bank: Established in 2012 and later acquired by the Macquarie Group, it has the mission of "*identifying opportunities and actions for mobilising private finance in the transition to a low-carbon economy in line with the goals of the Paris Agreement.*" (Macquarie)

Private investment is expected to play a significant role in funding the development and expansion of low-carbon sectors and commercialising emerging technologies. Nonetheless, early intervention, investment, and signaling to accelerate the shift to a net-zero economy are primarily expected to come from public finance and institutions, while private investment will come later when the necessary conditions have been established.

Figure 8 Breakdown of R&D funding by source as a share of GDP

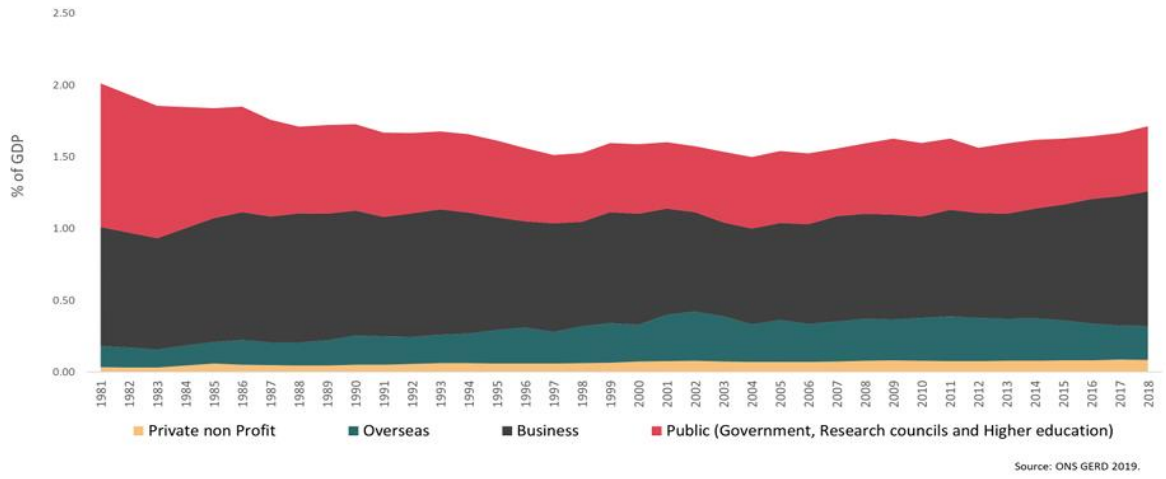

Figure 8: Breakdown of R&D funding by source as a share of GDP, UK Research & Development Roadmap (2020)

3.4. Objectives

Goals analysed since now are the long-term expression of the UK Net Zero Strategy, and the only time boundaries to which they are tied is the 2050 target stated in the Paris Agreement.

Differently, objectives break down these goals into smaller, short-term oriented steps. Before going through a sectoral analysis in which goals and objectives will be analysed for each sector target of the UK Net Zero Policies, it is essential to introduce the concept of Carbon Budget, the general objective to which the UK binds its commitment to reducing GHG emissions.

A **Carbon Budget** is the maximum amount of cumulative net global anthropogenic carbon dioxide (CO2) emissions that would result in limiting global warming to a given level with a given probability (IPCC, 2018b).

The UK has set out five-yearly Carbon Budgets (CBs), which legally bind the government to limit the amount of greenhouse gas emissions the country can produce in a given period.

In particular, the Committee on Climate Change (CCC), an independent advisory body established by the UK government to provide advice on climate change policy, is responsible for setting the CBs. The first five were set in the Climate Change Act 2008, establishing objectives until 2032.

The first (2008-2012) and second (2013-2017) CBs, have been met, respectively, with a GHG reduction of 24% (CCC, 2014) and 40% (BEIS, 2019b) compared to 1990 levels.

Positive results are also expected for the third (2018-2022), the fourth (2023-2027) and the fifth (2028-2032) CBs.

The Sixth Carbon Budget is the latest legally binding target for reducing greenhouse gas emissions in the UK. It covers the period from 2033 to 2037 and sets a target for the UK to reduce emissions by at least 78% below 1990 levels.

Here follows a recap table of the CBs target that represents the actual general objectives of the UK Net Zero Strategy:

Table 5 Recap table of the CBs target

	Carbon Budget 3	**Carbon Budget 4**	**Carbon Budget 5**	**Carbon Budget 6**
Years	2018-2022	2023-2027	2028-2032	2033-2037
MtCO2e limit (annual equivalent)	2,544 (509)	1,950 (390)	1,725 (345)	965 (193)
Base year (1990) emissions	859.6	859.6	859.6	883.3*
Percentage Reduction on 1990 (implied for carbon budgets)	41%	55%	60%	78%

Table 5: Recap table of the CBs target, Data retrieved from (BEIS, 2021a)

**The base year value for CB6 is higher taking into consideration 23.7 MtCO2e for International Aviation and Shipping (IAS)*

The 78% reduction target for 2037 is an interim target for reaching net zero by 2050. It represents a significant reduction in emissions that will require significant effort and investment from all sectors of the UK economy.

In the following sections will be conducted a sector by sector analysis to understand the role of each sector in the transition as well as its specific goals and objectives that the UK Government set to stay in line with the CBs.

3.5. Sector by Sector Analysis

The sector by sector analysis is the result of the collection of information from many different Government documents. The classification of sectors will be as indicated in *Net Zero Strategy: Build Back Greener* (BEIS, 2021a); then a substantial list of goals and objectives will be constructed by cross-referencing information taken from documents outlining the UK strategy in general such as *Energy White Paper: Powering our Net Zero*

Future (BEIS, 2020b) and *The Ten Point Plan for a Green Industrial Revolution* (HM Government, 2020), and more specific sector documents such as *Transport Decarbonization Plan* (DfT, 2021) or *Industrial Decarbonisation Strategy* (BEIS, 2021e).

To meet the target objective of the CBs and achieve the aforementioned general goals, the UK's Government has divided its efforts in policymaking and target-setting into seven sectors:

1. Power
2. Fuel Supply & Hydrogen
3. Industry
4. Heat and Buildings
5. Transport
6. Natural Resources, waste and fluorinated gases
7. Greenhouse Gas Removals

Each sector has its own unique challenges and opportunities, and by focusing on each sector individually, the government can create specific policies and targets that will help to reduce greenhouse gas emissions and meet the overall goals of the CBs.

Before analysing each sector in detail, a comprehensive view respectively of the as-is situation and the expected pathway is presented:

Figure 9 % Emission by Sector

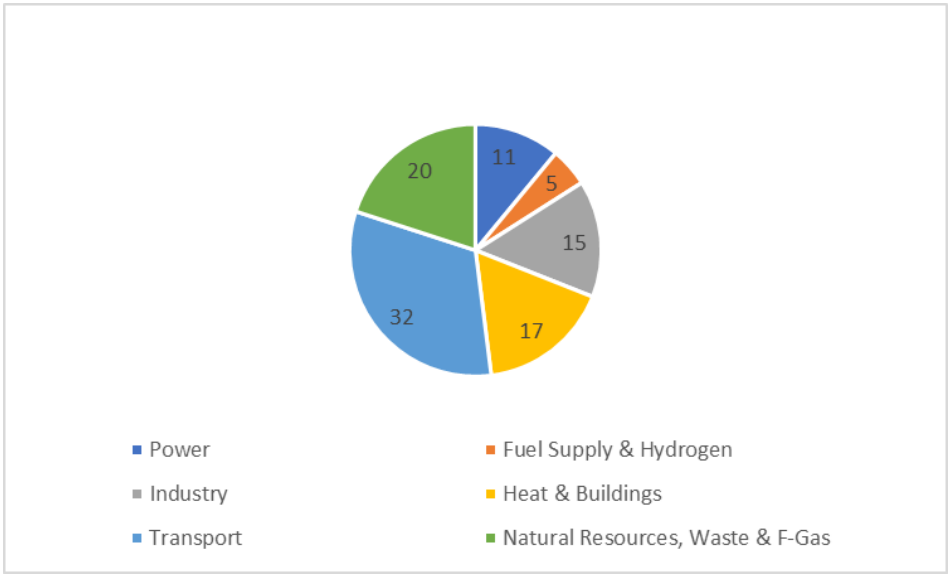

Figure 9: % Emission by Sector, Data referring to 2019, retrieved from: (BEIS, 2021a)

Figure 10 Indicative delivery pathway to 2037 by sector

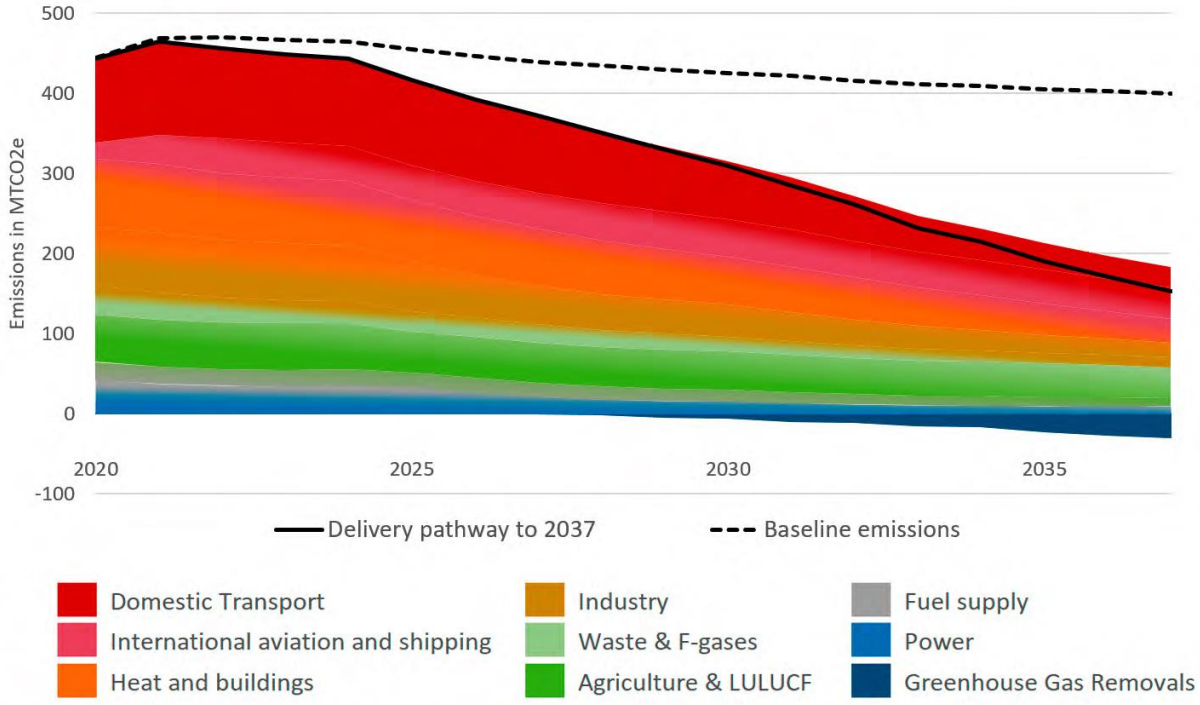

Figure 10: Indicative delivery pathway to 2037 by sector, BEIS Analysis (2021)

In the following sections, for each of the seven sectors, an overview of the as-is situation will be provided. Then will be presented the targeted emission reduction pathway and the emission cap stated in the CBs. Finally, a list with the specific goals (if present) and objectives setted.

3.5.1. Power

The power sector includes the generation, transmission, and distribution of electricity. In 2019, the power sector accounted for 11% of the UK's total GHG emission (BEIS, 2021f).

While decarbonising the sector, a reliable and affordable power supply must always be guaranteed: the decarbonisation of other sectors like transport and industry will increasingly rely on electricity generated from renewable sources.

By 2050, even if it is still unclear the exact share of renewable resources on which the economy will rely, an increase in the energy demand is expected to range from 40% to 60%. Satisfying such an increment in demand while providing clean and affordable energy will be an ambitious challenge for the power sector.

Figure 11 Electricity mix today & illustrative 2050 mixes

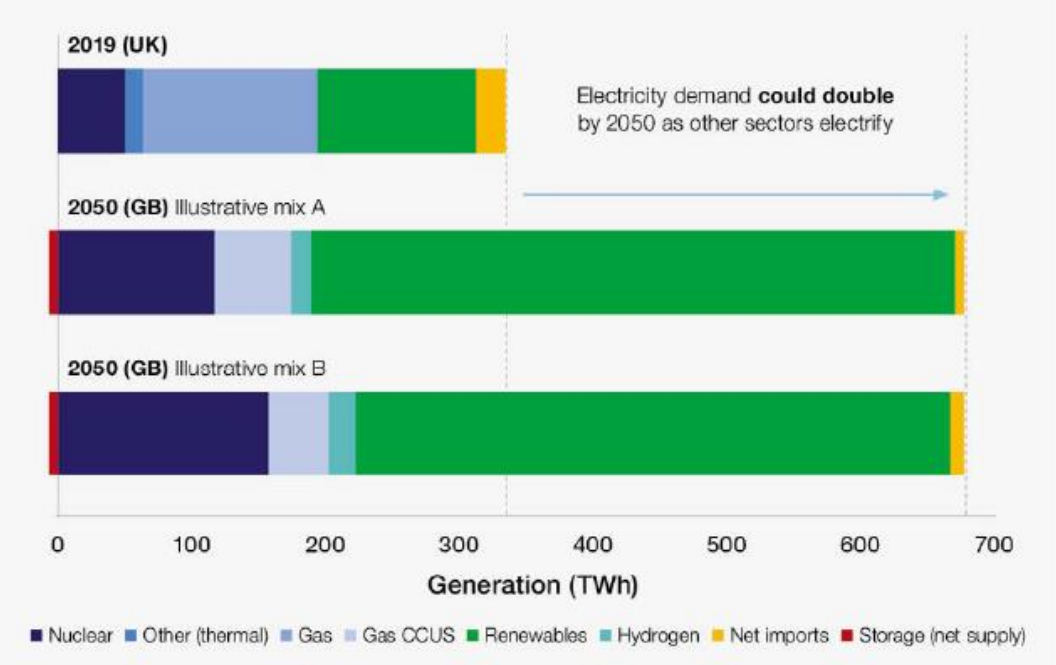

Figure 11: Electricity mix today & illustrative 2050 mixes, Energy White Paper: Powering Our Net Zero Future (2020)

The UK aims to reduce the power sector's contribution by up to 71-76% by 2030 and 80-85% by 2035 compared to 1990 (BEIS, 2021a).

According to the 6th carbon budget, the power sector's emissions should be reduced within the range of 8.2 to 11.1 MtCO2e by 2037 compared to 57.9 MtCO2e in 2019 (CCC, 2020b). The following graph shows the yearly targeted emissions for the power sector; the details and year by year emission targets can be found in **Table 8**:

Figure 12 Indicative power emissions pathway to 2037

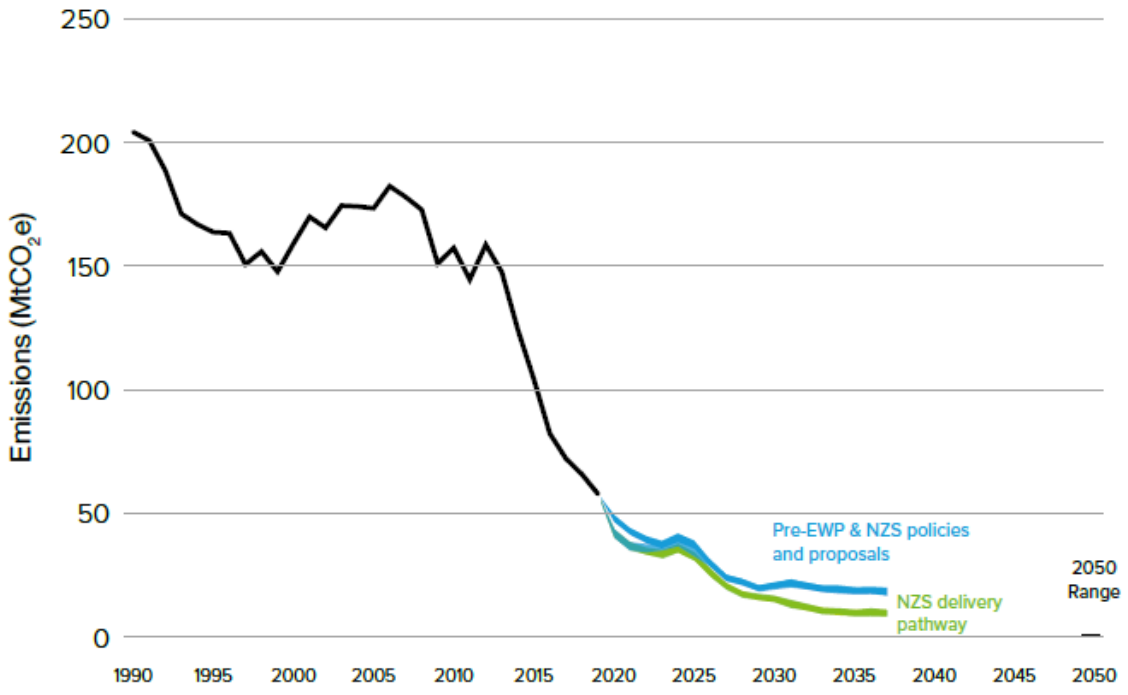

Figure 12: Indicative power emissions pathway to 2037, Net Zero Strategy: Build Back Greener (2021)

The above mentioned targets are not made in a vacuum. The UK net zero policy documents highlight some specific objectives to ensure these targets are achievable. Below are presented the main goals for the power sector. The related objectives are classified by the type of energy source*, for each will be provided a brief explanation and a list of the targets.

**Hydrogen will be analysed in detail in the next section*

The **Goal** is:

To deliver energy reliably, while ensuring fair and affordable costs and accelerating our transition to clean energy. (BEIS, 2020b). With a particular commitment in ***Advancing Offshore Wind*** and ***Delivering New and Advanced Nuclear Power*** (HM Government, 2020).

1. Renewables

Even if the UK plans to leverage on renewables, which for geographical and technological reasons is more advantaged compared to other countries like wind, solar and bioenergy, a specific target has yet to be set regarding the last two.

The **objectives** are:

- To generate 75% of the UK's electricity from renewable sources by 2030 (BEIS, 2020b)
- To quadruple the UK's offshore wind capacity to 40 GW by 2030 (BEIS, 2021a)
- Generate at least 1GW from floating offshore wind by 2030 (BEIS, 2021a)
- To phase out unabated coal-fired power generation by 2024 (BEIS, 2020b)

2. Nuclear

Nuclear power remains an important source of reliable, clean electricity, currently supplying around 16% of the UK's energy needs (BEIS, 2020b).

The **objectives** are:

- Bring at least one large scale nuclear project to the point of Final Investment Decision (FID) by the end of this Parliament (BEIS, 2021a)
- Reduce the cost of nuclear new build projects by 30 % by 2030 (BEIS, 2020b)
- Develop a Small Modular Reactor (SMR) by 2030 (BEIS, 2021a)
- Design and build an Advanced Modular Reactor (AMR) demonstrator by 2030 (BEIS, 2021a)
- Build a commercially viable fusion power plant by 2040 (BEIS, 2020b)

3. Power CCUS

The gas-fired generation with CCUS can provide flexible, low-carbon capacity to complement high levels of renewables (BEIS, 2020b)

The **objectives** are:

- At least one operational power CCUS plant by 2030 (BEIS, 2021a)

3.5.2. Fuel Supply & Hydrogen

The fuel supply and hydrogen sector refer to the production, distribution, and use of different fuels and hydrogen in the UK. In 2019, this sector contributed 5% of the total greenhouse gas emissions (BEIS, 2019a).

While reaching the 2050 goals, several sectors will necessitate low-carbon energy. In scenarios where electrification is not a feasible or economical option, the availability of cleaner fuel and solutions will be crucial to reaching net zero emissions.

In that scenario, hydrogen is one of the new low-carbon solutions the UK will increasingly rely on. Today, around 95% of global hydrogen production is fossil-fuel based. A complete switch to clean hydrogen is required, together with a significant increase in production capacity (BEIS, 2020b).

Figure 13 Illustartive hydrogen demand in 2030 and 2035

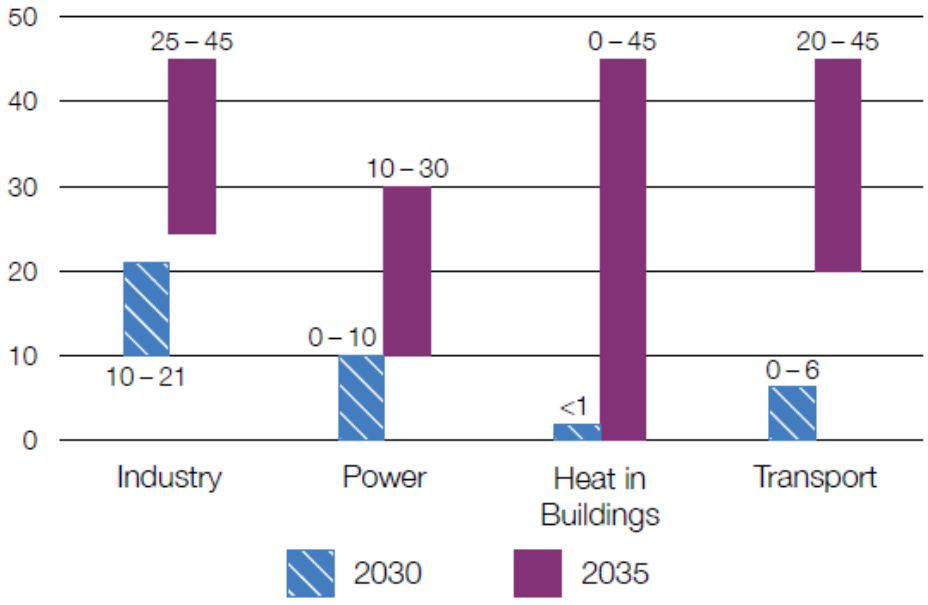

Figure 13: Illustartive hydrogen demand in 2030 and 2035, UK Hydrogen Strategy

According to the UK's net zero policy, the aim is to reduce the contribution of the fuel supply and hydrogen sector by up to 53-60% by 2035 compared to 1990 (BEIS, 2021a).

In particular, according to the 6th carbon budget, the emissions of the fuel supply and hydrogen sector should be reduced within the range of 8.7 to 10.3 MtCO2e by 2037 compared to 25.8 MtCO2e in 2019 (CCC, 2020b). The following graph shows the yearly targeted emissions for this sector. The details and year by year emission targets can be found in **Table 8**:

Figure 14 Indicative hydrogen emissions pathway to 2037

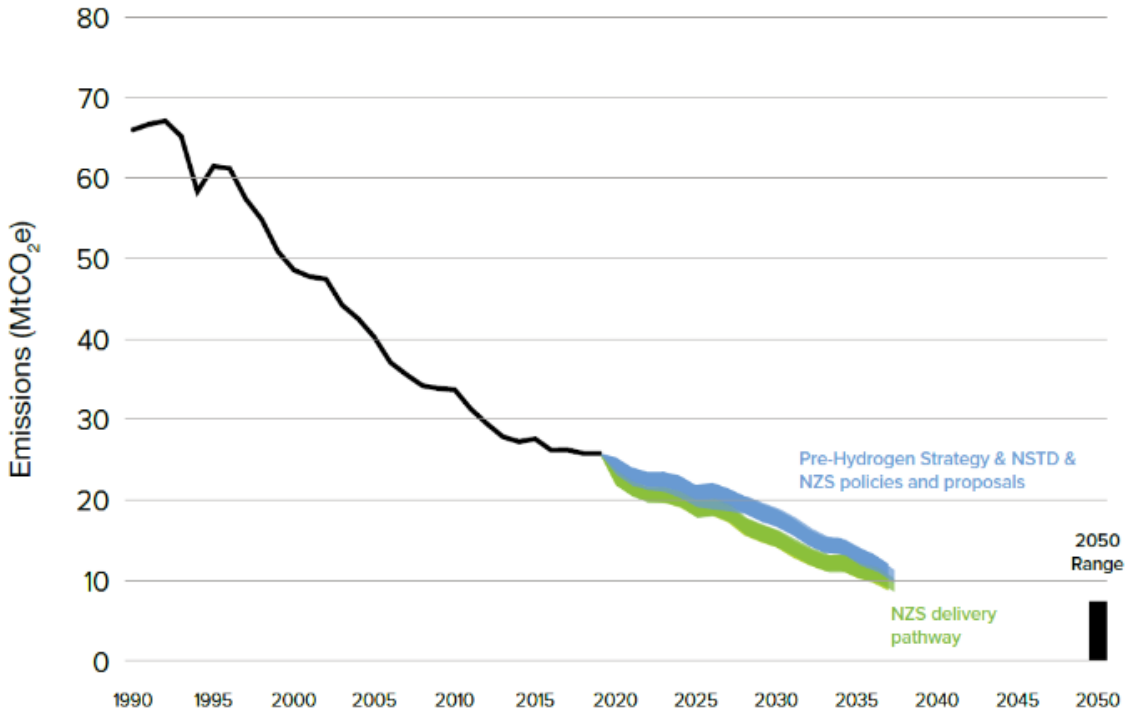

Figure 14: Indicative hydrogen emissions pathway to 2037, Net Zero Strategy: Build Back Greener (2021)

The UK net zero policy documents highlight some goals and objectives to ensure these targets are achievable. Below are presented the main goals, then the related objectives are classified by fuel type, for each will be provided a brief explanation and a list of the targets.

The **Goals** are: **To *reduce the dependency on fossil fuels*** (BEIS, 2021a) and ***Driving the Growth of Low Carbon Hydrogen*** (HM Government, 2020)

1. Oil and Gas

The UK still strongly depends on oil and gas to power its economy. In 2021, oil and gas accounted for 76% of UK energy demand (BEIS, 2022a).

To reduce the related emissions, the targeted objectives are:

Reduce 10%; 25%; 50%; 90; and 100% of emissions generated from oil and gas production, respectively, by 2025; 2027; 2030; 2040; and 2050 compared with the 2018 baseline (BEIS, 2022a).

- Replace 15,500km of iron mains to reduce 17% of gas leakage by 2027 (BEIS, 2021a)

2. Low-carbon fuels

Low-carbon fuels will play an important role, especially in the early stages of the decarbonisation of the transport sector, while electrification will gain more importance in later phases.

- Increase the RTFO* main obligation from 9.6% in 2021 to 14.6% in 2032 (DfT, 2021)
- Deliver 10% Sustainable Aviation Fuel (SAF) by 2030 (DfT, 2022)
- At least 5 commercial scale UK SAF plants under construction by 2025 (DfT, 2022)

**Renewable Transport Fuel Obligation: a policy in the UK that requires fuel suppliers to ensure that a certain percentage of the fuels they supply come from renewable sources*

3. Hydrogen

The opportunities for reducing CO2 emissions coming from the utilisation of hydrogen are many, but Low carbon hydrogen is not yet competitive with traditional fuels from a cost point of view (BEIS, 2021d).

In that direction, the UK government has created a detailed strategy (BEIS, 2021d) supporting the development of hydrogen technologies and infrastructure as soon as possible to satisfy the increasing demand for the resource.

The objectives towards meeting this goal are:

- Produce 5 GW of low-carbon hydrogen by 2030 (BEIS, 2021d)

- Pilot first hydrogen heating trial at a village scale by 2025 (HM Government, 2020b).
- Pilot the first hydrogen-powered town by 2030 (BEIS, 2021d)

3.5.3. Industry

The industry, also known as the industrial sector, includes a wide range of activities involved in the production of goods and services, such as manufacturing, construction, mining, and utilities. In 2019, this sector contributed 15% of the total greenhouse gas emissions (BEIS, 2021a).

The localisation of this sector's emission is not heterogeneously widespread, and its understanding is essential for analysing the UK's Industrial Decarbonization Strategy. Around half of the emissions related to industrial activities are located in specific clusters – geographical areas with large industry concentrations.

Figure x shows the six most significant clusters by level of carbon dioxide emissions.

Figure 15 Map of major industry cluster emission 2018

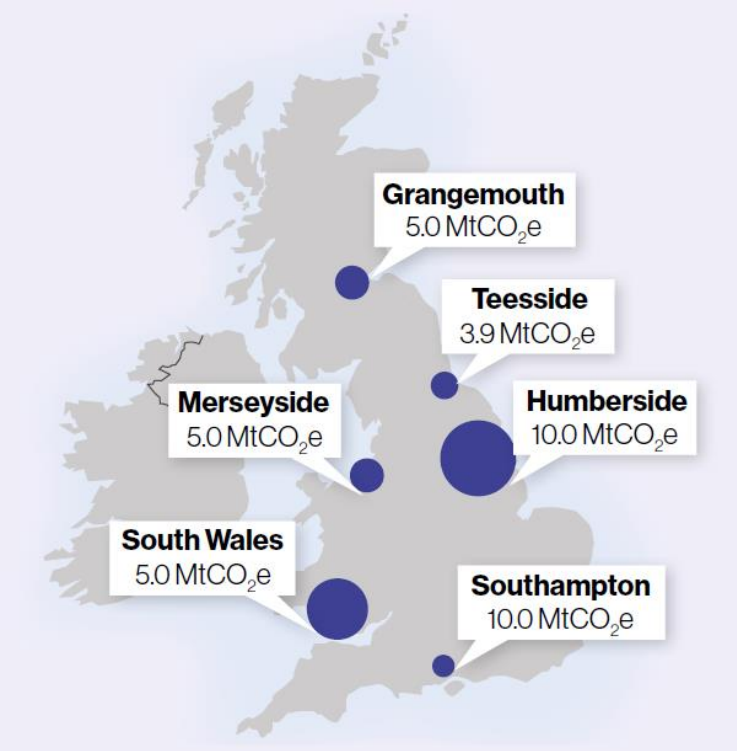

Figure 15: Map of major industry cluster emission 2018: Industrial Decarbonisation Strategy (2021)

Industrial clusters are locations where related industries are located nearby. By being located together, these clusters can enjoy several benefits, such as access to shared decarbonisation infrastructure, which can help reduce the unit cost for each tonne of carbon abated. Additionally, being in a cluster provides opportunities for resource and energy efficiency, learning and innovation sharing.

Carbon Capture, Use and Storage (CCUS), a technology that captures and transports CO2 from industrial and power plants and stores it away from the atmosphere, will be critical for decarbonising industrial clusters.

In that direction, the UK Government has established a ***Cluster Sequencing Process:***

A process to establish across the UK new ***Super Places***, clusters that have been identified based on their potential for large-scale emissions reductions, as well as the presence of key infrastructure, businesses, and institutions that can support the transition to a low-carbon economy. Once identified a Cluster (A transport and storage (T&S) network for carbon dioxide plus at least two associated CO2 capture projects), the UK Government, thanks to a multi-phase approach, provides tailored support to accelerate the development of the Super Place and create a virtuous cycle of investment, innovation, and job creation.

Going back to the big picture, the UK's net zero policy aim is to reduce the industry sector's contribution by up to 63-76% by 2035 compared to 1990 ((BEIS, 2021a).

According to the 6th carbon budget, the emissions from the industry should be reduced within the range of 13.6 to 24.1 MtCO2e by 2037 compared to 78.2 MtCO2e in 2019 (CCC, 2020b). The following graph shows the yearly targeted emissions for this sector. The details and year by year emission targets can be found in **Table 8**:

Figure 16 Indicative industry emissions pathway to 2037

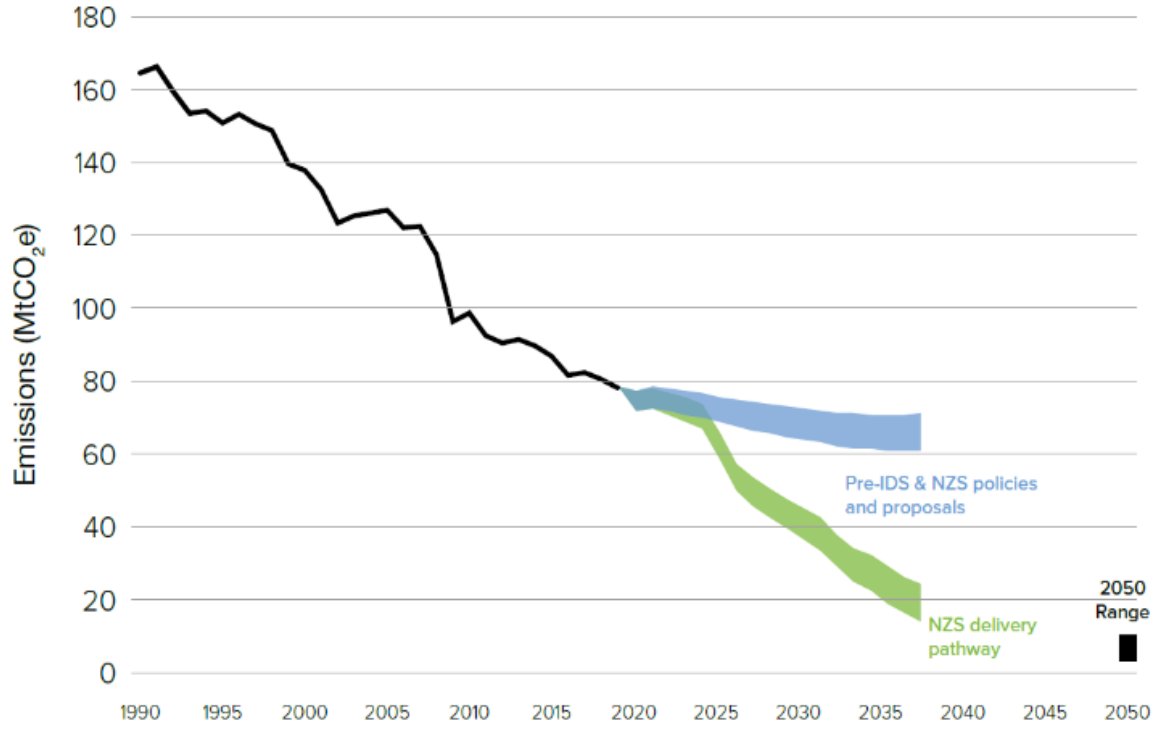

Figure 16: Indicative industry emissions pathway to 2037, Net Zero Strategy: Build Back Greener (2021)

To make sure that these targets are achievable, the UK net zero policy documents highlight two main goals and the related objectives:

1. Create a sustainable future for UK manufacturing industry through improved energy efficiency and the adoption of clean energy technologies (BEIS, 2020b)

- Increase the share of low-carbon fuels to 50% of total industrial energy consumption by 2035 (BEIS, 2021e)
- 20 TWh/year of fossil fuel use replaced with low-carbon alternatives in 2030 (BEISe, 2021)

2. Establish the UK as a world leader in the deployment of CCUS (BEIS, 2020b)

- First two clusters connected to CCUS infrastructure by 2025 (BEIS, 2021e)
- Four low-carbon clusters by 2030 (BEIS, 2021e)
- First net zero cluster by 2040 (BEIS, 2021e)

- Around 3 MtCO2 of industry emissions captured each year by 2030 (BEIS, 2021e)

3.5.4. Heat and Buildings

The heat and building sector refers to the industries and activities related to the use and management of energy in buildings, including residential, commercial, and industrial buildings. In 2019, this sector contributed 17% of the total greenhouse gas emissions (BEIS, 2021f), making it the second largest source of emission after the transport sector. The vast majority of emissions of this sector are generated by residential housing heating.

The energy efficiency of existing buildings directly influences energy demand, and about 66% of residential houses are at Energy Performance Certificate D or worse (BEIS, 2020e).

Figure 16 Average EPC band

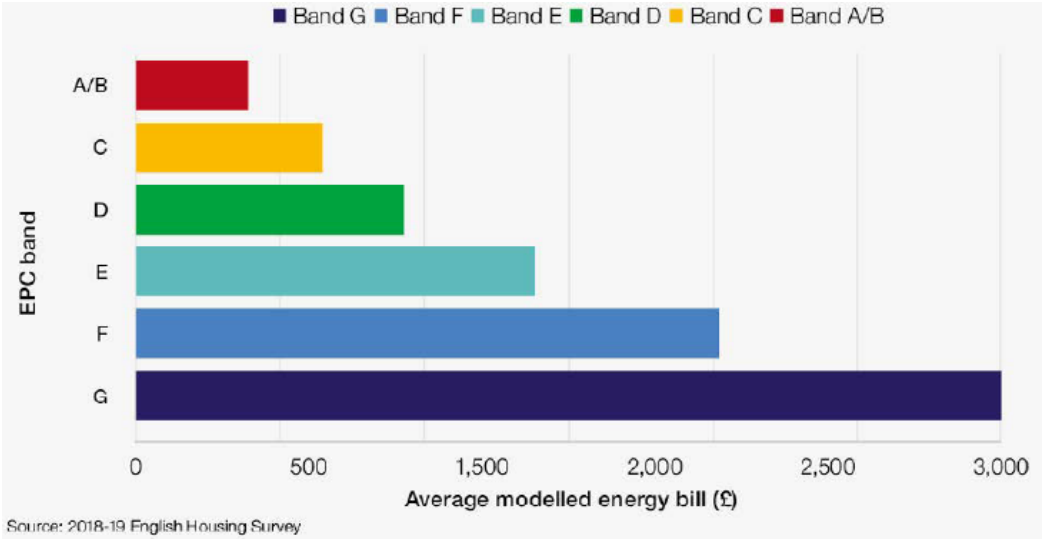

Figure 17: Average EPC band, Energy White Paper: Powering our Net Zero Future (2020)

Improving the energy efficiency of existing buildings will bring benefits in terms of energy demand reduction as well as economic benefits: it is estimated that upgrading

all UK homes to EPC C could provide annual energy bill savings of £7.5 billion (BEIS, 2020e).

Other benefits in terms of emission reduction will come from the increased adoption of heat pumps despite gas boilers. Today, gas boilers still represent the most convenient choice. So the Government's effort will be concentrated on reducing the heat pump cost enough to be the most convenient choice for households.

Finally, also the adoption of low-carbon sources of heat like Biomethane and hydrogen will have its role in reducing Heat & Buildings sector emissions.

According to the UK's net zero policy, the aim is to reduce the contribution of the heat and building sector by up to 47-62% by 2035 compared to 1990 (BEIS, 2021a).

According to the 6th carbon budget, the emissions of the heat and building sector should be reduced within the range of 24.9 to 38.8 MtCO2e by 2037 compared to 88.5 MtCO2e in 2019 (CCC, 2020b). The following graph shows the yearly targeted emissions for the heat and building sector. The details and year by year emission targets can be found in **Table 8**:

Figure 18 Indicative Heat & Buildings emissions pathway to 2037

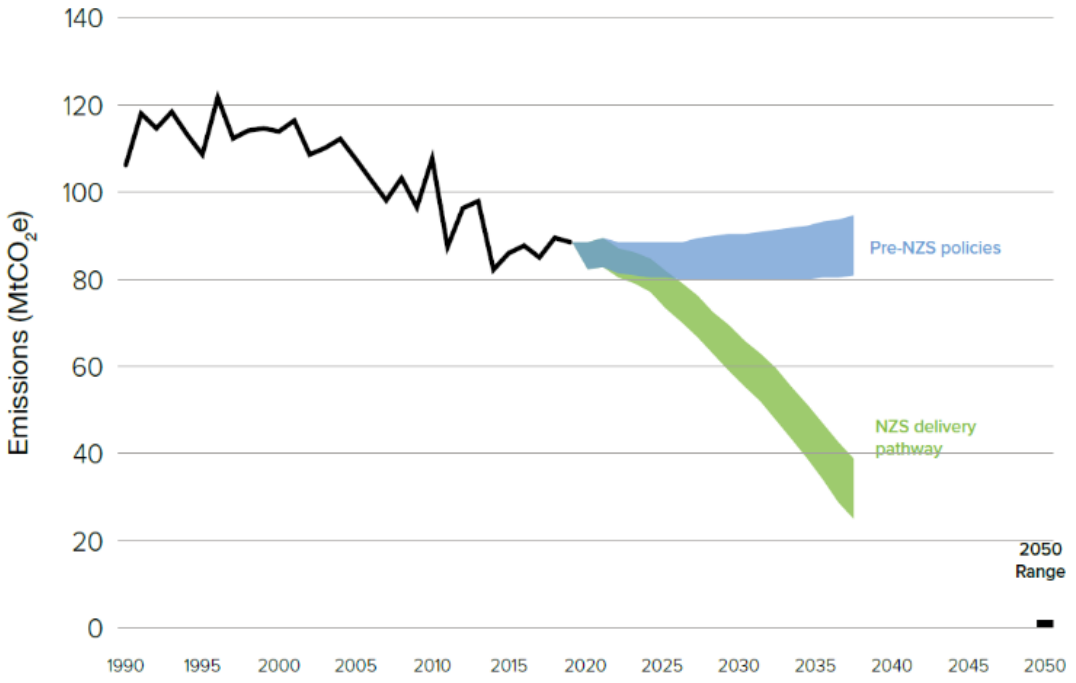

Figure 18: Indicative Heat & Buildings emissions pathway to 2037, Net Zero Strategy: Build Back Greener (2021)

UK policy documents highlight how to achieve these targets. In particular, the main **Goal** is:

Decarbonising the way we heat and power our buildings (BEIS, 2021a) *by* ***making our buildings more energy efficient and moving away from fossil fuel boilers*** (HM Government, 2020b).

The main **objectives** to achieve the goal are:

- To install 600,000 heat pumps per year by 2028 and 1.7 million per year by 2035(BEIS, 2021b)
- Reducing heat pumps costs by at least 25-50% by 2025 and to parity with gas boilers by 2030 (BEIS, 2021a)
- 2.8 million privately rented homes to meet a minimum energy performance standard of EPC Band C by 2028 (BEIS, 2020e)
- Cumulative number of homes with low-carbon heating of 6M by 2030 and 13M by 2035 (BEIS, 2021a)
- To ensure that all new homes are zero-carbon-ready by 2025 (BEIS, 2021b)
- The first trial of a village totally heated with hydrogen by 2025 (BEIS, 2021b)
- Convert around 4 million homes to using low-carbon hydrogen by 2035 (BEIS, 2021a)
- Deliver 2.8TWh of renewable biomethane heat per year in 2030/31 (BEIS, 2021a)
- Reduce emissions from public sector buildings by 75% by 2037 (BEIS, 2021a)

3.5.5. Transport

The transport sector refers to all activities related to the movement of people and goods, including using vehicles, planes, and ships. According to policy documents like "Net Zero Strategy: Build Back Greener" and the "Carbon Budgets", this sector is further classified into "Domestic Transport" and "International Aviation and Shipping (IAS)".

In 2019, the transport sector collectively contributed 32% of the total greenhouse gas emissions (BEIS, 2021a). Going more into detail, domestic transport alone accounts for

27% of the UK's total GHG emissions (BEIS, 2021f), the country's highest single source of CO2 emissions.

The figure below shows the taxonomy of the domestic transport sector by emission source.

Figure 19 UK domestic transport emissions 2019

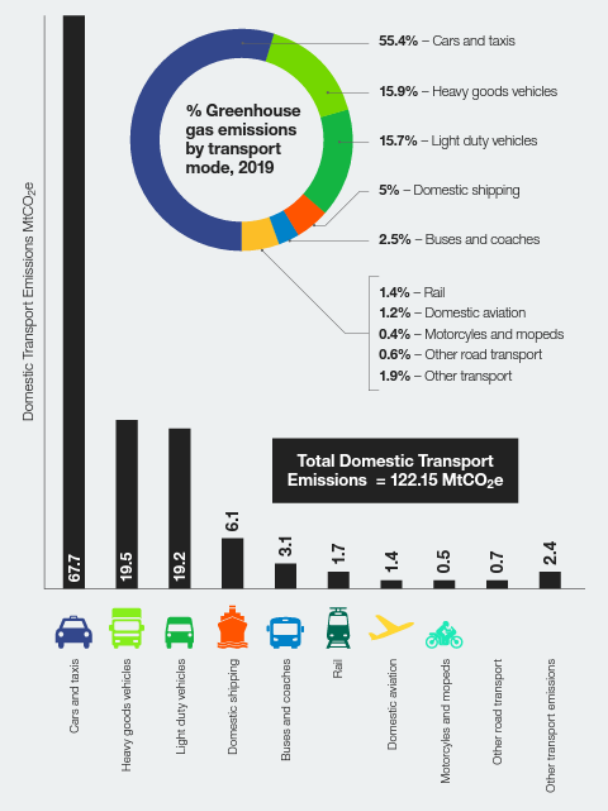

Figure 19: UK domestic transport emissions 2019, Department for Transport, 2021

As the figure shows, road transport, and in particular passenger cars, represent the major source of emissions, responsible for around 90% of the total. In that context the UK positions the transition to Electric Vehicles (EVs) as crucial to decarbonising the transport sector.

Moreover, as stated in the Transport Decarbonization Plan (TDP), achieving Net Zero in the sector brings benefits not only for the environment:

Will improve citizens' health by removing a source of pollution and daytime noise levels above the recommended limits; Will provide a more efficient and safe way for

everybody's daily movement; Will improve reliability and connectivity of public transports.

Given that context, it is possible to better understand the ambitious goals and objectives of the sector.

According to the UK's net zero policy, the general goal is to reduce the transport sector's contribution by up to 47-59% by 2035 compared to 1990 (BEIS, 2021a).

According to the 6th carbon budget, the emissions of the domestic transport sector should be reduced within the range of 19.7 to 34.0 MtCO2e by 2037 compared to 122.3 MtCO2e in 2019 (CCC, 2020b). The following graph shows the yearly targeted emissions for domestic transport; the details and year by year emission targets can be found in **Table 8**:

Figure 20 Indicative domestic transport emissions pathway to 2037

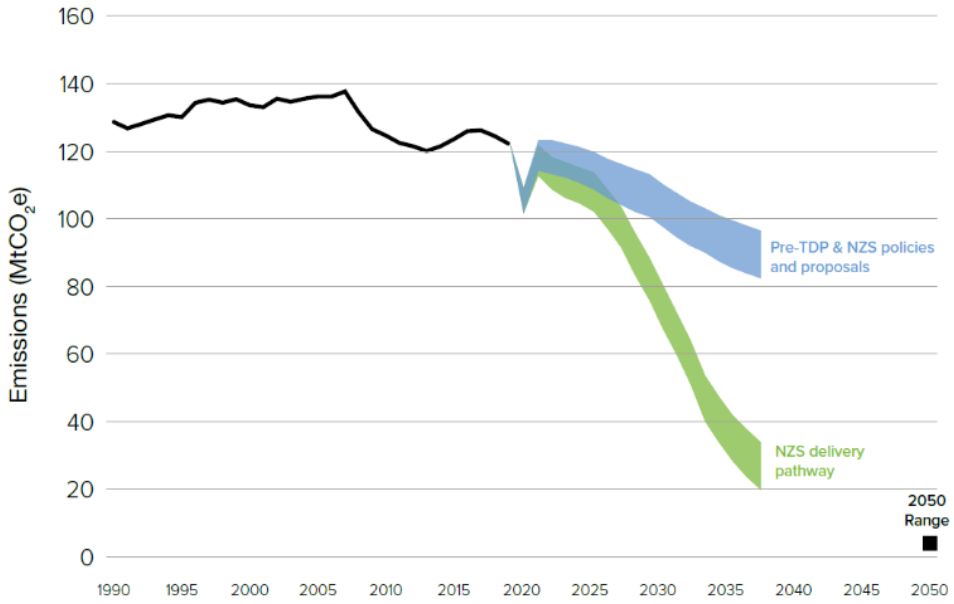

Figure 20: Indicative domestic transport emissions pathway to 2037, Net Zero Strategy: Build Back Greener (2021)

For what concern IAS, the sector emissions should be reduced within the range of 36.4 to 44.2 MtCO2e by 2037 compared to 44.5 MtCO2e in 2019 (CCC, 2020b). The following

graph shows the yearly targeted emissions for the IAS sector; the details and year by year emission targets can be found in **Table 8**:

Figure 21 Indicative IAS emissions pathway to 2037

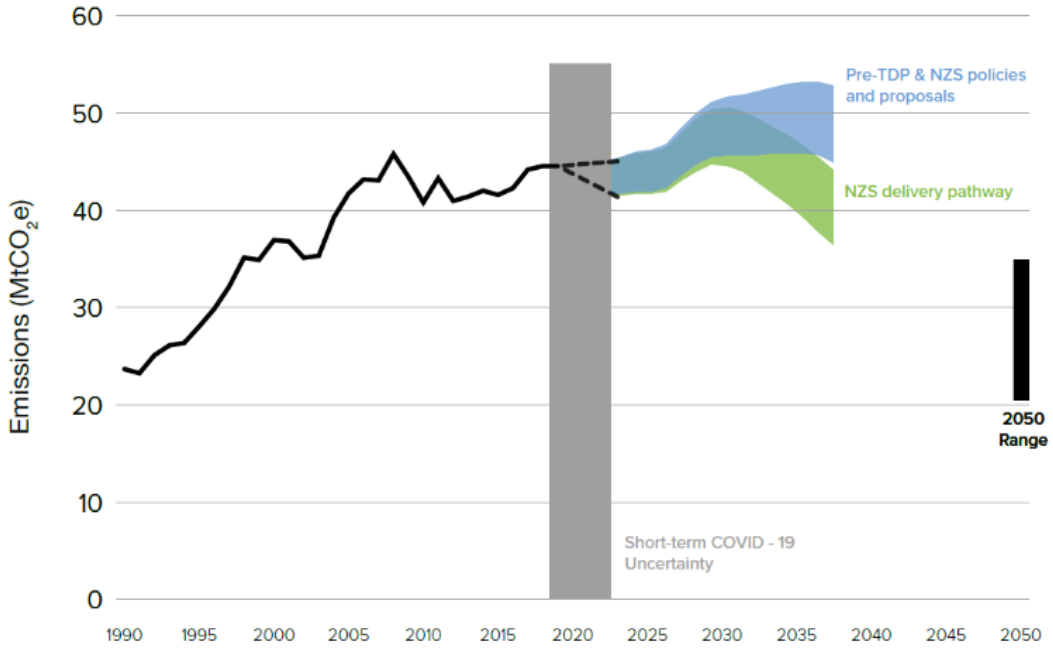

Figure 21: Indicative IAS emissions pathway to 2037, Net Zero Strategy: Build Back Greener (2021)

The UK net zero policy documents highlight some goals and objectives to ensure these targets are achievable. The goals and objectives for this sector are collected and understood from different Government reports, among them the Transport Decarbonization Plan (DfT, 2021), the most recent and complete document about the Department for Transport net zero strategy.

As emerged from the analysis, six are the Goals for the transport sector, for each will be provided a brief explanation and a list of related objectives.

1. Accelerating modal shift to public and active transport (DfT, 2021)

Passenger cars are the primary emission source, so increasing the share of trips taken by public transport, cycling, or walking is essential. For example, it is estimated that by filling a typical double-decker bus, it is possible to remove up to 75 cars from the road and the related emissions (DfT, 2021).

To achieve this goal, it will be necessary to provide sustainable means of transport covering the different lengths of the citizens' need for movement, leveraging active transport and city buses for short trips, coaches to connect close cities and railways for longer distances.

In that direction, the **objectives** toward meeting this goal are:

- 50% of all journeys in towns and cities walked or cycled by 2030 (DfT, 2021)
- Double cycling from 0.8 billion trips in 2013 to 1.6 in 2025 (DfT, 2021)
- Increase walking to 300 trips per person per year in 2025 (DfT, 2021)
- Increase the percentage of children aged between 5 and 10 that usually walk to school, from 49% to 55% by 2025 (DfT, 2021)
- Introduction of 4,000 zero-emission buses, either battery electric or hydrogen by 2030 (12% of England's local operator bus fleet) and the infrastructure needed to support them (DfT, 2021)
- Remove from the network all diesel-only trains by 2040 (DfT, 2021)
- Create 170 miles of new electrified track between London, Birmingham and Crewe by the early 2030s (DfT, 2021)

2. Decarbonising Road Transport (DfT, 2021)

This goal represents one of the most significant opportunities in terms of GHG emissions reduction. According to the Transport Decarbonization Plan, a fleet 100% composed of EVs could reduce domestic transport emissions by 91%.

In order to achieve such an ambitious target, the Government has already legislated a mandate to end the sale of new petrol and diesel cars. Moreover, it is already working to create an infrastructure network capable of meeting the demand. In the meantime, low-carbon fuels, including low-carbon hydrogen, will continue to be essential in maximising net zero savings.

The **objectives** toward meeting this goal are:

- Zero Emission cars % over the total fleet of 25% by 2030 and 50% by 2035 (BEIS, 2021a)
- Target % pathway of new sold car by emission type until 2032 (CCC, 2020a)

1. **Table 6** Proportion of car and van mileage by each powertrain among all new vehicles sold in each year, in the CCC Balanced Net Zero Pathway

	2020	2022	2024	2026	2028	2030	2032 (and beyond)
Fossil fuel vehicles (including mild and full hybrids)	92%	77%	52%	27%	18%	2%	0%
Plug-in hybrid electric vehicles	3%	10%	17%	17%	8%	<1%	0%
Battery-electric vehicles	5%	12%	31%	56%	74%	97%	100%

Table 6: Proportion of car and van mileage by each powertrain among all new vehicles sold in each year, in the CCC Balanced Net Zero Pathway, Policies for the Sixth Carbon Budget and Net Zero

- Government car and van fleet zero emission by 2027 (DfT, 2021)
- Develop infrastructures able to recycle up to 95% of a single battery by 2035 (DfT, 2021)
- Support the installation of 6,000 ultra-rapid charge points across the strategic road network by 2035 (DfT, 2021)

3. Decarbonising how we get our goods (DfT, 2021)

The logistics sector, concerning how goods move around the country, must also be decarbonised. This will mainly happen by shifting to full electric vans and heavy goods vehicles and increasing the modal shift towards less polluting means of transport like freight rail and coastal shipping.

The **objectives** toward meeting this goal are:

- 100% of newly sold Heavy Goods Vehicles (above 3.5t) will be zero emission by 2035 (DfT, 2021)
- 100% of newly sold Medium size trucks (up to 26t) will be zero emission by 2035 (DfT, 2021)
- Remove around 900,000 HGV loads off the road each year by incentivising modal shift (Internal DfT analysis)
- 33% share of zero fuels being used in UK shipping by 2035 (CCC, 2020a)
- Remove from the network all diesel-only freight trains by 2040 (DfT, 2021)

4. Place-based solutions to emissions reduction (DfT, 2021)

This goal places at its heart empowering local leaders and authorities to deliver local-tailored decisions and solutions to influence how citizens travel. Since there are very diverse initiatives and actions for many cities around the UK, no specific objectives will be reported. In general, the Government is mainly committed is in funding local initiatives and providing a *Local Authorities Toolkit* that provides guidance to shift towards a net zero emission local transport network before 2050

5. UK as a hub for green transport technology and innovation (DfT, 2021)

The intention of the UK to position itself as a world leader in green technologies has already been discussed in the general goals of its Net Zero Strategy. Also in the transport sector, the aim is to lead the development of mobility solutions that can reduce car dependency and drive a shift to a better-connected multimodal transport system.

The **objectives** toward meeting this goal are:

- Increase total R&D investment to 2.4% of GDP by 2027 (DfT, 2021)
- Increase car occupancy (average number of persons occupying a car, including the driver) from 1.55 to 1.7 by 2030 (BEIS, 2021a)
- Develop the first zero-emission aircraft by 2030 (DfT, 2022)

6. Reducing carbon in a global economy (DfT, 2021)

The UK plans to significantly reduce the environmental impact of the IAS sector through a combination of new aerospace technology such as electric and hydrogen aircraft, development and commercialisation of sustainable aviation fuels and influence consumers to make more sustainable choices like avoiding unnecessary flights when other more sustainable means of transport are available.

In that direction, the **objectives** toward meeting this goal are:

- Deliver 10% Sustainable Aviation Fuel (SAF) by 2030 (DfT, 2022)
- At least 5 commercial scale UK SAF plants under construction by 2025 (DfT, 2022)
- All airport operations in England to be zero emission by 2040 (DfT, 2022)

- Creation of CORSIA* the first ETS covering emissions related to international flight by 2024** (DfT, 2022)

**Carbon Offsetting and Reduction Scheme for International Aviation*

***The actual UK ETS already cover the flight from and to the EU*

3.5.6. Natural Resources, waste and fluorinated gases

Natural Resources, Waste, and F-gases (NRWF) sector collect emissions from three distinct sub-sector: "natural resources" include agriculture, forestry, and other land use (AFOLU) (inclusive of peatlands and soils). "Waste", also including wastewater, refers to any discarded material or substance that no longer has a use or value and "Fluorinated gases sector" (F-gases) refers to the production and use of gases that contain fluorine, such as hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), which are commonly used in refrigeration and air conditioning systems, as well as in some industrial processes (BEIS, 2021a). In 2019, this sector contributed 20% of total greenhouse gas emissions (BEIS, 2021f).

According to the UK's net zero policy, the aim is to reduce the contribution of this sector by up to 39-51% by 2035 compared to 1990 (BEIS, 2021a).

According to the 6th carbon budget, the emissions of the heat and building sector should be reduced within the range of 35.1 to 45.7 MtCO2e by 2037 compared to 63.1 MtCO2e in 2019 (CCC, 2020b). The following graph shows the yearly targeted emissions for this sector. The details and year by year emission targets can be found in **Table 8**:

Figure 22 Indicative Natural Resources, waste and F-gases emissions pathway to 2037

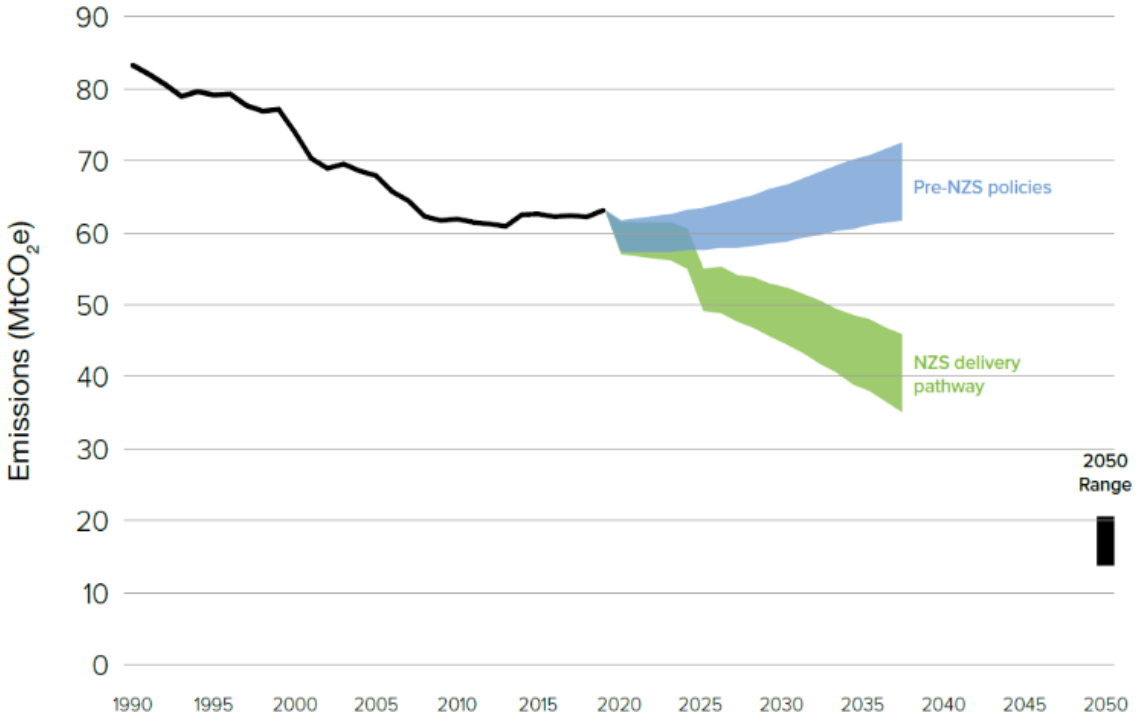

Figure 22: Indicative Natural Resources, waste and F-gases emissions pathway to 2037, Net Zero Strategy: Build Back Greener (2021)

The above mentioned targets are not made in a vacuum. To make sure that these targets are achievable, the UK net zero policy documents highlight some goals and objectives.

The goals for the NRWF sector will be divided into its three sub-sector components defined at the beginning of the section, for each will be provided a list of related objectives.

1. AFLOU

By 2050, we will have a resilient and prosperous countryside, where farmers and land managers are supported to reduce emissions and deliver a range of environmental outcomes (BEIS, 2021a)

The **objectives** toward meeting this goal are:

- 75% of farmers in England will be engaged in low-carbon practices by 2030, rising to 85% by 2035 (BEIS, 2021a)

- Increasing planting rates to 30,000 hectares per year by the end of this Parliament and maintaining new planting at least at this level from 2025 onwards (BEIS, 2021a)
- Restore at least 35,000 hectares of peatlands in England by 2025 and 280,000 ha of peatland in England by 2050 (BEIS, 2021a)

2. Waste

Commitments to eliminate all avoidable waste, including plastic, with the increased adoption of circular economy principles (BEIS, 2021a)

The **objectives** toward meeting this goal are:

- Increase municipal recycling rates to 65% by 2035(BEIS, 2021a)
- No more than 10% of municipal waste is landfilled by 2035 (BEIS, 2021a)
- Elimination of biodegradable municipal waste to landfill by 2028 (BEIS, 2021a)

3. F-gases

By 2050, current F-gas use will have been predominantly replaced by alternative gases or technologies (BEIS, 2021a)

The **objectives** toward meeting this goal are:

- Reducing HFC consumption by 85% by 2036 (BEIS, 2021a)
- F-gas Regulation's target of a 79% reduction by 2030 (BEIS, 2021a)

3.5.7. Greenhouse Gas Removals

The Greenhouse Gas Removals (GGR) sector refers to activities that remove greenhouse gases, such as carbon dioxide, from the atmosphere and store them in a way that prevents their release back into the atmosphere. Sectors such as industry, agriculture and aviation will be challenging to decarbonise completely. GGR is therefore essential to compensate for the residual emissions (BEIS, 2021a).

The GGR solutions fall into two categories (BEIS, 2021a): Nature-based approaches: such as afforestation and soil carbon sequestration; and Engineering-based approaches: such as Direct Air Carbon Capture and Storage (DACCS), Bioenergy with

Carbon Capture and Storage (BECCS), wood in construction, biochar, and enhanced weathering (EW). The latter category, today still requires high initial capital and entails non-insignificant operational costs, making private investment unattractive in the absence of a stable revenue stream for the provision of negative emissions (BEIS, 2021a).

According to the 6th carbon budget, this sector should be capturing or removing GHGs from the atmosphere within the range of -44 to -15 MtCO2e by 2037 compared to 0 MtCO2e in 2019 (CCC, 2020b). The following graph shows the yearly targeted capture of GHGs for this sector. The details and year by year targets can be found in **Table 8**:

Figure 23 Indicative GGR emissions pathway to 2037

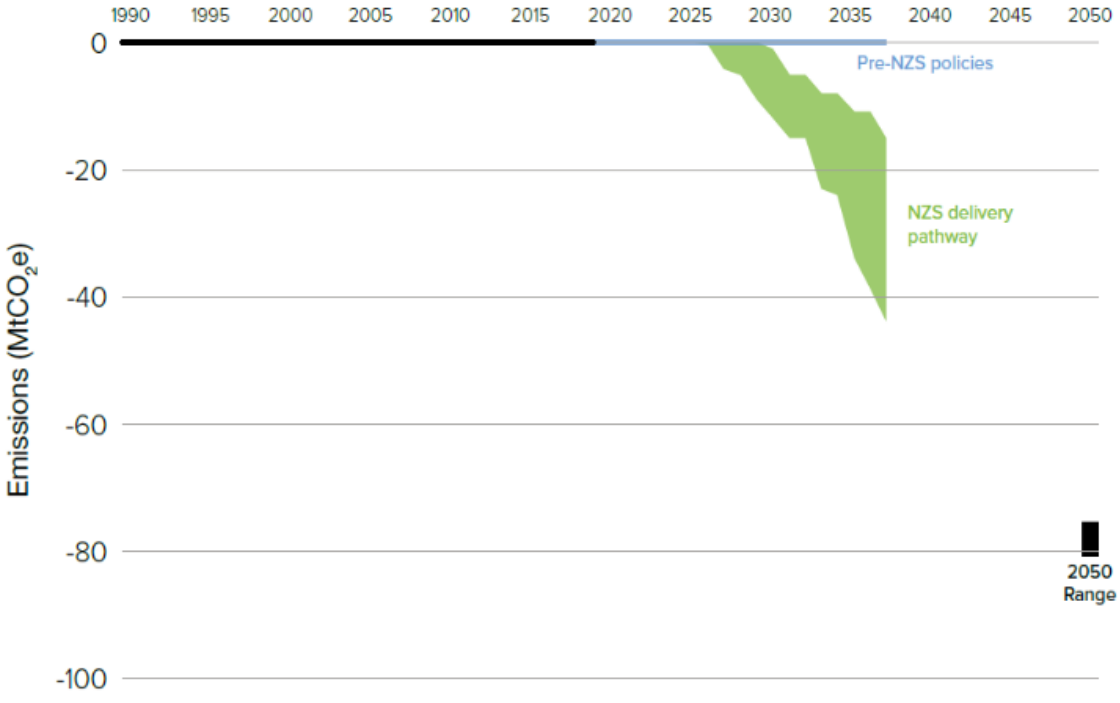

Figure 23: Indicative GGR emissions pathway to 2037, Net Zero Strategy: Build Back Greener (2021)

The UK goals and objectives to achieve the aforementioned targets are listed below.

The **Goal** is:

To balance residual emissions to achieve net zero (BEISa, 2021)

The main **objectives** to achieve the goal are:

1. **Nature-based approaches**

- 50,000 hectares as annual target area of afforestation by 2035 (BEIS, 2021a)

2. **Engineering-based approaches**

- Deploying at least 5 MtCO2/year of engineered removals by 2030 (BEIS, 2021a)

3.6. Objectives and indicative emission pathway recap tables

Table 7 Objectives' recap table

Sector	Objective	Target	Deadline	Source
Power	UK's electricity generation from renewable sources	75%	2030	(BEIS, 2020b)
	UK's offshore wind capacity	40GW	2030	(BEIS, 2021a)
	Floating offshore wind generation	1GW	2030	(BEIS, 2021a)
	Coal-fired electricity generation reduction	100%	2024	(BEIS, 2020b)
	Large scale nuclear project to the point of Final Investment Decision	At least 1	End of the current parliament	(BEIS, 2021a)
	Reduce the cost of nuclear new build projects	30%	2030	(BEIS, 2020b)
	Small Modular Reactor developed	At least 1	2030	(BEIS, 2021a)
	Advanced Modular Reactor (AMR) demonstrator designed and developed	At least 1	2030	(BEIS, 2021a)
	Commercially viable fusion power plant	At least 1	2040	(BEIS, 2020b)
	Operational power CCUS plant	At least 1	2030	(BEIS, 2021a)
Fuel Supply & Hydrogen	Reduction of emissions generated from oil and gas production (Compared to 1990 level)	10%; 25%; 50%; 90%; 100%	2025; 2027; 2030; 2040; 2050	(BEIS, 2022a)
	Replace 15,500km of iron mains to reduce 17% of gas leakage	15,500km	2027	(BEIS, 2021a)
	Increase the RTFO* main obligation	14.6%	2032	(DfT, 2021)
	Sustainable Aviation Fuel (SAF) delivered	10%	2030	(DfT, 2022)

	Commercial scale UK SAF plants under construction	5	2025	(DfT, 2022)
	Low-carbon hydrogen production	5GW	2030	(BEIS, 2021d)
	Pilot first hydrogen heating trial at a village scale	1	2025	(HM Government, 2020b)
	Pilot the first hydrogen-powered town	1	2030	(BEIS, 2021d)
Industry	Share of low-carbon fuels on total industrial energy consumption	50%	2035	(BEIS, 2021e)
	Fossil fuel use replaced with low-carbon alternatives	20 TWh/year	2030	(BEIS, 2021e)
	Clusters connected to CCUS infrastructure	2	2025	(BEIS, 2021e)
	Active low-carbon clusters	4	2030	(BEIS, 2021e)
	First net zero cluster	1	2040	(BEIS, 2021e)
Heat and Buildings	Installed heat pumps per year	600k; 1,7M	2028; 2035	(BEIS, 2021b)
	Reducing heat pumps costs	25-50%	2025	(BEIS, 2021a)
	Heat pumps costs at parity with gas boilers	Not applicable	2030	(BEIS, 2021a)
	Privately rented homes to meet a minimum energy performance standard of EPC Band C	2.8M	2028	(BEIS, 2021e)
	Cumulative number of homes with low-carbon heating	6M; 13M	2030;2035	(BEIS, 2021a)
	All new homes are zero-carbon-ready	100%	2025	(BEIS, 2021b)
	first trial of a village totally heated with hydrogen	1	2025	(BEIS, 2021b)
	Homes converted to using low-carbon hydrogen	4M	2035	(BEIS, 2021a)
	Renewable biomethane heat delivered per year	2.8TWh	2030/2031	(BEIS, 2021a)

	Reduce emissions from public sector buildings	75%	2037	(BEIS, 2021a)
Transport	Journeys in towns and cities walked or cycled over the total	50%	2030	(DfT, 2021)
	Double cycling from 0.8B trips in 2013	1.6B	2025	(DfT, 2021)
	Increase walking trips per person per year	300	2025	(DfT, 2021)
	Increase the percentage of children aged between 5 and 10 that usually walk to school	55%	2025	(DfT, 2021)
	Introduction of zero-emission buses, either battery electric or hydrogen	4,000	2030	(DfT, 2021)
	Remove from the network all diesel-only trains	100%	2040	(DfT, 2021)
	Creation of new electrified track between London, Birmingham and Crewe	170 miles	Early 2030s	(DfT, 2021)
	Zero Emission cars % over the total fleet	25%; 50%	2030; 2035	(BEIS, 2021a)
	Target % pathway of new sold car by emission type	See Table *	2032	(CCC, 2020a)
	Government car and van fleet zero emission	100%	2027	(DfT, 2021)
	Develop infrastructures able to recycle given % of single batteries	95%	2035	(DfT, 2021
	Support the installation of 6,000 ultra-rapid charge points across the strategic road network	6,000	2035	(DfT, 2021)
	Zero emission newly sold Heavy Goods Vehicles (above 3.5t)	100%	2035	(DfT, 2021)
	Zero emission newly sold Medium size trucks (up to 26t) will be	100%	2035	(DfT, 2021)

	Remove HGV loads off the road each year by incentivising modal shift	around 900k	Not applicable	(Internal DfT analysis)
	Share of zero fuels being used in UK shipping	33%	2035	(CCC, 2020a)
	Remove from the network all diesel-only freight trains	100%	2040	(DfT, 2021)
	Increase car occupancy	1.7	2030	(BEIS, 2021a)
	Develop the first zero-emission aircraft	1	2030	(DfT, 2022)
	Sustainable Aviation Fuel (SAF) delivered	10%	2030	(DfT, 2022)
	Commercial scale UK SAF plants under construction	5	2030	(DfT, 2022)
	All airport operations in England to be zero emission	100%	2040	(DfT, 2022)
	Creation of CORSIA	Not applicable	2024	(DfT, 2022)
Natural Resources, waste and F-gases	England's farmers will be engaged in low-carbon practices	75%; 85%	2030; 2035	(BEIS, 2021a)
	Increasing planting rates per year	30,000 hectares	End of the current parliament	(BEIS, 2021a)
	Hectares of peatlands restored in England	35,000 ha; 280,000 ha	2025; 2050	(BEIS, 2021a)
	Increase municipal recycling rates	65%	2035	(BEIS, 2021a)
	municipal waste is landfilled	Max 10%	2035	(BEIS, 2021a)
	Elimination of biodegradable municipal waste to landfill	100%	2028	(BEIS, 2021a)
	Reducing HFC consumption	85%	2036	(BEIS, 2021a)
	F-gas Regulation's reduction target	79%	2030	(BEIS, 2021a)
	annual target area of afforestation	50k ha	2030	(BEIS, 2021a)

Greenhouse Gas Removals	engineered removals deployed	5 MtCO2/year	2030	(BEIS, 2021a)
All	Increase total R&D investment as % of GDP	2,4%	2027	(DfT, 2021)

Table 8:Indicative sectors emissions pathway to 2037, Build Back Greener Data (2021)

Table 8 Indicative sectors emissions pathway to 2037

S#	Sector	Pathways	Range	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
1	Power	Pre- EWP & NZS Policies and proposals	Upper end of range	43,3	38,3	37,5	38,0	40,6	36,2	31,2	25,2	23,4	20,8	22,1	23,1	22,1	20,7	20,6	19,9	20,2	19,8
			Lower end of range	40,3	35,4	34,5	34,8	37,0	32,8	28,2	22,6	20,9	18,5	19,5	20,3	19,3	18,0	17,8	17,2	17,3	16,9
		NZS Delivery pathway	Upper end of range	43,3	38,3	36,2	35,2	37,6	34,2	27,5	21,9	18,6	17,1	16,6	14,8	13,3	12,0	11,5	11,1	11,4	11,1
			Lower end of range	40,3	35,4	33,2	32,0	34,0	30,8	24,4	19,3	16,1	14,7	14,0	12,0	10,5	9,3	8,7	8,3	8,5	8,2
2	Fuel Supply & Hydrogen	Pre- EWP & NZS Policies and proposals	Upper end of range	24,8	23,7	23,0	22,9	22,3	21,0	21,0	20,7	20,5	19,6	18,8	17,7	16,4	15,4	15,2	13,9	12,8	11,3
			Lower end of range	23,1	22,0	21,2	21,0	20,3	19,0	19,0	18,6	18,3	17,4	16,6	15,6	14,3	13,4	13,1	12,0	11,0	9,6
		NZS Delivery pathway	Upper end of range	23,6	22,3	21,6	21,6	21,0	19,9	20,1	19,3	17,8	16,9	16,3	15,0	13,9	13,2	13,2	12,2	11,5	10,3
			Lower end of range	21,8	20,5	19,8	19,7	19,1	17,9	18,0	17,2	15,6	14,7	14,1	12,8	11,9	11,2	11,2	10,3	9,7	8,7
3	Industry	Pre- EWP & NZS Policies and proposals	Upper end of range	76,7	77,9	77,4	76,8	76,1	75,3	74,5	73,8	73,1	72,5	71,9	71,3	70,8	70,5	70,4	70,4	70,5	70,7
			Lower end of range	71,4	72,1	71,2	70,3	69,3	68,3	67,2	66,2	65,3	64,4	63,5	62,7	61,9	61,4	60,9	60,6	60,4	60,3
		NZS Delivery pathway	Upper end of range	76,7	77,6	76,1	74,8	73,5	65,4	56,7	53,0	49,9	47,3	44,7	42,1	37,7	33,9	31,8	28,7	26,2	24,1
			Lower end of range	71,4	71,8	70,0	68,4	66,7	58,4	49,4	45,5	42,1	39,2	36,4	33,5	28,8	24,7	22,3	18,9	16,1	13,6
4	Heat & Buildings	Pre- EWP & NZS Policies and proposals	Upper end of range	88,6	89,5	88,3	88,4	88,3	88,3	88,7	89,2	89,8	90,2	90,6	91,0	91,4	91,9	92,4	93,2	93,9	94,6
			Lower end of range	82,4	82,9	81,3	80,9	80,5	80,1	80,0	80,0	80,1	80,1	80,0	80,0	79,9	79,9	80,0	80,3	80,4	80,6
		NZS Delivery pathway	Upper end of range	88,6	89,2	87,2	86,3	84,8	81,7	78,9	76,1	72,6	69,3	66,0	62,9	59,3	55,4	51,4	46,8	42,4	38,8
			Lower end of range	82,4	82,6	80,2	78,9	77,0	73,5	70,2	66,9	63,0	59,2	55,4	51,9	47,9	43,5	38,9	33,9	29,0	24,9
5	Transport	Pre- EWP & NZS Policies and proposals	Upper end of range	109,1	123,3	123,0	122,2	121,2	119,5	117,7	116,1	114,5	112,9	110,1	107,5	105,2	103,0	101,0	99,3	97,9	96,5
			Lower end of range	101,4	114,1	113,3	111,9	110,5	108,4	106,2	104,2	102,2	100,3	97,3	94,5	92,0	89,6	87,5	85,5	83,8	82,2
		NZS Delivery pathway	Upper end of range	109,1	121,8	118,0	116,5	115,1	113,3	108,4	103,5	95,8	88,5	80,1	72,4	64,3	53,5	47,7	42,1	37,8	34,0
			Lower end of range	101,4	112,6	108,3	106,2	104,3	102,1	96,8	91,5	83,5	75,9	67,3	59,4	51,1	40,1	34,1	28,3	23,8	19,7
6	Natural Resources, Waste & F-Gas	Pre- EWP & NZS Policies and proposals	Upper end of range	61,5	61,8	62,1	62,5	63,0	63,4	63,9	64,4	65,1	65,8	66,5	67,4	68,2	69,0	69,9	70,7	71,5	72,3
			Lower end of range	57,2	57,2	57,2	57,3	57,4	57,5	57,6	57,8	58,1	58,5	58,8	59,2	59,6	60,0	60,5	60,9	61,2	61,6
		NZS Delivery pathway	Upper end of range	61,2	61,3	61,2	61,2	60,5	54,9	55,1	54,1	53,6	53,0	52,2	51,5	50,4	49,5	48,4	47,9	46,8	45,7
			Lower end of range	56,9	56,7	56,2	55,9	54,9	49,0	48,8	47,4	46,6	45,6	44,5	43,3	41,9	40,5	39,0	38,1	36,6	35,1
7	Greenhouse Gas Removals	Pre- EWP & NZS Policies and proposals	Upper end of range	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
			Lower end of range	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
		NZS Delivery pathway	Upper end of range	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-1,0	-5,0	-5,0	-8,0	-8,0	-11,0	-11,0	-15,0
			Lower end of range	0,0	0,0	0,0	0,0	0,0	0,0	-0,1	-4,0	-5,0	-9,0	-12,0	-15,0	-15,0	-23,0	-24,0	-34,0	-39,0	-44,0

4. Findings: Answer to the second research question

This section is dedicated to the answer of the second research question which is "What types of projects have been done in the UK to achieve net zero?". Before we conclude the types of projects, it is necessary to build some context and define the scope of this question. In the literature review section, we have already explored the inherent complexity in achieving the net zero goal. There are multiple dimensions through which this subject can be analysed. For example lots of projects are being done in different fields like energy sector, transport sector, housing and building sector etc. Analysing all at once is too big for the scope of this report. That is why we need to define the scope of our research and finally by establishing a link between the first research question, we will present our analysis.

4.1. Scope definition

As mentioned above, achieving net-zero is a complex process that requires changes at both the individual and systemic level. We also need to develop cross functional cooperation between different fields and sectors. There is not one absolute solution to achieving net zero. Humanity needs to take up this challenge at every level, in every field and in every walk of life. Whether it is technological development, changing our social norms, changing our consumption habits and our individual preferences. In conclusion, the topic is very broad and it is difficult to summarise this topic in one report. Therefore, for the scope of this report, we need to draw some boundaries to give our research a relatively more concentrated and focused view. In this section, we

will define the scope of our research and also mention some of the salient features to highlight the importance of our chosen scope in the context of this report.

As evident from the title of this report, our focus is on understanding and studying the UK's net zero policy. So we will limit our scope to projects done in the UK but even in the UK, there are thousands of projects going on to achieve net zero. In 2018, the UK became the first major economy to adopt a legally binding target to bring greenhouse gas emissions to net zero by 2050 (UK Gov, 2021). Since then, we saw an organized and structured framework taking place in the UK to achieve this target. In 2020, the UK published an energy white paper (BEISb, 2020) as a precursor to a more formal and broad net zero strategy. Then in 2021, the UK published a very comprehensive document called "Net Zero Strategy: Build Back Greener" (BEISa, 2021). This document is the holy grail of the UK's approach to climate change. This document not only gives a very detailed picture of the current scenario but also clearly mentions the pathway for the future.

To make the goal of achieving net zero by 2050 more manageable, the UK has identified seven main sectors. The chart below mentions the seven sectors and their relative contribution to GHGs. By dividing its net zero strategy into these seven sectors, the UK can develop specific policies and measures that are tailored to the unique challenges and opportunities within each sector and also to utilize the advantages of economies of scale and scope thus increasing the likelihood of achieving its overall net zero target.

4.1.1. Focus on transport sector

In the graph mentioned above, the transport sector in the UK is the biggest source of emissions. This sector is responsible for 32% of the total GHG emissions in the UK. The net zero strategy documents further classify this sector into Domestic Transport and International Aviation and Shipping. The domestic sector alone contributes to 27% of the total emissions (BEISa, 2021). This sector has already been discussed in detail in

the first research question. In this section we just want to highlight the salient features to explain why it is worth focusing on the transport sector.

Decarbonizing the transport sector does not mean that the introduction of electric vehicles, buses or trains will solve the problem. This sector requires changes at both system level and at individual preferences level. According to the UK government's net zero policy, the aim is to completely stop the sale of new internal combustion engines cars, buses and vans by 2030 and eventually hybrid vehicles will also be banned 2035 (DfT, 2021). To achieve this objective, the government needs to take initiatives which are diverse in terms of their approach and outcomes, for example, providing incentives to individuals and companies to switch to electric vehicles, expanding charging infrastructure, and investing in research and development of zero-emission technologies. This means that the UK has to upgrade and build new eco friendly assets. The government also needs to encourage the use of active travel modes like cycling and walking, and promote the use of shared mobility services. This means that the UK has to bring a social revolution and change the individual preferences.

Another interesting aspect of this sector is that it also includes International Aviation and Shipping transportation. The technological advancement to decarbonise the aviation and shipping industry is still lacking any real progress. The government plans to reduce the emissions from aviation and shipping by at least 50% by 2050 (BEISa, 2021). This means a lot of investment has to be done in research and development projects.

In conclusion, given the diversified actions and range of projects that the government needs to initiate, this sector has the potential to be a good case study for this research question as the objective of this question is to explore different types of projects being done in the UK to achieve net zero. The transport sector being the biggest contributor of GHG emissions is rapidly going through a revolution and there are plenty of projects being done under this sector which will be very useful in collecting relevant data. For the reasons mentioned above, we have decided to limit the scope of our research to the transport sector only.

4.1.3. Stakeholder identification

The discussion about any project in any aspect is incomplete without taking the stakeholder into consideration. Stakeholders are individuals or groups who have an interest or are affected by a project (Freeman, 2010). In project management, stakeholders play a crucial role in the success of a project (Ika & Pinto, 2022). Stakeholders can provide valuable input and feedback on the project requirements, including their needs and expectations. This not only helps project managers to identify and prioritize the requirements and ensure that they are met but also shapes the core idea, goals, objectives and eventually the deliverables of the projects (Frooman, 1999).

Stakeholders have a critical role in project management. They provide inputs on the requirements. They influence project outcomes. They play a vital role in mitigating risks by sharing risks (Turner & Müller, 2003). There is a significant amount of literature available on the topic of stakeholder management. Different frameworks have also been established like Mitchell's framework for the identification of stakeholders (Mitchell et al., 1997). Keeping within the scope of this report, a relevant approach to stakeholder classification is presented through the project system organization conceptual framework by Denicol, et al. The PSO identifies the multiple and evolving actors across the multi-level and multi-layer megaproject system and defines four roles often used to label the stakeholders in megaprojects: owner, sponsor, client, and partner (Denicol et al., 2021).

In this section, we are interested in finding different types of net zero projects. The project owner is mainly the one who conceives the idea. The owner sets the project goals objectives, product specifications and also has a higher authority when it comes to design input and defining the scope of the project (ISO, 2012). From an economic and the availability of resources perspective, the owner has the higher responsibility for arranging the funding sources, managing the project risks and ensuring the project

completion within the iron triangle i.e. budget, time and quality (PMBOK, 2017). Therefore, it is important to identify who is the project owner.

Different types of owners have access to different resources, they have different strategic visions, different technological and managerial expertise. The owner is directly responsible for approving project deliverables, including plans, designs, and final products or services. Therefore an important aspect, in the context of this research question, is to examine who is the owner behind the project under consideration. This will give us an insight about what type of owner is interested in what type of project. This will be helpful in categorizing projects into different types particularly by analysing whether the project is owned in the public sector or the private sector.

The public and private sectors are two distinct domains in which businesses and organizations operate. Both sectors have different objectives, operations, and resources. Understanding the differences between these two sectors is essential for individuals and businesses that interact with them. The differences between public and private sectors from an industrial, technological, availability of resources, knowledge, and economic perspective essentially controls the type of projects preferred and initiated by these sectors. Some of the differences between the public and private sector are mentioned below (Nutt, 2006).

The public sector is:

- more concerned with providing services that facilitate the public such as education, healthcare and mass transit systems.
- more focused on relying and leveraging on the well established and proven technologies and contributes to only incremental improvement in those technologies.
- more risk averse and generally slow in adopting disruptive innovations.
- highly affected by the political situation. The main sources of funding is through taxes and government appropriations therefore the funding model can be highly unpredictable.

- more focused on knowledge sharing rather than knowledge generation. The focus of the public sector is on developing best practices, sharing of research and data and collaborating on policy development.

Whereas, the private sector is:

- more focused on the creation of goods/ products. Private sector also provides services but those services are more luxury oriented and the main objective is to generate profits.
- known for its innovation and technological development. Due to the inherent characteristics of competitive markets, the main focus of the private sector is to improve efficiencies, automate processes and to reduce costs which allows the private sector to create more disruption and is quick to adopt new technologies.
- more resource-rich compared to the public sector. It has greater access to the capital markets, investors and other funding sources. This allows the private sector to invest more in research and development.
- more competitive and private companies try to stay ahead of their competitors by making better products and providing better services due to which it relies more on knowledge creation.

To sum up the scope of the second research question, we will focus on the transport sector in the UK and we will analyse projects that are initiated under public and private sector ownership to understand what different types of projects are undertaken by each of the two sectors, whether there are any commonalities between the types of projects or is there any preference of certain type of project by one sector or vice versa.

4.2. Establishing link with the first research question

In the first research question, we explored the UK's net zero policy in detail. We analysed and consulted different policy documents and found out that the UK's net zero policy is divided into seven sectors. These sectors have their own goals and objectives which are aimed to achieve the main target of achieving net zero by 2050. In

this research question, our aim is to analyse what types of projects are being done in the UK in the transport sector. To carry the discussion forward, goals and objectives of the transport sector are the most suitable bridge to transition from the first research question to the second research question.

In project management, setting clear goals and objectives is a critical step towards achieving success. Goals and objectives serve as the guiding force behind project planning, execution, and control. Without them, a project can easily lose focus and direction, resulting in missed deadlines, budget overruns, and dissatisfied stakeholders (Schmidt, 2015).

In the literature review, we have already discussed the difference between goals and objectives. This is exactly in line with our analysis that we presented in the first research question. The UK's net zero policy followed four main guiding principles that set the foundation for the setting of goals and objectives for each sector. The UK's net zero policy for the transport sector states six main goals which gives us a pathway to the future. These goals tell us that the desired outcome will be achieving net zero. Under each of these goals, the policy further states several objectives that tells us what kind of projects should be done leveraging on the resources and technical expertise of the country in general. Defining the goals and objectives of a project provides SMART targets and milestones. By aligning policy goals and objectives with project management goals and objectives, project managers can ensure that their projects are aligned with the overall business objectives and deliver the expected results (Owen et al., 2012).

We live in a complex world which is also evolving rapidly. A solution that seemed plausible in the past may not work in the future. Similarly, a solution in one part of the world may not seem to be applicable in another part of the world. The reasons can be numerous e.g. climatic differences, social and cultural differences, availability of resources and technology etc. Similarly, there are more than one way of achieving a specific goal. That is why our starting point will be the goals and objectives of the

transport sector and we will discuss different projects undertaken in the UK to achieve them.

4.3. Types of net zero projects and programs

As mentioned above, we will explore different projects under each category of goals of the transport sector mentioned in the UK's net zero strategy. In the literature review section, we have discussed different frameworks and methodologies of project classification. Classification in any field of studies is an essential tool that helps organize and make sense of the vast and complex array of information that scientists gather about that field of studies. We are particularly focusing on the sustainability by the projects and their contribution towards net zero. In this perspective, the most relevant classification of net zero project is presented by Marco Terenzi, in which he argues that there are mainly four types of net zero transition projects (Terenzi, 2023). In the section below, we will discuss some real projects and see if they can be classified according to Terenzi's proposal.

4.3.1. Accelerating modal shift to public and active transport

The first goal of decarbonizing the transport sector according to the UK's net zero policy is to increase the use of public transport. Modal shift refers to the process of moving from one mode of transport to another. Accelerating modal shift involves a range of measures that can be implemented by the government and other stakeholders to make public and active transport more attractive and accessible. In the context of the UK's net zero policy, modal shift aims to encourage people to shift away from personal cars and towards public and active transport options, such as buses, trains, cycling, and walking. But changing people's preferences is not the complete solution if the means of public transportation are not decarbonised. To decarbonise public transport, the UK needs to invest in R&D, introduce new clean energy-based transportation means and upgrade the existing means of transportation to reduce their

carbon emissions. Given below are the leading projects in the UK that aims to achieve this goal.

1. Project Title: HydroFLEX

Project Description: Most of the the UK's railway system relies on diesel-powered trains. One alternative could come from the utilisation of electrified railways, however, it is an expensive solution, with a typical figure in 2010 prices being £1 million per km per single line for mainline electrification (Calvert et al., 2021). So, hydrogen propulsion has been considered as an alternative.

The idea of building a hydrogen powered train was first conceptualised during the Rail Live event held in the UK in 2018 (RT, 2019). The project was launched by Porterbrook, a rolling stock leasing company, in partnership with the University of Birmingham's Centre for Railway Research and Education (BCRRE) in 2018 (Porterbrook, n.d.) and proof of concept was approved in 2019 (RT, 2019). The initial phase of the project involved converting a Class 319 electric train into a hydrogen-powered train, using a combination of fuel cells and lithium-ion batteries. First HydroFLEX was successfully tested on the mainline rail network in the UK in September 2020 (UBir, n.d.).

Since then, the HydroFLEX project has evolved with the development of a second prototype train, which is expected to be more efficient and have a longer range than the original prototype. The second prototype will be based on a Class 321 electric train and will feature new components, including a higher-capacity battery system and an improved fuel cell stack (UBir, n.d.).

Stakeholders involved: The HydroFLEX project is a collaboration between the private and public sectors in the UK. The project was initiated by Porterbrook, a rolling stock leasing company, and is being developed in partnership with the University of Birmingham's Centre for Railway Research and Education (BCRRE), which is a public sector research institution (Porterbrook, n.d.).

The project has received funding and support from both the private and public sectors. In March 2020, the UK government announced a £23 million ($30 million) fund to support the development of hydrogen-powered trains, which included funding for the HydroFLEX project (UBir, n.d.). It has also received support from industry partners, including Alstom, a global rail transport company, which is providing technical support for the project.

Overall, the HydroFLEX project is a good example of how public-private partnerships can drive innovation and accelerate the development of sustainable transport solutions. By combining the resources and expertise of the private and public sectors, the project is able to access funding, technical knowledge, and regulatory support, which can help to overcome some of the challenges associated with developing new technologies and bringing them to market.

Project Type: This project has evolved in two stages. Before the Rail Live event the technology did not exist. The idea was conceived during the event. Porterbrook decided to invest in this idea and collaborated with BCRRE for research and development. The aim of this stage was to deliver a new technology of hydrogen powered trains. After two years of R&D, the mainline railway tests started in 2020 (RT, 2019). Until this stage, this project came under the category of R&D.

Since the outcome of the first stage was successful, the parent company, Porterbrook decided to invest further. Porterbrook plans to make this technology available by 2023 to retrofit current in-service trains to hydrogen - helping decarbonise the rail network and make rail journeys greener and more efficient (UBir, n.d.). In this second stage, the approach taken was to retrofit an existing electric train.

with the new power system, instead of designing and constructing an entirely new vehicle (Calvert et al., 2021). Hence, this project also corresponds to the category of upgrade assets.

2. Living Streets - Walk To School Outreach (WTSO)

Project description: Living Streets - Walk To School Outreach (WTSO) is a community-based initiative aimed at promoting active and sustainable transport for school children. This is done by encouraging and promoting walking or cycling to school as a healthier, safer, and more sustainable alternative to driving. The WTSO program also aims to create a sense of community by encouraging families to walk or cycle together and to support local businesses along the way. This organisation is working under the vision that they want to create a nation where walking is the natural choice for everyday local journeys (Living Streets, n.d.).

The program works by partnering with schools, local government, community groups, and businesses to develop a range of initiatives that encourage children to walk or cycle to school (UK Gov, 2020). These initiatives include creating walking or cycling groups that meet at designated locations and walk or cycle to school together, running safety campaigns that educate children and parents about road safety, including the use of pedestrian crossings and cycling helmets, working with local government to improve infrastructure such as footpaths and cycling lanes, making walking or cycling to school safer and more enjoyable, organising fun events, such as walk-to-school days or bike rides, to encourage participation and create a sense of community and developing rewards programs to incentivise participation, such as free healthy breakfasts for children who walk or cycle to school (Living Streets, n.d.).

Stakeholders involved: As mentioned in the project description, the program involves partnering with different schools, local governments, community groups and businesses to achieve the objectives of this program. This program has complete support and backing from the UK government, in particular since 2016 the DfT has invested about £4.6 millions. But the program was initiated by an independent organisation called "Living Streets". This is a 90 years old organisation. Its foundation was laid on 13th August 1929 when young journalist Tom Foley and political reformer Viscount Cecil held the first meeting of the Pedestrians' Association in Essex Hall in the Strand, London (Living Streets, n.d.). It was due the campaigns of this organisation

that led to the UK's first zebra crossing and the introduction of speed limits. Living Streets is a registered charity and a registered company limited by guarantee, governed by a board of between eight and 16 Trustees, who also act as Directors of the limited company (Living Streets, n.d.). Therefore, the ownership of this program falls in the private sector.

Project Type: The goal of this program is mainly to promote a culture of active transport like walking or cycling for local journeys. This concerns mainly with the paradigm shift in the individual preferences of the people. According to the statistics provided by the UK government, a century ago, 70% of primary school children used to walk to school and now that percentage has reduced to 51% (UK Gov, 2020).

Moreover, even if travelling to education is the most frequent single purpose of walking journeys there is huge potential to increase the proportion of children walking to school and reduce emissions (DfT, 2021). In 2019, private car journeys covering distances of less than five miles constituted 58% of all car journeys. By encouraging people to switch from using cars for short trips to walking or cycling, could lead to a reduction in current car emissions of 68 MtCO2e (DfT, 2021).

So in that context, the objective of the WTSO program is to have 55% of primary school children walking to school by 2025 (Living Streets, n.d.). There is no technology or research involved in this project. The only outcome is the shift in the public mindset. Therefore, this project falls under the category of intangible projects with behavioural changes as key deliverable.

3. Project Title: York's Zero Emission Park and Ride fleet

Project Description: York's Zero Emission Park and Ride fleet is a transportation system that operates in the city of York, in the north of England. The fleet consists of a number of buses that run on electric motors, making them completely emissions-free. These motors are powered by the rechargeable batteries that are charged overnight, using low-cost electricity from the grid, and are then used to power the buses during

the day (iTravel York, 2020). The buses have a range of up to 150 miles on a single charge, making them well-suited to the needs of the Park and Ride system.These buses are used to transport people from car parks on the outskirts of the city into the city center, with the aim of reducing traffic congestion and air pollution (YorkMix, 2020).

The York Zero Emission Park and Ride fleet is an important part of the city's efforts to reduce its carbon footprint and improve air quality. By using electric buses instead of diesel-powered buses, the system produces zero emissions during operation. This has a positive impact on the air quality in the city, reducing the amount of harmful pollutants released into the atmosphere (Y&HCC, n.d.). In addition to the environmental benefits, the York Zero Emission Park and Ride fleet also offers economic benefits (YorkMix, 2020). The system is cheaper to operate than traditional bus services, as electric buses have lower operating costs than diesel buses. This means that the city can provide a high-quality, affordable public transport service to residents and visitors, while also reducing its carbon footprint.

Stakeholders involved: The main stakeholders involved in this project are the City Council of York. The city council has partnered with First York which is a private company for running the operations. Whereas the electric double decker buses are developed and manufactured by Optare which is also a private limited company. The city council of York has provided funding of £2.7m for this project (YorkMix, 2020). The main initiative was taken by the city council of York with the aim to make the city centre emission free. The ownership of the project falls under the public sector as the main funding was provided by the city council of York.

Project Type: Through this project, the city council has replaced all the old fleet of diesel powered buses in the city centre of York. They had to build new car parking in the outskirts of the city for the visitors to park their cars. Also a number of charging points had to be built around the city for smooth operation of the service. The purchase of new electric buses, construction of parking spaces and charging points all shows that this project falls under the category of new assets.

4.3.2. Decarbonising Road Transport

The second goal of decarbonising transport in the UK's net zero policy is to drastically reduce the carbon emissions produced by vehicles on the country's roads in order to meet the UK's commitment to achieving net zero carbon emissions by 2050. To achieve this goal, the UK government has set out a range of policies and a number of projects are completed and being completed as of now to achieve this goal. Some of those projects are discussed below:

1. Project Title: Disruptive cooling systems for electrification sub-systems

Project Description: The aim of this project is to create an innovative electric motor design that incorporates new cooling technologies for the rotor, stator, and power electronics. This new design is expected to improve performance by 15 to 20% compared to existing automotive approaches and help achieve the 2030 Automotive Council UK power targets by 2021. This new concept will also enable motor downsizing, weight reduction, improved vehicle packaging, and cost savings, contributing to the government's goal of increasing electrification in various transport sectors (CoPED, 2022).

To achieve this, Ricardo will utilize advanced digital design and analysis tools to develop the concept and evaluate its performance in relevant automotive environments. These updated tools will also help to reduce the development time for motors and drives by half. The project will result in a well-developed 3D CAD concept design that considers manufacturing considerations and can be communicated to a global customer base (CoPED, 2022). This design will serve as a foundation for future programs aimed at moving the technology towards production readiness. Overall, the project will accelerate the development of electrification technology and enable Ricardo's customers to remain competitive in this rapidly evolving industry.

Stakeholders involved: This project was initiated by Ricardo. Ricardo is a global strategic, environmental, and engineering consultancy at the intersection of transport,

energy and global climate agendas, solving the most complex issues to help achieve a safe and sustainable world (Ricardo, n.d.). Innovate UK which is an initiative of the UK government provided funding for this project but the main ownership of this project remains in the private sector.

Project type: This project's main deliverable is new knowledge. The knowledge generated through this project will be used in the automobile industry to make more efficient EVs. The outcome of this project is neither producing any tangible product nor is it bringing any social change. This project strictly falls under the category of research and development.

2. Project Title: Low Carbon Vehicle Innovation Platform (LCVIP); Ultra Low Emissions Vehicles (ULEV) programme

Project description: The Low Carbon Vehicle Innovation Platform (LCVIP) is a program aimed at promoting the development of low carbon vehicles in the UK. This project is part of a broader UK initiative to reduce greenhouse gas emissions and improve air quality by encouraging the adoption of low emission vehicles. The Ultra Low Emissions Vehicles (ULEV) project is a specific initiative under the LCVIP program that focuses on promoting the development of ultra-low-emission vehicles. ULEVs are defined as vehicles that emit less than 75g of carbon dioxide per kilometre driven, and they include electric vehicles, plug-in hybrid vehicles, and hydrogen fuel cell vehicles (OLEV, n.d.).

Stakeholders involved: This initiative is funded by the UK government. Although this project requires expertise from the private sector, the main ownership of this project falls under the public sector.

Project type: The ULEV program is designed to support the research, development, and deployment of low emission vehicles, as well as the associated charging and refuelling infrastructure. The program includes various funding streams to support research and development activities, as well as demonstrations of ULEV technology in real-world settings. The ultimate goal of the ULEV program is to accelerate the

adoption of low carbon vehicles in the UK, reduce greenhouse gas emissions, and improve air quality. By encouraging the development of ULEVs and supporting their deployment, the program aims to create a more sustainable transportation system that benefits both the environment and the economy. Therefore, this project is related to the research and development category.

3. Project Title: The Clean Vehicle Retrofit Accreditation Scheme

Project Description: The Clean Vehicle Retrofit Accreditation Scheme is a project aimed at reducing emissions from older diesel vehicles by retrofitting them with clean vehicle technology. The project is focused on reducing harmful emissions such as nitrogen oxides (NOx), particulate matter (PM), and carbon monoxide (CO) from diesel vehicles, which can have significant negative impacts on air quality and public health (Zemo, n.d.). The project involves the development of a certification scheme that ensures retrofit technologies meet specific emissions standards and are installed correctly. The accreditation scheme is designed to provide fleet operators with confidence that retrofitted vehicles meet emissions targets and comply with relevant regulations, such as the London Ultra Low Emission Zone (ULEZ) and Clean Air Zones (CAZ). The retrofit technologies used in the project include selective catalytic reduction (SCR), diesel particulate filters (DPF), and exhaust gas recirculation (EGR) systems, which can significantly reduce emissions from diesel vehicles (EST, n.d.). These technologies are installed by accredited retrofit suppliers, who have demonstrated their ability to install the systems correctly and ensure their ongoing maintenance.

Stakeholders involved: This project is initiated by the partnership between Energy Saving Trust (EST) and Joint Air Quality Unit (JAQU). EST is an independent organization working to address the climate change emergency (EST, n.d.). JAQU on the other hand is a partnership between the Department for Environment, Food and Rural Affairs (Defra) and the Department for Transport (DfT) that will use personal data to monitor the impact of policies designed to tackle roadside nitrogen dioxide

(NO2) pollution. Therefore, the ownership of this project lies in both the public and private sector.

Project Type: This project is initiated with the purpose to modify existing vehicles and make them compliant with the latest vehicle emissions laws. As mentioned in the description, this project converts old diesel vehicles into low emission vehicles by retrofitting them with clean vehicle technologies. Therefore, this project falls under the category of upgrade asset.

4.3.3. Decarbonising how we get our goods

The idea behind this goal is to reduce the GHG emissions produced due to the transportation, and distribution of consumer goods. Consumer goods refers to everything that we consume in our daily life from food, electronics, clothing, luxury items, kitchen items, furniture etc. Like other goals, the UK government is working on several strategies, such as promoting the use of renewable energy sources in the marine sector and developing technologies to convert marine engines to clean energy sources such as hydrogen and solar power. Other projects correspond to improving the energy efficiency of transportation. Mentioned below are some of the competing projects in the UK to achieve this goal.

1. Project Title: Hydrogen in an Integrated Maritime Energy Transition

Project description: The aim of this project is to demonstrate decarbonisation or low emission technologies in the maritime sector. The project will focus on designing, developing, and testing four solutions, including resilient shore-side power systems using hydrogen and solar, combustion of hydrogen in marine propulsion engines, marinised hydrogen storage containers, and hydrogen fuel cell systems for auxiliary power on vessels (UKRI, 2023). The main focus is on decarbonising ferry service and cruise terminal operations in Orkney, and the demonstrations will provide evidence

to support broader adoption of hydrogen technologies for maritime decarbonisation (EMEC, n.d.).

Stakeholders involved: This project is led by the European Marine Energy Center Ltd and funded by the UK's department for transport in and Innovate UK. EMEC is an innovation catalyst and the pioneer in transition towards a low carbon future in the marine sector. EMEC claims that more ocean energy converters have been tested at EMEC than at any other site in the world. In this project we see collaboration between the UK's department for transport and EMEC therefore we can conclude that the ownership of this project is by both the public and the private sector.

Project type: As it is evident from the description that the output of this project is not a commercial product. This project aims to demonstrate decarbonization technology for marine engines. Therefore the type of this project is research and development.

4.3.4. Place-based solutions to emissions reduction

This goal is an intelligent way of tackling the challenge of decarbonising the transport sector. Different cities, towns and even different zones in a city have different levels of emissions based on the traffic volume and business of those zones. This involves working with local bodies and businesses to identify the core sources of emissions and to implement the relevant actions to increase the effectiveness. For example, the project discussed above, York's zero emission park and ride fleet is an example for such a solution where the city council of York has banned the entry of cars inside the city center. They have built car parkings on the outskirts where visitors can park their cars and they can use the EV bus service for approaching anywhere within the city center. This project renders the city center completely free from the emissions from the road transport.

Similarly, the UK government is focusing on improving the train service between different regions of the country where the traffic volume is higher on the roads to allow people to use the mass transit systems. The projects under this particular goal also refer to the other goals of the transport sector therefore they have already been discussed

under other sections. However a detailed summary of the projects is presented in table X which shows different types of project as a result of place based solutions.

1. Project title: HOV (High Occupancy Vehicle) Lane in Leeds

Project description: The HOV (High Occupancy Vehicle) Lane project in Leeds has two main objectives. The first is to reduce traffic congestion on the M621 motorway and the second is to improve air quality. These objectives are achieved simply by creating a dedicated line for the cars or vehicles carrying more than one passenger. This will allow the cars in dedicated line to move faster and also incentivise people to prefer car pooling which will result in less number of cars on the road (ITS, n.d.).

Stakeholders involved: The project is being implemented by Leeds City Council, in partnership with the West Yorkshire Combined Authority and Highways England (Johnson, 2022). Therefore, the ownership of this project falls under the public sector.

Project type: This project is a perfect example of a place based solution. The outcome of this project is the change in individual preferences towards car pooling and hence reduction in the number of cars on the road. This project incentivizes people by giving them a faster route so that they spend less time traveling. In our modern day life, most of the people spend considerable time on the roads traveling from one place to another. This will allow people to save their traveling time and can spend it on the things that matter to them. As this project does not deliver any commercial project, nor any new knowledge, therefore, this project falls under the category of intangible projects.

4.3.5. UK as a hub for green transport technology and innovation

Through this goal, the UK wants to position itself as the world leader in green transportation technologies. The UK wants to develop a thriving industry that will create more jobs and economic benefits besides achieving the main goal of decarbonising the transport sector. This goal is the basis of establishment of many new companies and start-ups in the UK which are doing very promising projects to

research and develop hydrogen or electric powered jet engines. Not only in the aviation sector, but this goal has also allowed the entry of many new companies which are producing efficient electric cars and buses and exporting them outside the UK as well. Some of the projects related to this goal are mentioned below:

1. Project title: ZeroAvia- HyFlyer II project

Project description: The aim of this project is to develop a zero-emission, hydrogen-electric powertrain for regional aircraft. In 2020, the company ZeroAvia demonstrated the world's first flight of a commercial grade aircraft with hydrogen-electric engine (ZeroAvia, 2023). The company aims to use this successful demonstration of hydrogen-electric jet engines to develop larger and more powerful zero emissions powertrains.

Stakeholders involved: This project was initiated by ZeroAvia which is a private company. The company is working with aircraft manufacturers, owners and operators to deliver zero emissions jet engines. The mission of the company is to have a hydrogen-electric engine in every aircraft (ZeroAvia, 2023). Although this project has received funding from the UK's Aerospace Technology Institute. Other partners include British Airways, EMEC and University of Nottingham. Since the company ZeroAvia is a private limited company and was started solely with the mission to develop zero emission aircrafts therefore, the ownership of this project is in the private sector.

Project type: This project has already demonstrated a successful proof of concept for the world's first hydrogen-electric jet engine yet there is not a commercial aircraft that has been launched through this project. Although this project has a very high potential for producing a viable commercial product and can be categorized as a new asset project in the future, as of now this project can only be classified as a research and development project.

4.3.6. Reducing carbon in a global economy

With this goal the UK plans to significantly reduce the environmental impact of the IAS sector through a combination of new aerospace technology such as electric and hydrogen aircraft, development and commercialisation of sustainable aviation fuels and influence consumers to make more sustainable choices like avoiding unnecessary flights when other more sustainable means of transport are available. some of the key projects to achieve this goal are discussed below:

1. Project Title: Gatwick solar farm

Project description: This project aims to install a large-scale solar energy system at Gatwick Airport in London, United Kingdom. This project will generate clean, renewable energy to power the daily operations and reduce the carbon footprint of the airport. The solar farm will cover an area of approximately 50 hectares and have a capacity of up to 50 megawatts (MW) of electricity. This solar farm will consist of photovoltaic (PV) solar panels, which convert direct sunlight into electricity. The energy generated by the solar farm will be fed directly into the airport's electricity grid, reducing the need for fossil fuel-based energy sources and reducing the airport's greenhouse gas emissions (VINCI, 2022). It will generate approximately 34,000 tonnes of carbon dioxide emissions per year. This is equivalent to the annual emissions of around 7,000 cars. The project is also expected to have positive economic impacts, as it will create new jobs during the construction and maintenance phases and provide a reliable source of energy for the airport (PEi, 2012).

Stakeholders involved: This project is initiated by Orta Solar in partnership with the UK's civil aviation authority. Therefore; the ownership of this project is the partnership between both the public sector and private sector.

Project type: This project aims to build a sustainable airport with low carbon emissions. Gatwick airport will become the world's first airport with its own solar farm. Therefore this project lies under the category of new asset.

Table 9 Summary Table with types, stakeholders and key deliverables

Table 9: Summary Table with types, stakeholders and key deliverables

S.no	Project Title	Description	Ownership	Project Type	Key Deliverable
1	A12 Chelmsford to A120 widening	● Improve safety for road users, especially at the junctions and slip roads through better design while also removing the current direct private accesses onto the A12. ● Reduce traffic congestion by increasing the capacity of the road, making journey times more reliable. The proposed scheme will save motorists as much as 1.5 hours in a working week if they travel daily between junctions 19 and 25. ● Make improvements for walkers, cyclists, horse riders and public transport users, to give them better connections and safer, more enjoyable journeys.	Public Sector	Upgrade Asset	Technology, Enabling conditions
2	A303 Amesbury to Berwick Down	● Free-flowing dual carriageway replacing the current single lane on the A303 between Amesbury and Berwick Down including a twin bore tunnel under the majority of the World Heritage Site and a by-pass and viaduct to the north of Winterbourne Stoke. ● Improve biodiversity, promote modal shift to public transport and provide a positive legacy for nearby communities.	Public Sector	Upgrade Asset	Technology, Enabling conditions
3	A417 Air Balloon	● Connect the two dual carriageway sections of the A417 near Birdlip in Gloucestershire, taking account of both the environmental sensitivity of the site and the importance of the route to the local economy. ● Add dedicated lanes for walkers, cyclists and horse riders, while retaining other sections to maintain local access for residents.	Public Sector	New Asset	Technology, Enabling conditions
4	A428 Black Cat to Caxton Gibbet	● Provide a new off-line two lane dual carriageway between Black Cat roundabout on the A1 in Bedfordshire and Caxton Gibbet roundabout on the A428 in Cambridgeshire. ● Net zero for own operations by 2030. ● Net zero for maintenance and construction activities by 2040. ● Supporting the rapid shift to zero carbon travel on roads by 2050.	Public Sector	New Asset	Technology
5	A66 Northern Trans-Pennine	● Dualling of the remaining single-carriageway sections on the A66 between M6 J40 Penrith and A1M Scotch Corner, creating a continuous dual carriageway across the Pennines. ● Promote modal shift to public transport.	Public Sector	Upgrade Asset	Technology, Enabling conditions

6	Bedtime Stories ad. Campaign	● A minute-long ad, which launched in 2018, features a father telling his daughter a bedtime story about "a very very strange" world with "horrible consequences" for children. ● Promote DECC's Act on CO2 carbon reduction initiative.	Private Sector	Intangible	Behavioural change
7	Brighton Mainline Upgrade Programme	● Upgrade the Brighton Main Line and address bottlenecks along the line. ● Smaller projects along the line including modified signal positions and enhanced track layouts to allow faster journeys and greater operational flexibility. ● Promote modal shift to public transport.	Public Sector	Upgrade Asset	Technology, Enabling conditions
8	Crossrail Programme	● A new high-frequency rail service which will increase rail-based capacity in London by up to 10% and cut journey times across London and the South East. ● Promote modal shift to public transport.	Public Sector	New Asset	Technology, Enabling conditions
9	Cycling Rail Scheme in Ashford	● Improve cycling access to stations and increases sustainable journeys by funding installation of cycle racks, security systems, ramps and cycle paths. ● Construction of a new cycling hub at Ashford International station, providing secure bike parking for 96 bikes and freely-available parking for a further 220. ● There were around 300 to 350 bikes parked at Ashford International station on typical weekdays, compared to around 100 bikes earlier in the decade.	Public Sector	New Asset	Technology, Enabling conditions
10	Didcot Garden Town	● Create a green community supporting the building of 15,000 homes, designed to encourage people to choose sustainable modes of transport.	Public Sector	New Asset	Technology, Enabling conditions, Practice
11	Disruptive Cooling Systems for Electrification Sub-Systems	● Develop an electric motor concept that will deliver 10-20% motor downsizing and weight reduction, improved vehicle packaging as well as total vehicle cost reduction. The final output from the project will be a well-developed 3D CAD concept design with manufacturing considerations, The output, will be used to communicate the vison to our UK and global customer base	Private Sector	R&D	New knowledge
12	East Coast Digital Programme	● The programme is seeking to bring about transformation through the introduction of digital technologies such as the European Train Control System; replacing conventional signalling with digital signalling on the East Coast Mainline South. This is the first mainline deployment of digital signalling and a critical pathfinder in the strategy to roll-out this technology across the whole rail network to provide a range of benefits such as increasing performance and lowering whole life costs.	Public Sector	Upgrade Asset	Technology

13	East Coast Mainline Programme	● The East Coast Main Line Enhancement Programme is a collection of track and power upgrade schemes between London King's Cross and Edinburgh to increase capacity and to enable the introduction of the Intercity Express trains through the East Coast franchise. ● Promote modal shift to public transport.	Public Sector	Upgrade Asset	Technology, Enable conditions
14	East West Rail Configuration State 1	● The East West Rail (EWR) programme will create a rail link from Oxford to Cambridge, and is a key part of the government's ambition for the Oxford to Cambridge Arc. EWR is being delivered as a single integrated programme, structured around the phased introduction of services (Connection Stages). East West Rail Connection Stage 1 (CS1) delivers services between Oxford and Bletchley/Milton Keynes. ● CS1 will re-construct and upgrade a partly disused railway between Bicester and Bletchley. This will allow for the introduction of new passenger services, improving connectivity and journey times along the corridor to support transport, housing and economic growth needs.	Public Sector	Upgrade Asset, New Asset	Technology, Enable conditions
15	Edinburgh Tram Network	● Edinburgh Trams is a tramway in Edinburgh, Scotland, operated by Edinburgh Trams Ltd. It is a 14-kilometre (8.7 mi) line between St Andrew Square in the New Town and Edinburgh Airport, with 15 stops.	Public Sector	New Asset	Technology
16	Ely Area Capacity Enhancements Programme	● Ely is geographically located on the West Anglia Main Line and the Cross-Country Corridor at the centre of five converging rail lines. Current infrastructure restricts the ability to operate any additional passenger or freight services through the area. The Cross-Country Corridor runs east to west through Ely and alongside passenger services, supports a nationally important freight route between the Port of Felixstowe, Britain's busiest container port, and regions including the Midlands and North-West. ● The programme will consider operational and infrastructure interventions required across the region to enable additional freight and passenger services to operate, supporting long-term growth. This includes modifications at Ely North Junction, in the Ely Station Area and to level crossings on the lines of route.	Public Sector	Upgrade Asset	Technology
17	Gatwick airport Electric Forecourt	● A partnership between Gatwick Airport and sustainable energy company GRIDSERVE will build the Gatwick Electric Forecourt – an electric charging located on the Ring Road South approach to Gatwick's South Terminal and adjacent to the M23 – it will enable 36 Electric Vehicles to be charged simultaneously, with high-power chargers that can deliver up to 350 kW of charging power	Public & Private Sector	New Asset	Technology
18	Gatwik Solar Farm	● First UK's airport with a solar power generation on site, thanks to 50 kW solar PV system	Public & Private Sector	New Asset	Technology

19	Great Western Route Modernisation (GWRM)	● An extensive programme to modernise existing infrastructure on the Great Western mainline. It has created faster and more reliable services, better stations and increased freight capacity. ● Promote modal shift to public transport.	Public Sector	Upgrade Asset	Technology, Enable conditions
20	HOV (High Occupancy Veichle) Lane in Leeds	● UK's first High Occupancy Vehicle (HOV) lane was introduced ● Only buses, coaches, other vehicles carrying 2 or more people allowed on the lane	Public Sector	Intangible	Enable conditions
21	HS2 Phase1	● HS2 will form the backbone of the UK's transport network, connecting eight out of ten of Britain's largest cities. By making it easier to move between the North, Midlands and South, cutting many journeys by half, HS2 will make it easier for people to live and work where they want. ● Promote modal shift to public transport.	Public Sector	New Asset	Technology, Enable conditions
22	HS2 Phase2a	● HS2 will form the backbone of the UK's transport network, connecting eight out of ten of Britain's largest cities. By making it easier to move between the North, Midlands and South, cutting many journeys by half, HS2 will make it easier for people to live and work where they want. ● Promote modal shift to public transport.	Public Sector	New Asset	Technology, Enable conditions
23	HS2 Phase 2b	● HS2 will form the backbone of the UK's transport network, connecting eight out of ten of Britain's largest cities. By making it easier to move between the North, Midlands and South, cutting many journeys by half, HS2 will make it easier for people to live and work where they want. ● Promote modal shift to public transport.	Public Sector	New Asset	Technology, Enable conditions
24	HydroFlex	● An electric passsenger train self-powered by adding a hydrogen-hybrid power system.	Public & Private Sector	R&D, Upgrade Asset	New knowledge, Practice
25	Hydrogen in an Integrated Maritime Energy Transition	● Project to develop hydrogen-based clean maritime solutions. The project explored solutions for decarbonising ferries as well as shore-side activities in ports.	Public & Private Sector	R&D	New knowledge
26	Innovative EV bus bars (EVBus)	● It is an Innovate UK collaborative project between STL and TWI Ltd, aiming to investigate an innovative Copper to Aluminium bonding technique for use in zero emission vehicle (ZEV) busbars. Busbars are an integral part of EV battery packs. Improving the busbar can lead to lighter packs, therefore extending the range of ZEVs.	Public & Private Sector	R&D	New knowledge
27	Intercity Express Programme	● It is an initiative of the Department for Transport (DfT) in the United Kingdom to procure new trains to replace the InterCity 125 and InterCity 225 fleets on the East Coast Main Line and Great Western Main Line.	Public Sector	New Asset	Technology
28	Living Streets- Walk To School Outreach (WTSO)	● Promoting walking in primary schools journeys below five miles. ● Provide the biggest opportunity for switching short car journeys to cycling and walking offering the potential to reduce the 68MtCO2e of current car emissions.	Private Sector	Intangible	Behavioural change

29	Lower Thames Crossing	● The Lower Thames Crossing (LTC) is a proposed new expressway connecting Kent, Thurrock and Essex through twin bored tunnels under the Thames. It will almost double the road capacity across the River Thames east of London and is the largest single road investment project in the UK since the M25 was completed more than 30 years ago. ● As a vital part of the UK's transport infrastructure, it will act as a catalyst for national and local economic growth. Building a reliable, modern new road that is fit for the future will help connect the nation's busiest ports to the distribution hubs in the North, Midlands and beyond. It will improve network resilience and the performance of the existing crossings at Dartford, transforming the regional and national road network.	Public Sector	New Asset	Technology
30	Midland Main Line Programme	● Sixth path into London and electrification from Bedford to Kettering and Corby, enabling environmental benefits, increase in capacity and improved peak long distance journey times. ● Infrastructure required to allow new bi-modes (to be introduced on the route) to operate in electric mode with no negative timetable impact.	Public Sector	New Asset	Technology, Enable conditions
31	Midlands Rail Hub	● Support the growth of the Midlands economy through better connections between the economic centres of Birmingham, Leicester and Nottingham. To make the most of the opportunities of the Integrated Rail Plan/HS2 and allow up to 10 additional trains (in each direction) to serve Central Birmingham. Up to 20 proposal are being examined across the region, but the centre piece of the scheme are two chords (connecting the Camp Hill Line to the Snow Hill Line) at Bordesley in Central Birmingham. This would allow trains that currently serve New Street to be diverted to Moor Street and Snow Hill stations, providing new journey opportunities and a convenient interchange with HS2's Curzon Street Station (via Moor Street). The scheme was a 2019 manifesto commitment and remains a key priority. Several elements of the Western Corridor (including Kings Norton - Barnt Green and Snow Hill Platform 4) are "Project Speed" candidates for acceleration and early delivery.	Public Sector	New Asset	Technology, Enable conditions
32	Phillips 66 Limited-Humber Refinery	● The project supports Humber Zero, a first-of-a-kind project backed by UK Research and Innovation, the largest public funder of research and innovation in the UK. Humber Zero is a collaboration between the Humber Refinery and combined heat and power company VPI-Immingham, a subsidiary of commodity trader Vitol, with participation from other businesses, organizations and academic institutions. Its goal is to capture up to 8 million tons of carbon dioxide per annum by 2030.	Private Sector	New Asset	Technology

33	Quick Change Sodium-Ion Traction Battery for Commercial Vehicle Applications	● The aim of the project is to publicly introduce a lower cost sodium-ion traction battery alternative to the commercial vehicle industry.	Private Sector	R&D	New knowledge
34	South West Route Capacity	● The aim of the South West Route Capacity Programme was to deliver increased capacity into and from London Waterloo during the busiest times of the day through: . Improvements to London Waterloo platforms 1-4 . The reopening of the Waterloo International Terminal . The lengthening of platforms to accommodate 10 carriage trains between Reading, Ascot to London Waterloo station. ● Promote modal shift to public transport.	Public Sector	Upgrade Asset	Technology, Enable conditions
35	Thameslink Programme	● A significantly enhanced high-frequency rail service which will increase rail-based capacity in London and across the wider South East and provide new journey opportunities.	Public Sector	New Asset	Technology, Enable conditions
36	Transpennine Route Upgrade	● The TRU programme will deliver journey time improvements, additional services, increased passenger capacity, enhanced performance and reliability and improved environmental performance to the main rail link across the Pennines between Manchester and York via Huddersfield and Leeds. ● Promote modal shift to public transport.	Public Sector	New Asset	Technology, Enable conditions
37	Vehicle Electrical Systems Integration (VESI)	● The aim of the project was to develop new technologies and methodologies for the integration of electrical systems in vehicles, with a particular focus on reducing the weight, complexity, and cost of these systems.	Private Sector	R&D	New knowledge
38	Western Rail Link to Heathrow	● The Western Rail Link to Heathrow (WRLtH) is a proposed new rail link between Langley Station on the GWML and Heathrow Airport Terminal 5. It would speed up journeys to Britain's busiest airport by allowing passengers from the west of England and Wales to travel to the airport without going into London Paddington. Government support for the scheme is subject to the agreement of a satisfactory business case and an acceptable financial contribution from Heathrow Airport Limited. ● Promote modal shift to public transport.	Public Sector	New Asset	Technology, Enable conditions
39	York's Zero Emission Park and Ride fleet	● £3.3 million from the UK Government to introduce 21 electric double decker buses and vehicle charging infrastructure. Joining 12 already operating to form the UK's largest zero emission park and ride bus fleet.	Public Sector	New Asset	Technology

40	ZeroAvia- HyFlyer II project	● The aim of this project is to develop a zero-emission, hydrogen-electric powertrain for regional aircraft. In 2020, the company ZeroAvia demonstrated the world's first flight of a commercial grade aircraft with hydrogen-electric engine (ZeroAvia, 2023). The company aims to use this successful demonstration of hydrogen-electric jet engines to develop larger and more powerful zero emissions powertrains.	Private Sector	R&D	New knowledge
41	ZEROe Demonstrator	● Test hydrogen combustion propulsion technology on an A380 multimodal platform	Private Sector	R&D	New knowledge

5. Findings: Answer to the third research question

This section addresses the third research question: "How successful are those projects in achieving net zero?".

For each of the four project types analysed in the previous research question, two case studies characterised by different degrees of success will be analysed. An exception will be made for the unsuccessful case of R&D project that instead is missing, further explanation will follow in the dedicated section 5.3.

The success of the projects will be evaluated utilising the Lavagnon Ika & Jeffrey K. Pinto framework introduced in the paper: *"The "re-meaning" of project success: Updating and recalibrating for a modern project management."* (Ika & Pinto, 2022).

5.1. Three domains of success

The framework evaluates the success of projects under three different domains: project plan success, business case success and green efficacy.

1. **Project Plan success** refers to the extent to which the project objectives and goals outlined in the project plan have been achieved. In other words, project plan success is about measuring the project's success based on how well it adhered to the plan and met the requirements, timelines, budget, and other specifications outlined in the project plan. The sample of projects collected includes only projects already completed. Hence, being project plan success assessed immediately or soon after project completion (Ika & Pinto, 2022), this will be the easier domain to analyse.
2. **Business Case success** refers to the degree to which the project delivered the intended benefits or value to the organisation. It is about measuring the project's success based on how well it achieved the strategic objectives from a medium-term point of view.

3. **Green Efficacy** refers to the extent to which the project successfully achieved its environmental goals or sustainability targets. Among the three domains, this is the most long-term oriented.

The last two domains require a longer time horizon to correctly evaluate the success of a project. For example, a typical assessment of the economic rate of return (ERR) of a World Bank-funded project may include benefit flows that last 25-30 years. Sustainability considerations may take decades or centuries (Maltzman & Shirley, 2015).

Given that constraint and given that the project sample of the analysis contains only projects completed in the last decade, in some cases, it is still not possible to state with empirical evidence whether or not the projects were successful.

However, given the importance of the green efficacy domain for the scope of this research, this domain will be analysed, referring to the expected environmental benefits and the project's contribution in reaching the UK Net Zero Objectives analysed before.

After this clarification, it is possible to analyse some examples of successful and unsuccessful projects for each of the four categories: New Asset, Upgrade Asset, Intangible and R&D.

5.2. Projects Type: New Asset

Intercity Express Programme

In 2002, the intercity fleet operating around the United Kingdom was reaching the end of its expected lifecycle, being brought into service at the end of the 70's. Moreover, DfT studies demonstrated that by 2015-16, many trains would be operating well above capacity (National Audit Office, 2013).

In that context, DfT started to plan the Intercity Express Programme (IEP) to procure and introduce a completely new fleet of trains.

At the beginning, three options were considered for improving services on intercity routes: new intercity express trains, upgrades to existing intercity trains; and buying

new trains based on designs already in service. Due to a higher benefits-cost ratio, the first option was chosen, making the IEP fall into the P&P category of New Asset.

The programme formally started in 2005. DfT was in charge of sponsoring the procurement of 866 Super Express electric and bi-mode train carriages from the selected manufacturer Agility Trains, a company led by Hitachi Rail.

In particular, DfT was responsible for guaranteeing the train manufacturer that the franchise operator would enter into contracts to utilise the trains for 27,5 years (National Audit Office, 2014).

To assess if project plan success was achieved, it is possible to analyse to what extent the project objectives and goals expected have been realised and if the project met the requirements of time and budget.

The main objectives behind the new procurements were: reducing the long-term cost of the fleet; Increased capacity per train; Faster and more reliable journey times; Improve safety; and creating more environmentally sustainable trains (National Audit Office, 2014).

According to Global Railway Review, these objectives were fulfilled (Hammond, 2014). The new trains are characterised by faster acceleration and higher maximum speed, 19% more seats and greater luggage capacity. Regarding the long-term cost, having new trains means a lower cost of maintenance, both for the train and the tracks; the latter are in fact less damaged from lighter trains like the new intercity fleet.

The IEP also performed well regarding cost and time, almost sticking to the same initial budget and schedule. The latest expectation of DfT estimates that, including future payment, the programme's total cost should be around £7.65 billion (National Audit Office, 2014).

The programme was completed by delivering the last train in 2020, just two years after the date hypothesised in 2005: the initial estimation was to conclude the programme in 2018, but some delays occurred due to the government's review of all infrastructure projects during the spending review and the challenge of securing finance as a result

of the financial crisis and euro crisis between 2008 and 2012 (National Audit Office, 2014).

Hence, having achieved the desired objective under the constraint of time and cost planned just with little reasonable variances, it is possible to conclude that the IEP has achieved project plan success.

Differently, it is not possible to completely assess whether or not business case success has been achieved, given the little time that has passed since the end of the programme. However, according to the latest expectations, the programme should be able to deliver the intended benefits to the organisation with a benefit-cost ratio of 2.7 to 1 (National Audit Office, 2014).

Table 10 Benefit-cost ratios of the two programmes (trains and wider infrastructure progrmmee)

Benefit-cost ratios of the two programmes (trains and wider infrastructure programme)

Intercity Express	
Date	Benefit–cost ratio[1,2,3]
December 2006	5.0
May 2009	1.2
December 2009	2.0
June 2012	2.7

Benefit–cost ratios do not include wider economic benefits.

Table 10: Benefit-cost ratios of the two programmes (trains and wider infrastructure progrmmee), National Audit Office (2014)

Lastly, it is possible to analyse the third domain of success: green efficacy.

Already in 2007, DfT abandoned the idea of introducing diesel-powered versions of the Intercity Express, choosing a mix of electric and bi-mode trains (electric + diesel) instead. The second type is however characterised by a reduction in the weight of the

train of 15–40% per seat, almost 86 tonnes less in total, which leads to a 15% reduction in fuel consumption (Agility Trains, n.d.).

Moreover, one of the main objectives of the programme was to increase the capacity of the Intercity express network in order to face the expected increase in demand, so for sure the IEP goes in favour of the UK Net Zero Goal of "Accelerating modal shift to public and active transport (Dft 2021)".

Hence, also if it is too early to assess precise environmental benefits of the programme, it is reasonable to think that IEP will also achieve green efficacy, being so, an example of "holy grail" project achieving all three domains of success.

Edinburgh Tram Network (ETN)

Since 1956, various companies and corporations have operated horse-drawn, cable-driven, and electric trams for public transport. However, after that year, the tram services were dismissed in favour of buses and a few commuter rail lines.

In the late 20th century, there was a renewed interest in trams in the UK, and networks were reintroduced in Birmingham, Croydon, Manchester, Nottingham, and Sheffield. In that context, in 1999, the City of Edinburgh Council proposed a plan for a new tram network along Princes Street and Leith Walk to Newhaven with an operative fleet of 27 trams.

During its lifecycle, the ETN project encountered various problems, such as contractual disputes, worries about safety, and resistance from the nearby community. All these issues generated several delays in project delivery. First, in 2009 phase 1b of the project was delayed because of a funding shortfall, then after some projections that estimated the completion of the project in 2012 but went over budget, the Council decided to change the operator from the initial company to Edinburgh Trams Limited, delaying even more the delivery date (BBC News, 2009).

All the further issues that delayed the project are not going to be listed, it is enough to know, for the scope of the research, that ETN was completed just in 2014, far away

over budget. In particular, from an initial projected cost of £375 Million, the project ended up costing £776 Million without considering interest cost on a 30 years loan, bringing the overall cost of the project to over £1 Billion (McKie, 2014).

Hence the ETN project can be a clear example of project plan unsuccess.

In order to assess the business case success, it is possible to analyse the benefits the project has brought to the owner and operator Edinburgh Trams Limited.

The key trends for Edinburgh Trams Limited since it commenced operations in May 2014 are reported in the table below:

Table 11 Key trends of ETN from 2014 to 2021

	2014	2015	2016	2017	2018	2019	2020	2021
Turnover (£m)				12.99	15.81	16.75	5.19	6.29
Operating profit (£m)	-0.45	-0.25	0.25	1.60	-9.40	-7.88	-7.68	-7.21
Net Profit after tax (£m)				1.29	-7.62	-8.99	-8.87	-8.76

Table 11:Key trends of ETN from 2014 to 2021, Data retrieved from Annual reports of Edinburgh Transport Limited

Despite Edinburgh Trams made a pre-tax profit of £252,000 for 2016, against a predicted loss of £170,000, achieving profitability two years ahead of schedule, this result does not consider maintenance and infrastructure cost. Including also these costs, shows that the ETN has been operating in a huge operating loss since 2018 (Edinburgh Trams Limited, 2022).

Hence, also from a business case point of view, ETN was an Unsuccessful project.

Fortunately, green efficacy seems to be successful. In 2021 Edinburgh Trams Limited signed the Edinburgh Climate Compact, a binding commitment for businesses to reach Net Zero target emissions by 2030 (Edinburgh Trams Limited, 2022). Furthermore, the

operator is also adopting other measures regarding energy efficiency of its fleet in order to reduce their footprint.

Below is a recap table of the actual emission of the ETN

Table 12 GHG emission year by year

GHG emissions CO2e (tonnes)	2019	2020	2021	2022
Traction Power	542.64	469.28	527.84	332.65
Non-Traction Power	60.82	58.89	58.12	33.43
Heating Gas	133.60	114.14	76.82	97.27
Diesel	9.46	6.80	14.40	18.21
Total	746.52	649.11	677.18	481.56

Table 12: GHG emission year by year, Edinburgh Tram Limited, 2023

Lastly, it is possible to connect the ETN to the wider UK Net Zero Goal of "Accelerating modal shift to public and active transport (Dft 2021)" reported in the first research question.

As shown in the graph below, since 2014 the number of citizens utilising the tram network has increased by around 40%, meaning a lot of cars are off the road.

Figure 24 Number of ETN passengers over time

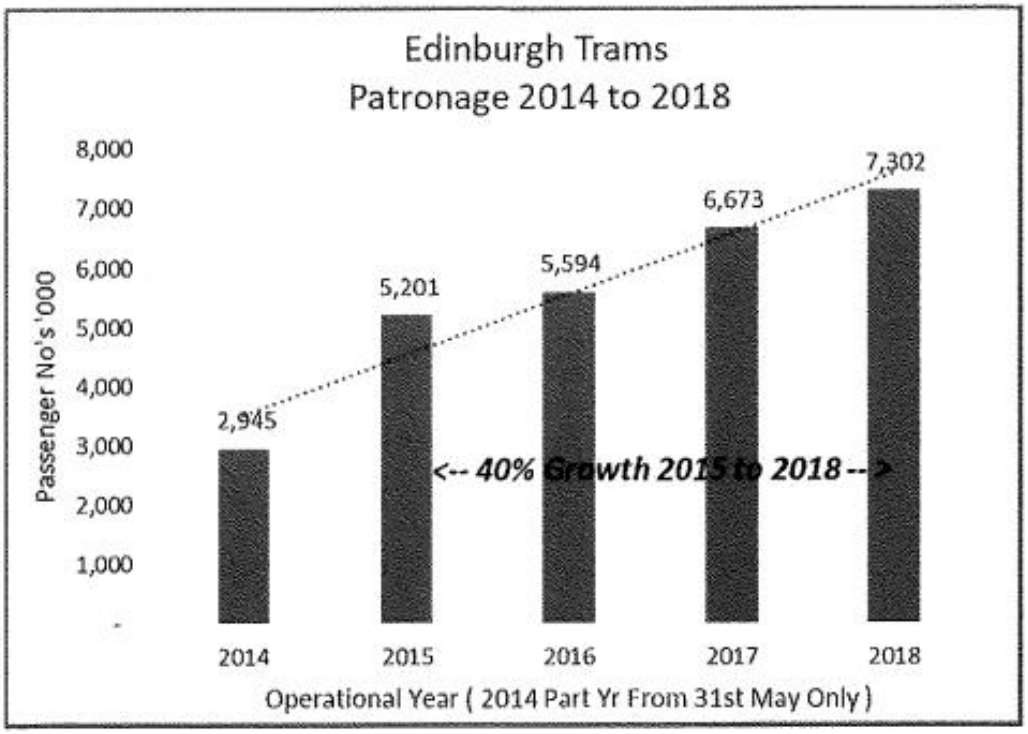

Figure 24: Number of ETN passengers over time, Edinburgh Tram Limited, 2018

So the ETN project, utilising the Tesseract model, falls into the category of projects that fail in both the project plan and business case aspects but succeed in green efficacy.

5.3 Projects Type: Upgrade Asset

HydroFlex- The first UK Hydrogen-Powered train

HydroFlex is a perfect *"holy grail"* case: a complete success under all three domains. The project was not over budget and was completed in the expected time. The concept development started in October 2018 and finished just after two months (Calvert et al., 2021); between that date and the Rail Live 2019 there were just nine months. In this time, equipment had to be procured, installed, tested, and finally operated (Calvert et al., 2021). Hence, project plan success was achieved.

During Rail Live 2019, some demonstrations were conducted with people on board, and all succeeded (Calvert et al., 2021). The demonstrations were so successful that even if HydroFlex was expected to be just a demonstrator prototype, DfT provided

further funding through its Innovate UK FOAK 3 programme to test HydroFlex on the UK mainline railway system.

Overall, the HydroFLEX project showed the possibility of operating hydrogen-hybrid trains, fulfilling its strategic objective and achieving business case success.

Regarding green efficacy, it is definitely too early to assess the outcomes of the project interim of Co2 reduction. However, given that the learning experience and data gathered from the HydroFLEX project will continue to inform the design of follow-on classes of hydrogen trains (Calvert et al., 2021), HydroFlex is contributing to the UK Net Zero Objectives, in particular, to "Remove from the network all diesel-only trains by 2040 (DfT, 2021)".

Thameslink Programme

The Thameslink Programme is a megaproject not yet concluded to upgrade and expand the Thameslink rail network in the south of London.

The programme was first proposed in 1991, but the work started just in 2009 after that permission was granted, and funding was approved.

The programme's main objective is to reduce overcrowding and increase the capacity of commuter services north and south of London and on London Underground (National Audit Office, 2013) by running higher frequency, longer trains on an expanded network (National Audit Office, 2017b).

In 2004 Thameslink was the second worst commuting route out of central London and already exceeded the passenger capacity by 2.7%, and at the time a consistent increase in passenger demand was expected (National Audit Office, 2013).

In that context, DfT sponsored the upgrade of the Thameslink rail network.

The programme consists of three interrelated projects:

1. Improvements to rail infrastructure (budget £3.55 billion)
2. Buying a fleet of longer, more reliable trains and building maintenance depots to support them (budget £1.6 billion)

3. Redesigning and reletting the Thameslink routes to deliver the new timetable and new connection (no info available about the budget for this project)

Considering also the high number of stakeholders involved, it is clear that overall the programme is highly complex.

Over its lifecycle, the programme has encountered many issues, raising questions about whether DfT underestimated the scale of work, the time it would take and the skills and resources needed to negotiate a deal of this complexity (National Audit Office, 2013).

In 2017, DfT had not yet fully mapped out the critical path of the programme to estimate a completion date (National Audit Office, 2017a).

The overall length of the project was initially estimated to be eight years, with a completion date in 2015. Soon the duration was revised to eleven years, and completion date in 2018.

Today, the Thameslink programme has not been completed yet and the most recent expectation date the completion of the project to 2026, a delay of 11 years from the initial projections (DfT, 2022b).

Below is provided a recap of the major milestone delays that have occurred until 2017.

Table 13 Key procurement dates

Key programme milestone	Planned delivery (set in the ITT)	Revised delivery (set 2010)	Actual delivery	Delay from original date (and reasons where available)
Invitation To Tender issued	November 2008	–	November 2008	None
Closing date for bids	April 2009	–	June 2009	2 months (bidders requested an extension to allow more time to develop the financial side of the bid)
Preferred bidder announcement	October 2009	March 2010	June 2011	20 months (6 months' delay caused by the Spending Review. During this period the Department also issued five sets of supplementary instructions to bidders)
Financial close and contract award	March 2010	October 2011	Expected Spring 2013	3 years, 1 month as at 26 April 2013 (Commercial close achieved in December 2012)
First new train in service operating at 16 trains per hour	First half of 2012	July 2015	–	3 years
All new trains in service operating at 24 trains per hour	December 2015	December 2018	–	3 years

Source: National Audit Office analysis of the Department's data

Table 13:Key procurement dates, National Audit Office, 2013

Also, the budget was revised and increased many times during the execution of the project.

The infrastructure budget increased by 9.4% from the 2012 budget (2017 prices) (National Audit Office, 2017b), and today the overall cost of the project is expected to be £7,166.70 (DfT, 2022b), an increase of 49% from 2013 data.

Hence the Thameslink programme is classified as a project plan unsuccess.

Regarding business case success, it is not easy to assess given that the project is not yet 100% completed, but it is possible to have some insight thanks to various update analysis conducted by the National Audit Office (NAO).

NAO sets out the programme's economic case by estimating the benefit-cost ratio.

As shown in the graph below, the ratio decreased over time since the beginning of the project, going from an initial 2.1 to 1 in 2007 to 1.24 to 1 in 2015 (National Audit Office, 2017a).

Figure 25 Change in Thameslink Programme benefit-cost ratio over time

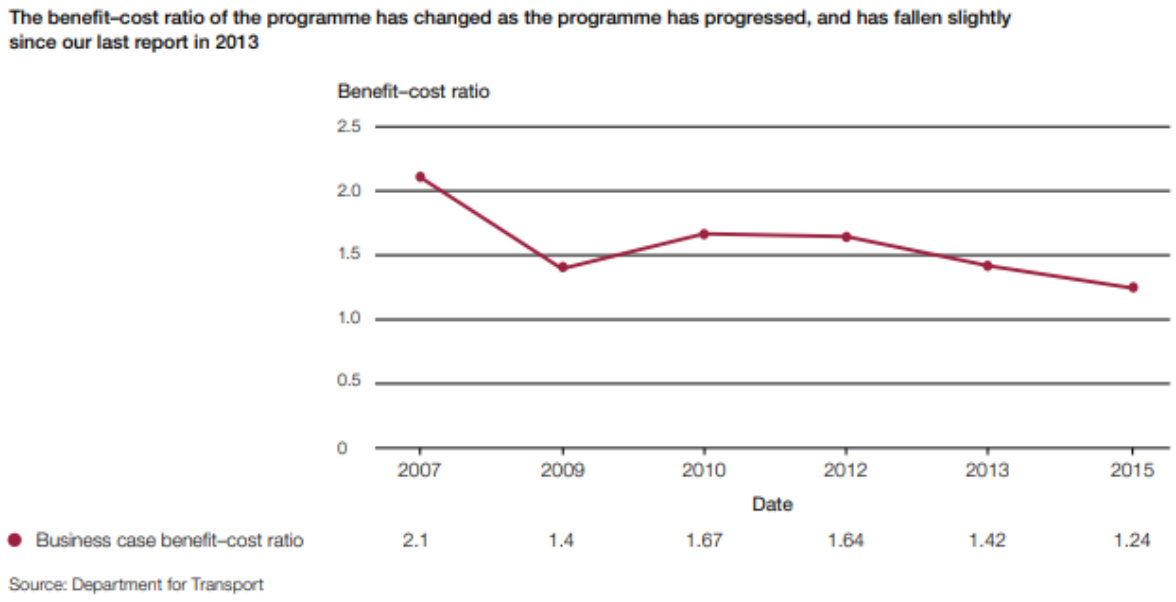

Figure 25: Change in Thameslink Programme benefit-cost ratio over time, National Audit Office, 2017a

Hence, even if the benefits-cost ratio decreased over time, the project's business case success seems achievable.

Lastly, regarding the green efficacy of the project, it is definitely too early to assess the exact benefits of such a megaproject. However, the programme's main objective is to increase the line's capacity, allowing more people to utilise the service. This goes in favour of the UK Net Zero Goal of "Accelerating modal shift to public and active transport (Dft 2021)".

Moreover, Govia Thameslink Railway, the line operator, is taking several commitments to reduce its footprint. So, it is reasonable to think that the green efficacy for this major railway programme will be achieved in future.

Table 14 Main environmental trends

Environmental impact decarbonisation and air quality	2021/22	2020/21	2019/20	Trend
Total carbon emissions from all scope 1&2 sources (tonnes)	163,880	183,818	220,563	Decrease
Carbon emissions per vehicle mile (all energy) (kilograms)	0.55	0.60	0.64	Decrease
Average fleet diesel efficiency (miles per gallon)	4.90	6.40	5.33	Decrease
Rail EC4T efficiency (vehicle miles/kilowatt hour)	0.41	0.41	0.41	–
Water	**2021/22**	**2020/21**	**2019/20**	**Trend**
Amount of water consumed (cubic metres)	396,706	330,662	330,662	Increase
Confirmed water losses (cubic metres)	51,929	33,219	33,219	Increase
Waste	**2021/22**	**2020/21**	**2019/20**	**Trend**
Total waste generated (tonnes)	4,056	3,275	6,634	Increase
Recycling rate (%)	37.6%	35.8%	31%	Increase
Climate Change Adaptation	**2021/22**	**2020/21**	**2019/20**	**Trend**
Climate Change Adaptation risk register (Yes/No)*	Yes	Yes	Not applicable	–

* Indicator reported from 2021 (no information for previous years)

Table 14: Main environmental trends, Govia, 2022

5.4. Projects Type: Intangible

Living Streets- Walk To School Outreach (WTSO)

As seen in the findings of the second research question, this is an example of an intangible project with behavioural change as key deliverable. To assess whether it has been a successful initiative or not it is possible to analyse the programme's outcomes. No data about project management success have been found. Differently, several statistics permit to assess business case success and green efficacy of the programme.

A final evaluation conducted by DfT (DfT, 2020) shows that the WTSO programme between 2017 and 2019, by working with 275 primary schools, has encouraged around 10,000 extra children and around 2,500 extra adults to walk to school. Overall the programme resulted in an increase of 38% in walking rates in participating schools, meaning 1.3 million fewer school run car journeys and 4 million new walking trips generated over the period of the programme.

Moreover, from an economic point of view, it is estimated that families could save up to 400£ a year by walking to school instead of using a car, and an independent study demonstrated that every 1£ spent on WTS project can result in a return of 7.64£ to the wider community (Living Streets, n.d.).

Finally, walking to schools also helps children achieve the recommended government target of 60 minutes of physical activity a day (Living Streets, n.d.).

So, given these statistics it's possible to state that the WTSO programme is a clear case of a successful intangible project.

Bedtime Stories

Another example of intangible project is the advertising campaign "bedtime stories", but in this case, the behavioural change desired as key deliverable of the project did not happen, instead triggering a wave of protests.

With the passing of the 2008 Climate Change Act, the UK Government's Department of Energy and Climate Change (DECC) (since 2016 is part of BEIS) developed the "Five Point Plan", a predecessor strategy of today's Ten Point Plan.

One of the five points to tackle climate change was represented by the "Act on CO2", a £6 million information campaign to challenge citizens to reduce their consumption and so their emissions (DECC, 2009).

Part of the campaign consisted in "bedtime stories", a short TV advertisement where a father tells his daughter a bedtime story. The story proposes a frightful Earth's future scenario in which animals and people suffer and die from the causes of climate change generated by human behaviour.

The advertising aimed to make adults feel guilty about their carbon emissions that were going to threaten their childrens' future.

The advertising resulted in a total mess: After just one month, the Advertising Standards Authority (ASA) received around 360 complaints about the ad. According

to the audience, the message promoted by the ad was too scary for childrens (BBC News, 2009).

Even if there is no information about project plan success, It is possible to state that the project was for sure a business case failure. In fact, the desired behavioural change did not occur and instead generated a wave of complainants questioning the scientific basis of the claim that climate change is man-made.

The problem causing the insuccess of the ad can be found in the tone of the message sought:

Fear-based messages can be an effective tool in gaining public attention, however, there is also a tendency for individuals to dismiss extreme situations as unlikely or too distant (U4 Anti-Corruption Resource Centre, 2011). Evidence of this also comes from the National Society for the Prevention of Cruelty to Children (NSPCC), according to which their most hard hitting campaigns were in many ways the least successful.

5.5. Projects Type: R&D

Vehicle Electrical Systems Integration (VESI)

As reported before in the first research question, one of the key principles of the UK Net Zero Strategy is to "work with the grain of consumer choice", this means that sustainable choices have to be the most accessible and convenient to customers.

Today, the need for EV vehicles is clear (DfT 2021), but the cost is the most significant barrier for customers. The cost of the battery mainly drives the high cost of EVs, in fact the cost of the electrical power train is much higher than that of the ICE vehicle(UKRI, n.d.).

To address these issues, a great deal of underpinning basic research needs to be carried out (UKRI, n.d.). In that direction HM Government is providing a huge amount of funds to R&D projects in the field of EV technologies.

Among the others is proposed as a case study the Vehicle Electrical Systems Integration (VESI) project, the largest power electronics project funded by the UK research councils as a single project (UKRI, n.d.). Funded with £3.154.532 by the UK's

Engineering and Physical Sciences Research Council (EPSRC), the project brings together 10 UK-leading research groups in power electronics and electrical machines, with the aim of developing new electric vehicle (EV) technologies that should solve two main issues: the cost and power density of the electrical drive system, both of which are key barriers to bringing EVs to the mass market (Warwick University, n.d.). The project involved several academic and industrial partners, including University of Warwick, University of Manchester, University of Bristol, City University of London and others among the academic.

Including Jaguar Land Rover, McLaren Automotive, and TRW Conekt among the industrial.

The VESI project divided the overall problem into six research themes (work packages, each assigned to a different academic partner:

1. Power Semiconductors (Warwick)
2. Design Tools (Newcastle, City, Manchester)
3. Packaging (Nottingham)
4. Motors (Cranfield and Newcastle)
5. Converters (Manchester, LJMU, Newcastle, Southampton)
6. Passive components (Bristol, Manchester, Sheffield)

After the completion of the project, all the six research themes were achieved, respecting time and cost projected and bringing new knowledge to the specific theme. Es. The VESI filter inductor prototype developed in work package n.6 allowed to deliver an inductor capable of an energy density of 1.2 J/kg, relatively higher if compared to commercial values of 0.1-0.2 J/kg, or even to the values hypnotised in prior publications of 0.2-0.8 J/kg (Mawby, n.d.)

Moreover, the project has led to 55 different scientific publications (UKRI, n.d.), the award of the ESCAPE project from EPSRC and also generated spin-outs like THE THINKING POD INNOVATIONS LTD (a start-up company focusing on innovative low-cost, power-dense solutions for power electronic conversion, in particular those employing wide band-gap semiconductors).

Lastly, the project has allowed the development of greater understanding and action amongst governments and policy makers in accompanying and supporting international standardisation of WBG-based power electronics (UKRI, n.d.).
Hence the VESI project is an example of a "holy Grail" R&D project with new knowledge and technology as key deliverables by achieving project plan success, business case success and green efficacy.

R&D unsuccessful case study

As mentioned before, neither sourcing from DfT's project database nor other Government documents nor from credible external sources, has been possible to find enough information to build this case study. The reason for this gap can be found in the characteristics of R&D projects undertaken in this field. Even if the UKRI provides funds to many UK private R&D projects, most of them are characterised by relatively small dimensions. Hence, they are not exposed to the same degree of transparency as, for example, infrastructure megaprojects. So, information about their failure under the three domains of success has not been found available.

6. Discussion

6.1. First research question

"What are the actual Goals, Principles and Objectives of UK Net Zero policy?"

The UK government has taken a serious commitment to tackle climate changes. In order to do that has built a consistent Net Zero Strategy based on Principles, Goals and Objectives.

The adopted Principles are the strategy's foundation, setting some fundamental values of how the transition to a greener economy should be set in place. In particular, Principle 1:" work with the grain of consumer choice", ensures that environmentally friendly choices should become the most convenient for consumers and that they should be able to have the necessary information on the impact of their consumptions.

Principle 2: "Ensure the biggest polluters pay the most" and Principle 3: "Ensure that the most vulnerable are protected through Government support" should make sure that the transition happens fairly and safely by ensuring that big corporations responsible for much more emissions rather than the average citizens bear the cost of this disproportion. At the same time, the transition should protect the poorest member of society through government intervention and support.

Lastly, Principle 4: "Work with businesses", recognises the importance of solid cooperation between businesses and the Government in fostering green innovation and sustainable practices.

These four Principles give the direction toward the general goals of the strategy. The UK is committed, of course, to: "End the domestic contribution to man-made climate change by 2050" and, simultaneously, take advantage of the opportunities generated by the transition and "Level up the country". In fact, in order to reach the first challenging goal, new technologies must be developed, new sectors will arise, and huge investments will be required, creating new job opportunities for UK citizens and an opportunity for UK businesses to establish themselves as leaders in green technologies.

Hence, to translate these broad and general goals into achievable actions, the UK Government continuously revise its strategy through objectives and target settings.

In particular, this research analysed how the Carbon Budgets fix the maximum amount of emission allowed in each five year period. As of today, the sixth CB is the latest legally binding target and sets a reduction of emissions by at least 78% below 1990 levels in the five year period 2033-2037. An ambitious target almost in line with the one settled by the EU of a 55% net reduction in GHG emissions by 2030 (European Commission, 2021).

In order to achieve these general goals and objectives, it is essential to decompose this overall strategy into a set of precise, short-term oriented actions all over each sector of the economy. So, the sector by sector analysis collects and highlights the set of objectives and target indicators that guide the Government in the transition. Objectives

that are not fixed but are subject to changes depending on new technological, economic and societal opportunities and, of course, boundaries.

6.2. Second research question

"What types of projects have been done in the UK to achieve net zero?"

Achieving such targets in terms of decarbonisation is not an easy task. Here comes the role of projects: projects and programs are essential for achieving a desired future by providing a structured approach to managing change (Huemann & Silvius, 2017).

So in the second research question, several transport sector projects have been analysed to understand how the public and private sectors are concretely acting to achieve the goals mentioned above and objectives. To better understand how each project contributes to the UK Net Zero Strategy, Marco Terenzi's classification of project type and key deliverables has been used.

The main insight from this part of the research is that all project types have their specific role in the transition, as well as decarbonisation potential.

For example, R&D projects are essential to deliver decarbonisation technologies in time for the binding deadlines and to fulfil the general goal of positioning the UK as a leader in the green transition or the more specific transport goal of positioning the UK as a hub for green transport technology and innovation.

Moreover, R&D projects are important considering Principle 1(Work with the grain of consumer choice). In fact, thanks to R&D projects like the Low Carbon Vehicle Innovation Platform (LCVIP) or Vehicle Electrical Systems Integration project (VESI), it will be possible to gradually reduce the cost of greener solutions like electric vehicles, making them more accessible to the vast majority of citizens.

Intangible projects have also demonstrated their importance in giving necessary information to citizens about the footprint of their activities and suggested alternative behaviours that are more environmentally friendly. In particular, thanks to projects like Living Streets- Walk To School Outreach (WTSO), it has been possible to understand the importance of intangible projects aiming at behavioural changes to

achieve the first priority goal for the transport sector: "*Accelerating modal shift to public and active transport*".

Lastly, new asset and upgrade asset projects have demonstrated essential in order to directly reduce emissions related to big infrastructures like railways, tram and bus networks and indirectly, by increasing their capacity and efficiency, always more people choose to utilise public transport rather than diesel cars.

These types of projects, given their complexity, tend to be the most costly and long in terms of duration but are also projects that can potentially change the country by shaping urban and non-urban mobility. Efficient and capillary transport infrastructure reduces the cost of delivered goods, facilitates the physical mobility of people and products, removes productivity constraints, and increases competitiveness (World Bank, 2022), so in the end, contributing to the UK Net Zero goal of levelling up the country while ending the domestic contribution to man-made climate change.

6.3. Third research question

"How successful are those projects in achieving net zero?"

The last step of the research has been to analyse the different degrees of success of the projects completed in the UK, utilising the Lavagnon Ika & Jeffrey K. Pinto framework.

Below is a summary table of how the projects selected have achieved or not project plan success, business case success and green efficacy.

Table 15 Projects' success recap table

Table 15: Projects' success recap table

P&P Type	Project	Goals and objective addressed	Project Plan Success	Business case success	Green efficacy

New Asset	Intercity Express Programme (IEP)	Accelerating modal shift to public and active transport	YES	YES	YES
	Edinburgh Tram Network	Accelerating modal shift to public and active transport	NO	NO	YES
Upgrade Asset	HydroFlex	Remove from the network all diesel-only trains by 2040	YES	YES	YES
	Thameslink Programme	Accelerating modal shift to public and active transport	NO	YES	YES
Intangible Project	Living Streets-Walk To School Outreach (WTSO)	-50% of all journeys in towns and cities walked or cycled by 2030 -Increase the percentage of children aged between 5 and 10 that usually walk to school, from 49% to 55% by 2025	YES	YES	YES
	"Bedtime Stories" ad. campaign	All	YES	NO	NO
R&D	Vehicle Electrical Systems Integration (VESI)	-Zero Emission cars % over the total fleet of 25% by 2030 and 50% by 2035 -Target % pathway of new sold car by emission type until 2032	YES	YES	YES

As seen from these examples, various can be the causes of success or failure of projects. Sometimes megaprojects like the IEP can be a complete success, and instead, a simple advertising campaign like Bedtime Stories can be a total failure. Or even sometimes, two projects run by the same organisation, like IEP and Thameslink programme, can have such diverse results in terms of success. However, investigating the critical success factor of these projects is not in the scope of this research. Instead, what matters for its purpose is the only commonality between almost all these projects: all achieved or are supposed to achieve green efficacy.

The point is that even if some projects took longer than expected, ran over budget and did not deliver the intended economic benefits, resulting to be a total failure under project plan and business case point of view, they still can deliver environmental benefits and be means through which the UK can reach its ambitious Net Zero goals and objective.

Finally, even if some projects seem to be not worth given their problems in sticking to time and budget, today is clear the evidence of the cost of inaction. According to the Office for Budget Responsibility (OBR), in their delayed action scenario, public sector debt could be 23% higher than in their early action scenario by 2050 (Office for Budget Responsibility, 2021).

The direct costs of decarbonisation throughout the next 30 years will be less than 1% of UK GDP (Rt Hon Chris Skidmore MP, 2023), and according to CCC, the indirect effect of the transition could instead generate a 2% additional growth in UK GDP.

Differently at worldwide level, transitioning to a decarbonised energy system based on green technologies by 2050 can save the world at least $12 trillion, compared to continuing our current levels of fossil fuel use (Way et al., 2022).

7. Conclusion

This report represents the case study about how the UK's public policy regarding climate change is impacting the landscape of projects and programs across the country. Before concluding the findings of this report, it is important to talk about the background and the set of ideas or theories that formed the foundation of our research. We believe in climate change as an established fact. The scientific data that has been thoroughly verified and analysed in multiple reports on climate change by the IPCC and other scientific organisations clearly shows that human activities have contributed to the rise in average atmospheric temperature of our planet and if we keep following the same trajectory, by the mid century we will reach at a point where the climate change will become irreversible and it will trigger a chain reaction of climatic disasters which will render our planet inhospitable for most of life. The world took its time to realise the seriousness of this threat but in 2015, in Paris, they finally joined hands to fight climate change and they agreed to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels (UNFCC, 2015). This target was

set after thorough analysis of scientific data from different fields that if we can limit the average increase in surface temperature within the above limit, we can control our climate and stop it from getting out of control.

Many different theories and ideas were put forward by the world community but the two ideas that got unanimous attention of the world leaders were sustainability and net zero. These ideas gradually picked up popularity and now they have become the core ideas of our present day human civilization especially in Europe and America. Both these ideas present a greener planet where conditions will be favourable for life and the resources of the planet will be utilised more carefully without damaging our ecosystem. Now here comes the important question that became the foundation of this report. "How do we achieve these ideas? How can we make our world more sustainable and reduce our GHG emissions to zero?" Questions like these are of particular interest for project managers. Questions like the one above encapsulate the very definition of project management as these questions trigger innovation and lead to the development of unique products or services to achieve specific goals within the constraints of cost, time and quality.

Questions like these are not only of interest for project managers, rather it concerns everyone. Every individual is concerned about the future of the planet on which they live. Everyone is concerned about the future of their generations. With rising awareness and concern on climate change among the general public, it was inevitable for the world governments to devise and clarify their policy about this issue. This led the world leading democracies to take concrete actions and they started publishing their climate change policies. Public policy is a tool through which social-economic problems are addressed on a national level. Public policy is formed around certain goals which are motivated by some principles and in order to achieve those goals, smart objectives are decided which gives us a frame of reference for the future.

Coming back to the question of how we can achieve net zero, we can conclude based on the arguments in the above paragraphs that the fields of project management and public policy can provide answers to this question. As discussed many times in

different sections of this report, to achieve net zero, there has to be sharing of knowledge between different fields. There is a greater need for mutual cooperation between different scientific fields as it will trigger innovation, process improvement and economies of scope and scale both. Closely observing the two fields of project management and public policy together, we found striking commonalities and between the two fields. Both these fields are intended to find solutions to new problems. Both these fields have goals and objectives that guide the decision making process and activities of the professionals working in those fields. These commonalities caught the focus of our report.

To highlight the importance of a deeper and constructive coordination between the two fields, we decided to analyse the UK as a case study. In 2018, the UK became the world's first major economy which adopted a legally binding target to achieve net zero by 2050. In 2020, an energy white paper was published by the UK government which served as a precursor to the UK's detailed net zero policy published in 2021. The UK is also a country which has a considerable reputation in the field of project management. Therefore we choose three interlinked questions to analyse the landscape of coordination between the fields of public policy and project management in the UK. In the next paragraphs we will conclude our findings to each of the research questions.

First research question was intended to understand the structure of the UK net zero policy. The problem with the policy documents is that they are crowded with data and can be very confusing to comprehend unless we have an agreed frame of reference. The frame of reference that we chose to analyse the UK's net zero policy was through defining its goals and objectives. Without any goals and objectives, the policy has no direction and can never be effective. The challenge was the goals and objectives are not explicitly mentioned in the policy report. We dived deeper to understand the evolution of net zero policy in the UK. In the first research question, we explained the structure of the UK's net zero policy. The policy is divided into six sectors. Each sector has its own specific goals and objectives. These goals and objectives, they all revolve

around the four main principles of preferring the consumer choice, ensuring the biggest polluter pays more, protecting the most vulnerable and working with business. Therefore, we observed that goals and objectives of each sector were very diverse.

The UK aims not only to build a better, greener world but it also wants to take it as an opportunity to strengthen its economy and aspire to become world leader in green energy. Despite many challenges like COVID-19 and Brexit, the UK reported good progress on its net zero targets. One of the main reasons for this success was the carefully crafted and cohesive public policy. The goals and objectives of each sector leverage on the strengths of that sector. For example in the energy sector, the UK wants to take advantage of its nuclear technology to transition into an emission free energy sector. The objectives are to enable more funding into nuclear technology while reducing the cost of nuclear power by 30%. Similarly reaping the advantage of its technological and geographical position, the UK has laid an objective to quadruple its offshore wind capacity to 40 GW by 2030. These are just a few examples of how elaborate and cohesively curated policy the UK has. Analysing the UK's public policy in detail, we can conclude that the carefully curated, well coordinated and cohesive goals and objectives are the main reason for the UK's good progress towards its target of achieving net zero by 2050.

The next questions were intended to understand the impact of the UK's public policy on the projects and programs in the country. P&Ps are drivers for change. They provide us the tools through which we can project a certain future and weigh its benefits or losses. In order to achieve net zero, projects and programs are crucial. Projects and programs are mostly restricted by the limitations of cost, quality and time hence it restricts innovation and slows down the speed of progress. Net zero is an urgent matter. We are already running late. Our survival depends on it. One way to achieve this goal sooner, is to promote certain types of projects and programs by devising a clear policy. This argument is supported by the findings of the second research question. In the case of the UK, we found in the analysis that all the projects are well protected and incentivized by the policy. We mainly focused on the transport

sector. We analysed data of 40 projects under the transport sector. The data about the projects were taken from the government database and we found all the projects were well connected to the policy goals and objectives. We categorised the projects into 4 categories as conceptualised by Marco Terenzi in his research paper. Our observations also represent the practical application of Marco's classification of net zero transition P&Ps. In the transport sector, the top goal towards the net zero future is to adapt a modal shift towards public transport. We found that the public sector P&Ps are mostly connected to this goal. Most of the public sector projects in the UK belong to the upgrade asset category where the existing infrastructure of public transport like trains, trams or buses is being improved and enhanced.

Exporting emission free transport is also mentioned as a policy goal and we observe that the UK government is providing support to many companies to invest in research and development projects. This has led to a new competition in the UK's private sector where we observe many interesting and innovative projects like converting diesel trains into hydrogen powered trains and making the first working prototype of a hydrogen based jet engine. Unlike the public sector which is more focused on upgrading asset types of projects, the private sector is more inclined towards the categories like research and development and new assets. We also observe that both private and public sectors are equally active in intangible projects where they are encouraging people to adopt walking or cycling for journeys shorter than 5 km. In conclusion, our observations support the idea of four categories of net zero transition P&Ps namely, upgrade asset, new asset, R&D and intangible.

In the last research question, we intended to establish that projects and programs are the most effective tools for the implementation of the UK's net zero policy and in general. For each of the 4 categories of net zero transition P&Ps, we analysed the success and failure case studies. The conclusion is that all the categories of net zero transition P&Ps are equally important to achieve net zero. It is difficult to objectively define one category better than another. All the categories have some success stories and some failures too. Another challenge for the third research question was the

agreed frame of reference for the project success. Project success is a subjective debate which is subjected to the individual interpretation of stakeholders involved. We used Ika and Pinto's framework of analysing project success using a tesseract model. We observed that some projects were successful along some dimensions while they did not perform well along other dimensions. For example the high speed project is a complete failure in terms of project plan success but in terms of its green efficacy objectives, it is a success that it will contribute a lot to the goal of modal shift to public transport. In short, all the four categories can contribute equally in net zero transition and the field of project management can prove to be very helpful in implementation of net zero policy effectively as well as efficiently.

This report concludes that the UK's net zero policy represents a success case of coordination between the fields of project management and public policy. There is a room for improvement which requires further research in this topic. Through the UK's case study, we have observed that a carefully curated public policy can direct the project and programs not only in the public sector but also in the private sector. In turn the projects and programs can play the most important role in the implementation of net zero policy.

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