February 2024

Strategic Assessment

CCS-TTD-XXXX-XX-BC-SN-000001

North London Carbon Capture Project
North London Waste Authority

Glossary

Glossary	
AACE	Advancement of Cost Engineering
AQMA	Air Quality Management Area
BAT	Best Available Technique
BCR	Benefit Cost Ratio
CAPEX	Capital Expenditure
CCC	Climate Change Committee
CCS	Carbon capture and storage
CCSA	Carbon Capture Storage Association
CCUS	Carbon capture, usage and storage
CCSC	Carbon Capture Steering Committee
COMAH	Control of Major Accident Hazard Regulations
CO_2	Carbon Dioxide
COP	Conference of the Parties
COSHH	Control of Substances Hazardous to Health
DBFOM	Design, Build, Finance, Operate and Maintain
DCO	Development Consent Order
DESNZ	Department for Energy, Security and Net Zero
EA	Environment Agency
EfW	Energy-from-Waste
EIA	Environmental Impact Assessment
EPC	Engineering, Procurement and Construction
ERR	Economic Regulatory Regime
FBC	Final Business Case
FEED	Front End Engineering Design
GGR	Greenhouse Gas Removals
GSP	Government Support Package
HMT	His Majesty’s Treasury
HPC	Hot Potassium Carbonate
HSC	Hazardous Substances Consent

ICC	Industrial Carbon Capture
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquified Natural Gas
LPA	Local Planning Authority
MAPP	Major Accident Prevention Policy
MRP	Minimum Revenue Payment
MSD	Market Stakeholder Development
MW	Megawatts
MWth	Megawatt Thermal
NLCCP	North London Carbon Capture Project
The Authority	North London Waste Authority
NLWP	North London Waste Plan
NMA	Noise Management Area
NPPS	National Procurement Policy Statement
NPS	National Policy Statements
NSTA	North Sea Transition Authority
NSIP	Nationally Significant Infrastructure Project
OBC	Outline Business Case
Ofgem	Office of Gas and Electricity Markets
OPEX	Operational Expenditure
PA2008	Planning Act 2008
P&R	Policy and Regulation
PIN	Prior Information Notice
PPA	Planning Performance Agreement
PWLB	Public Works Loan Board
RMP	Risk Management Plan
SA	Strategic Assessment
SOC	Strategic Outline Case
SoS	Secretary of State
SRO	Senior Responsible Officer
T&S	Transport and Storage

T&SCos	Transport and Storage Companies
TCPA	Town and Country Planning Act
UK ETS	United Kingdom Emissions Trading Scheme
UKIB	United Kingdom Investment Bank

Executive Summary

North London Waste Authority (the Authority) has established the North London Carbon Capture Project (NLCCP) to deliver an operational Carbon Capture (CC) plant at the Edmonton EcoPark as soon as practicable in the mid-2030s.

The Authority is currently building a new Energy Recovery Facility (ERF), which will replace the existing Energy-from-Waste (EfW) facility, providing the very best facilities to treat north London's residual waste. By implementing Carbon Capture and Storage (CCS) technology, this will strengthen its efforts to tackle the climate emergency, support the UK's overall effort to achieve Net Zero, and represent a source of pride for residents in the constituent north London Boroughs.

This Strategic Assessment (SA) makes the case for the NLCCP and sets out high level considerations on how such a scheme could be delivered. It has been written in line with HM Treasury (HMT) Green Book guidance on appraising programmes and projects, and builds on the previous pre-feasibility study and the additional SA Stage technical studies.

The SA concludes that the scheme strongly aligns with policies to tackle climate change, and would address a range of strategic challenges the Authority would otherwise face.

The most significant risk facing the NLCCP relates to developing a commercially viable and technically feasible solution to transport captured CO_2 from the Edmonton EcoPark to a licensed Transport & Storage company (T&SCo), which would then be expected to store the carbon in undersea geological formations, such as depleted oil and gas fields.

To make the costs of the scheme comparable or cheaper than the 'Do Nothing' case, the following two conditions would need to be met:

- The price of carbon under the UK's Emissions Trading Scheme (ETS) will need to exceed £133 per tonne of CO_2; and
- The ETS will need to be expanded beyond fossil fuel emissions, so that EfW emitters such as the Authority can monetise emissions from biogenic sources (a policy generally referred to as negative emissions).

The Authority has put in place a range of actions to mitigate these risks, including a Market and Stakeholder Development (MSD) workstream to gain a fuller understanding of the emerging carbon capture and storage market, understand the Transport and Storage (T&S) challenges, and also a programme of advocacy on key government policies.

As a result, this SA concludes that there are no project 'show-stoppers', and recommends that the NLCCP should progress to the next stage, which will culminate in the production of a shortlist of potential solutions and a preferred way forward; this will be reflected in a Strategic Outline Case (SOC).

Further key recommendations include:

- Undertake further research and technical studies to identify the most appropriate T&S solutions to develop of a shortlist of technically and commercially feasible options.
- Use the shortlist to explore further studies and procurement routes required for the preferred transport and permanent storage solution.
- Undertake further work to identify the most appropriate planning pathway, and how best to manage the interface between obtaining consents and procuring the delivery of the NLCCP.

Strategic Case

There is a strong case for developing the NLCCP, with the schemes strong alignment with policies to tackle climate change at international, national, regional, and local level.

The NLCCP would address the challenges the Authority would otherwise face in terms of CO_2 emissions, charges under the UK ETS, and the fact it is unable to significantly alter the nature of the fuel (i.e. residual waste that cannot be recycled) for the ERF.

The development of CC technology and a UK transport and storage industry should be expected to make the scheme more attractive over the coming years, and the NLCCP would be expected to create a number of 'green jobs' for the local economy, particularly during the construction phase.

A number of CC technologies have been reviewed and post combustion absorption – specifically amine and hot potassium carbonate (HPC) – currently appear to be the most favourable technology option for the NLCCP. This will be kept under review as the NLCCP progresses.

A range of emerging transport and storage options have been identified, which are assessed in the Economic and Financial Cases. Bacton has been selected as the theoretical location for a potential interface point with a T&SCo to allow options to be compared on a like for like basis. The modelled options are:

- Direct Pipeline to Bacton;
- Direct Trucking to Bacton;
- Intermediate pipeline to Isle of Grain and then Ship to Bacton;
- Intermediate trucking to Isle of Grain and then Ship to Bacton;
- Intermediate pipeline to Thames Port and then Ship to Bacton;
- Intermediate trucking to Thames Port and then Ship to Bacton;
- Intermediate barges to Thames Port and then Ship to Bacton; and
- Intermediate trains to Teesside Port and then Ship to Bacton.

The most significant risks to the NLCCP relate to finding a commercially viable transport solution, not being able to trade in negative emissions, and delays in obtaining planning consent. However, the process of assessing the NLCCP's risks has not identified any 'show-stoppers', and mitigation measures have been proposed for all those identified.

Strategic Case recommendations

The SOC stage (Stage 1) should explore the following key areas:

- What the optimal technology for the CC plant should be, which will require ongoing engagement with the supply chain; and
- What technically feasible, deliverable and commercially viable intermediate transport and storage solutions are available; this will require work to establish strategic partnerships with providers, investigate and assess alternative methods of transporting and storing carbon, and engage with stakeholders on shared storage facilities.
- What the preferred T&SCo or T&SCos should be.

The Authority should also engage with the Department for Energy Security and Net Zero (DESNZ) with a view to securing a more supportive policy framework on negative emissions and support for Energy-from-Waste operators and dispersed emitters in developing T&S solutions.

Economic Case

The Economic Case takes into consideration benefits of the CC plant in terms of direct benefits to the Authority, indirect benefits to wider public sector and indirect benefits to society. In the 'Do Nothing' option, there is an external financial cost to the Authority in the form of the ETS liability on the fossil-fuel derived CO_2 emissions as well as a societal issue in the form of the 700,000 tonnes of CO_2 released into the atmosphere by the ERF.

There is a societal value to preventing that CO_2 from reaching the atmosphere, which can be measured through the Economic Case. The value of this CO_2 is sufficient to create a positive Benefit Cost Ratio (BCR) in all of the other options, making all CC plant options preferable to the Do Nothing option.

Economic Case recommendations

In order to inform future Economic Case appraisals in the SOC and Outline Business Case (OBC) stages, the following further work should be conducted:

- Insofar as possible, model greater usage of shared transport modes with other emitters with a view to realising greater economies of scale, such as large ships; and
- Modelling of alternative transport methods such as electric trucks.

Commercial Case

The CC plant is expected to be achieved through three separate phases:

- pre-Front End Engineering Design (pre-FEED);
- Front End Engineering Design (FEED); and
- Engineering and Procurement and Construction (EPC) contract.

The EPC contract could combine all elements of works required at the Edmonton EcoPark site.

Based on soft market testing, the Authority should procure a number of FEED studies in order to facilitate a competitive EPC procurement for the plant. This reflects the complex nature of the NLCCP, and the understanding that no contractor would be prepared to bid for an EPC contract without having undertaken FEED studies.

The high-level procurement timeline based on the Indicative Plan to Operations shows:

- Stage 2 (OBC) completion in the second half of 2028;
- Awards for the CC plant EPC contract, transport and T&SCo by the second half of 2030; and
- Service operation by the second half of 2035.

Government policy on financial support for the CCUS market may impact on the commercial approach taken, with the following insights being particularly important:

- Trading in negative emissions would provide an important revenue stream for the NLCCP, and while the government has not enabled Waste Industrial Carbon Capture (ICC) projects to do so yet, it has publicly acknowledged the benefits of this approach, suggesting policy change in this area could occur; and
- There are currently no revenue support mechanisms open to dispersed emitters such as the NLCCP, and while this may change as the government transitions from the current Waste ICC contracts to a competitive allocation model in the late 2020s, the distances required to transport captured CO_2 may still make obtaining support challenging.

Commercial Case recommendations

The SOC stage should explore the following key areas:

- The scope of the separate studies required for intermediate transport and permanent storage and their interface with the FEED studies, which is focussed on the CC plant;
- Durations of any additional transport and permanent storage procurement activities;
- Whether – under an intermediate transport scenario – separate contractual arrangements would be required with multiple transport mode operators and an intermediate node, or this could be simplified through forms of packaging and sub-contracting (potentially with a T&SCo undertaking permanent storage);
- Whether the FEED contractors will be able to provide sufficient information on the expected CC plant and its operations to enable a planning application to be submitted prior to the EPC contractor – and thus the final designs – being selected;

- How the Authority could procure the EPC contractor from the pool of contractors undertaking FEED studies in alignment with public procurement regulations; and
- How the contracting and procurement approaches are impacted by the financing strategy adopted by the Authority, given the Government's direction of travel towards a competitive allocation model.

In addition, the Authority should ensure that the challenges facing it as a Waste Disposal Authority and a dispersed emitter are voiced by responding to upcoming government consultations and calls for evidence.

Financial Case

The Financial Case projects the direct revenues and costs for the Authority associated with delivering the NLCCP with the objective of understanding funding/ financing gaps, potential sources and overall affordability.

Given certain assumptions, the NLCCP can be cost comparable or cheaper than paying for UK ETS allowances on the carbon emitted. The main assumptions are as follows:

- That where carbon, capture and storage (CCS) is applied to ERF facilities, that the UK ETS allows for negative emissions credits, effectively allowing the EFW operator to sell additional CO_2 credits into the ETS, generating a revenue stream to the CC plant.
- That UK ETS allowances do reach the levels currently being forecast by DESNZ by the mid-2030's, levels of in excess of £133/t and that such levels are sustained.
- In order for CCS to be cheaper than paying UK ETS allowances, it would be advantageous if other emitters were transporting CO_2 in a similar way to the Authority, as economies of scale on transport (especially pipelines and shipping) would significantly reduce the financial impact on the Authority.

The Authority is a 'dispersed' emitter with modelled transport costs for the CC options (including capital repayment) in the range £30-40/t, which is comparable to estimates of the additional transport cost for other EFWs not near a cluster of £35/t. The sensitivities in Section 0 show that significant savings of up to £25/t could be made if many other emitters use the same transport mode.

For context, the figures have been expressed as £/t as it is acknowledged that the Authority's waste will vary over time and therefore the net impact on the levy will be a function of the number of tonnes of residual waste that the Authority treats at its facility (estimates for 2024/25 of ~570kt). Actual figures will vary depending on the level of Authority tonnages and whether the ERF accepts third party residual waste, which would improve economies of scale.

Finally, it is worth noting that the application of the UK ETS to waste facilities represents a significant new burden on the Authority's finances and hence the finances of the constituent Boroughs, regardless of whether they decide to implement CCS or not. This should be a material part of any discussions about future local authority financial settlements.

Financial Case recommendations

- Further investigation should be undertaken into the potential for local clusters or grouped emitters, as these options appear to be the most affordable if other emitters are also transporting CO_2; and
- Further investigation is made into the potential for low or zero carbon trucks, as these could offer the lowest cost and lowest CO_2 impact for the initial phase of removing the CO_2 from site.

Management Case

The Management Case for the NLCCP demonstrates a robust structure for managing the current SA stage and provides clear insights for the SOC stage.

At the SOC stage, the Business Case will be continuously updated, with the addition of pre-FEED studies, the shortlist of options and preferred way forward identified, and the development of the procurement and contracting strategy.

Timescales for the planning process will depend on which planning route identified as the most appropriate for the project. At this time, there are benefits and disbenefits to both the Development Consent Order (DCO) and Town and Country Planning Act (TCPA) pathways, and the decision of which pathway to utilise will be impacted by emerging government policy on Nationally Significant Infrastructure Projects (NSIPs).

On permitting considerations for the NLCCP, at this stage it is not expected that Control of Major Accident Hazards (COMAH) will apply, while further investigation is required to understand if Hazardous Substance Content (HSC) is required for the CC plant. If HSC is required, the Authority would apply for the appropriate permits at the same time as planning consent, having to show compliance with an established 'Exception Test' which relates to flood risk.

Management Case recommendations

The SOC and future stages of the Business Case should explore the following key areas:

- Further external assurance measures will need to be implemented as the NLCCP enters Gate 1 of the Gateway Review Process;
- The Authority should continue to consider the appropriate planning pathway for the NLCCP and review policy around new CC projects being proposed as NSIPs;
- Consider the extent to which further planning and environmental work could be carried out at the next stage of the CCS project to facilitate consideration and rationalisation of the emerging design options;
- Once a preferred CC technology is chosen, the NLCCP team should reevaluate if COMAH and HSC will apply to the CC plant;
- The Authority should consider what work should be prioritised to ensure consent can be obtained without delays; and
- Timely risk management should continue, with the regular identification, analysis, evaluation, and treatment of risks.

1 Introduction

1.1 Project background

The Authority was established in 1986 and is the statutory waste disposal authority for the London Boroughs of Barnet, Camden, Enfield, Hackney, Haringey, Islington, and Waltham Forest (the Constituent Boroughs). The Authority's primary function is to arrange for the transportation and disposal of waste collected by the Constituent Boroughs and to promote waste minimisation and recycling.

The Authority disposes of most of the Constituent Boroughs' residual waste (waste that cannot be recycled) at the Edmonton EcoPark located in north London. The Authority is replacing the existing EfW facility with a new, modern ERF as part of the North London Heat and Power Project (NLHPP).

The ERF will have the capacity to process up to 700,000 tonnes of waste each year and will generate around 78 megawatts of energy (MWe). The new ERF will contribute to the net zero economy by diverting waste from landfill and generating low carbon heating for local homes and businesses.

In recognition of the climate crisis, the NLHPP Carbon Management Strategy commits the Authority to achieving a net zero carbon status for the operational phase of the ERF.[1] As a result, the NLCCP has been established. This aims to deliver an operational CC plant at the Edmonton EcoPark as soon as practicable in the mid-2030s, once the existing EfW facility is demolished.

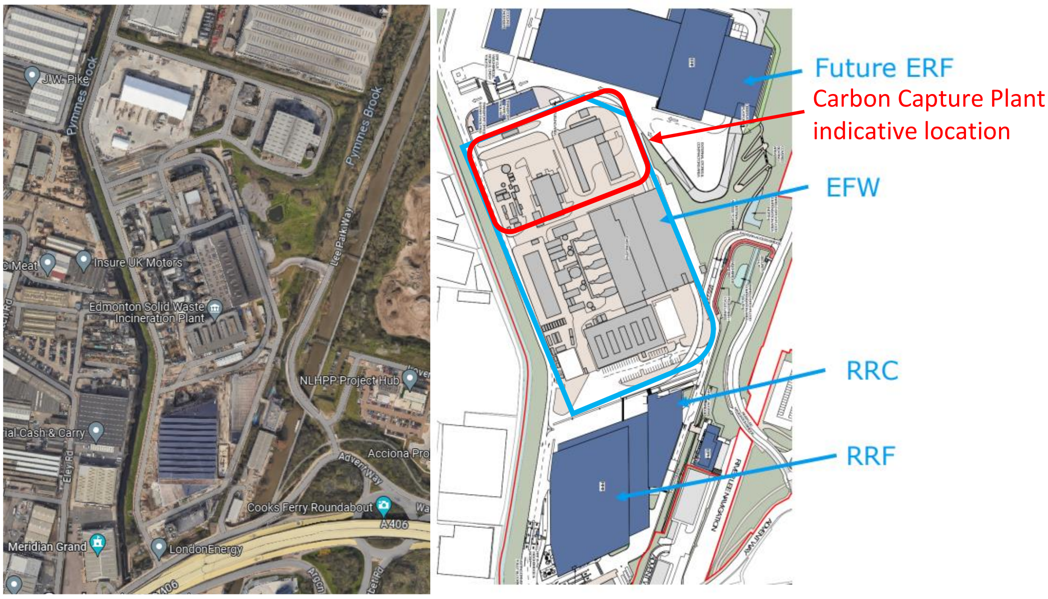

Figure 1: Edmonton EcoPark with existing ERF facility and indicative location of proposed CC plant

Key to the successful delivery of the CC plant is the parallel delivery of a viable transport and permanent storage solution. The Authority is exploring a range of pipeline and non-pipeline modes of transport to carry the captured CO_2 from the Edmonton EcoPark site to permanent geological storage.

By capturing and permanently storing CO_2 emissions from the new ERF, the Authority will align with national, regional and local net zero targets, and will support north London's wider objectives of creating green jobs, boosting the local economy, and contributing to local climate action.

1.2 Carbon Capture Usage and Storage

Carbon Capture Utilisation and Storage (CCUS) refers to a set of processes that capture CO_2 from gases produced at industrial facilities and either permanently store it in geological storage sites (this being CCS) or reuse it in industrial processes such as the production of chemicals, minerals, plastics

1 The Authority: North London Heat and Power Project – Carbon Management Strategy, 11 May 2021; link here.

and synthetic fuels (Carbon Capture and Utilisation (CCU)). CCS and CCU are considered together as CCUS.

The process for CCS – referred to as the CCS value chain – involves three steps:

- Capturing CO_2 from power plants or industry (including waste management processes) and compressing it to a liquid or dense state;
- Transporting the CO_2 to a T&SCo, which will then take responsibility for moving the CO_2 to deep geological storage; and
- Permanently storing the CO_2 in these sites.

This process is summarised in Figure 2 and each element is set out in more detail below.

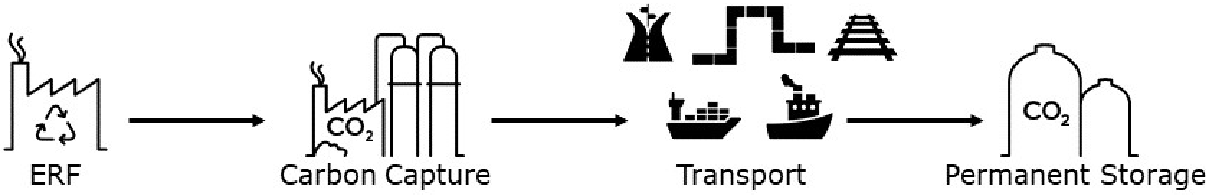

Figure 2: Carbon capture and storage value chain

1.2.1 Carbon capture

The NLCCP aims to implement a mature post-combustion CC technology at the new ERF, including appropriate compression and storage facilities. The CO_2 from the residual waste treated at the ERF will generally take two forms:

- **Biogenic carbon:** This is CO_2 that is part of Earth's natural carbon cycle, which is absorbed, stored and emitted through organic processes such as the lifecycle of trees and plants. Examples of waste containing biogenic carbon includes. food waste, green waste, paper, card or tissue.
- **Non-biogenic carbon (fossil):** This is CO_2 that is not from the natural carbon cycle, and instead stems from coal, oil, and natural gas. Examples of waste containing non-biogenic or fossil carbon including plastic or some textiles such as polyester or nylon).

It is important to note that the waste sector is unique in processing both biogenic and non-biogenic emissions; for example, biomass power stations would typically emit exclusively biogenic emissions, whereas gas power stations or steel production facilities would only produce non-biogenic emissions.

Actions for the reduction of greenhouse gas emissions typically target non-biogenic emissions on the basis that they are overtly manmade contributions to climate change. From a climate change perspective, biogenic CO_2 is considered to have a neutral impact.

By removing not only human-origin emissions, but emissions that would have happened naturally, the net emissions into the atmosphere against the 'baseline' natural cycle becomes negative, as less CO_2 is being released than would otherwise occur in nature. As a result, the CC plant is expected to make the ERF net negative.

1.2.2 Transport

As noted above, the next stage in the value chain is to transport CO_2 – either directly or via an intermediate node for further onward transportation – to a T&SCo, which would then take the carbon to deep geological permanent storage.

A T&SCo is defined as a company licensed to provide transport and storage services for CO_2. A number have entered the market in recent years, including some existing oil and gas companies. These have been supported by the government's cluster sequencing policy, which has seen funding allocated to four industrial clusters in the north-east and the north-west of England and in Scotland.

A key challenge for the NLCCP is that the ERF is what is referred to as a 'dispersed emitter', which encompasses those emitters that are inland or more 'isolated' relative to clusters of emitters, including those within the government's cluster sequencing competition.

As a result, the NLCCP is exploring a number of pipeline and non-pipeline modes (including road, rail, inland freight barges and shipping) to transport CO_2 from the Edmonton EcoPark site to a range of possible intermediate locations before being transported onwards to permanent storage.

1.2.3 Permanent storage

CC is expected to utilise deep geological formations underground as permanent storage, including depleted oil and gas fields or deep saline aquifers. Although suitable stores can be found onshore, the UK is expected to focus exclusively on offshore storage.

This is due to the scale of deployment needed to meet the UK's ambitions, combined with the fact that the UK has some of the most significant offshore CO_2 storage in the world, with potential capacity estimated at 78 billion tonnes.[2]

1.2.4 Status of Carbon Capture in the UK

CC technology is widely expected to be key in mitigating against climate change and helping the UK reach its CO_2 reduction targets, and there are 64 individual projects across the UK under development across a range of industries including cement manufacturing, iron and steel production and biomass energy.[3]

However, according to the Global CCS Institute as of November 2023, there were no operational applications of CCS in the UK.[4] While key enablers include a maturing CCS value chain, growth of the green jobs sector and a broadly-supportive policy and legislative framework, key barriers remain in relation to high infrastructure costs, lack of commercial viability and concerns around safety.

This SA will consider the Authority's proposed scheme in this context, and explore these themes further in the following sections.

1.2.5 Carbon Capture and Usage

Following early appraisals, the Authority's proposal is expected to focus on CCS as opposed to CCU. The three principal reasons for this are summarised below:

- While CO_2 can be permanently stored in concrete for use in construction by a chemical process referred to as mineralisation, at present there is no assessment of this solution over time, and therefore it is unlikely that this technology would be suitable for a number of years. In addition, the quantities required are small, posing the barrier of captured CO_2 supply exceeding demand;
- The supply of CO_2 requires purification to 99% to meet Food Standards Agency standards for 'food-grade CO_2' for all uses in the industry, which can be cost prohibitive; and
- As noted above, the market for CO_2 in the UK is small compared to the quantity of CO_2 requiring removal. A report commissioned by the Food & Drink Federation states that

[2] Department for Business, Energy and Industrial Strategy: Deep Geological Storage of CO_2 on the UK Continental Shelf, February 2023; link here.
3 Carbon Capture and Storage Association: UK Carbon Capture Project Pipeline, 1 December 2023; link here.
[4] Global CCS Institute: Global Status of CCS 2023, November 2023; link here.

'Industry sources estimate annual consumption of around 600,000 tonnes of CO_2'.[5] For comparison, the NLCCP alone is expected to capture 632,000 tonnes of CO_2 per year.

NLCCP's focus on CCS will remain under review as it progresses, and should any of the above factors evolve so as to make CCU more viable for the NLCCP, this will be considered at the appropriate stage.

1.3 Project stages

The NLCCP follows the HMT Guide to Developing the Project Business Case.6 In accordance with this guidance, the NLCCP's technical feasibility, commercial viability, affordability, and deliverability have been assessed through a SA Stage. This will be followed by a further three stages: Stage 1 –SOC; Stage 2 – OBC; and Stage 3 – Full Business Case (FBC). Upon successful approval of the FBC, construction will commence.

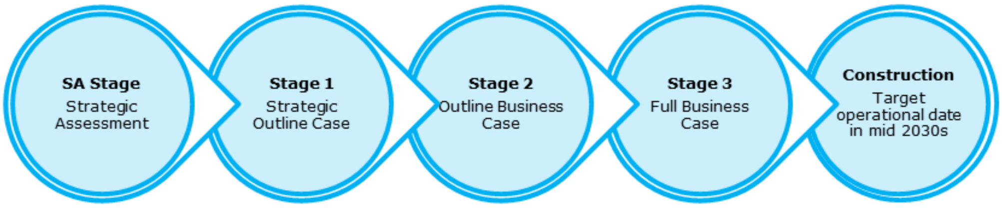

Figure 3: Progress through the NLCCP stages to construction

The SA Stage aims to define the NLCCP objectives and target outputs, explore technology and transport and storage options, the implications of the evolving policy and regulatory framework, funding requirements as well as the management and execution approach for subsequent delivery of the NLCCP. This should give stakeholders an early opportunity to influence the direction, scope, and content of the NLCCP. The NLCCP is currently at the SA Stage.

The SOC (Stage 1) is set to commence after completion of the SA Stage. This stage will reaffirm the strategic context for the NLCCP, make the case for change and identify a shortlist of options and a preferred way forward.

The OBC (Stage 2) is set to commence following the completion of Stage 1, and should enable agreement on a single preferred option. It should involve the submission of an Environmental Permit application, Environmental Impact Assessment and a full planning application. At the conclusion of Stage 2, the Authority's senior decision makers will be able to consent to the procurement phase of the NLCCP and the beginning of Stage 3.

The FBC (Stage 3) will run in parallel with the procurement of the CC plant, intermediate transport solution and an agreement with a T&SCo. The approval of the Final Business Case should align with receipt of planning consent and enable all delivery contracts to be awarded.

The Construction, Implementation and Monitoring Stage will see construction of the CC plant, after successful progress through the previous Stages. The CC plant has a target operational date of around the mid 2030s.

1.4 Current stage and workstreams

The NLCCP is currently in the SA Stage with the workload being split across six different workstreams:

- **Project Management (PM) and Assurance:** Establishing all project management controls putting in place the necessary governance and gateway procedures based on the HM Treasury Guide to Developing the Project Business Case and the Infrastructure and Projects Authority Assurance Process;
- **Engineering and Technical:** Undertaking detailed design development to deliver CC solution which considers all integrated requirements with the ERF and future transport and permanent storage network;
- **Business Case Development:** Developing the NLCCP Business Case following the Five Case model guidance established by HMT Guide to Developing the Project Business;

[5] Food & Drink Federation: Falling flat: lessons from the 2018 UK CO_2 shortage, 30 April 2019: link here.
[6] HM Treasury: Guide to Developing the Project Business Case, 2018; link here.

- **MSD:** Leading and assisting on the building of effective relationships with all relevant internal and external stakeholders, potential transport and storage operators and other regional emitters. Also, identifying and accelerating opportunities to establish a regional and/or London-wide CC cluster;
- **Planning, Environmental & Stakeholder:** Leading on planning and environmental policy review, circulation of updated environmental constraints maps, and commencement of stakeholder mapping for consenting process; and
- **Economic and Financial:** Leading and developing an initial model and working with the Engineering and Technical workstream to secure model inputs and agree model parameters. Also preparing the Economic and Financial Cases of the SA and subsequent Business Cases, and supporting MSD and Policy & Regulation (P&R) workstreams.

1.5 Purpose and structure of this Strategic Assessment

This SA sets out the case for the NLCCP, and provides an initial view on how such a scheme could be delivered. As noted, this has been written in line with HMT guidance, and the five chapters are as follows:

- Strategic Case: This chapter sets out the strategic context against which the NLCCP is being developed; the issues that the Authority would face without the NLCCP and those drivers that make developing it attractive; a summary of the strategic objectives and critical success factors that will guide the NLCCP's development; details on the proposed intervention and options; and an overview of the key risks, dependencies and constraints that the NLCCP is likely to face;
- Economic Case: This chapter seeks to monetize the societal benefits of delivering the NLCCP set out in the Strategic Case, and weighs these against the societal costs, thus providing a clear view on the likely societal value of the scheme;
- Commercial Case: This chapter sets out how the various elements of the scheme might best be packaged, the potential procurement and contracting approaches, and how this will be impacted by the revenue funding models currently available to CCUS projects and the government's indicated future direction of such models;
- Financial Case: This chapter provides an initial view as to the likely capital costs of delivering the NLCCP, and those associated with operating the CC plant once complete. It also explores the likely funding sources that could be drawn upon in order to meet these costs; and
- Management Case: This chapter sets out possible delivery timescales, project management, assurance and risk management governance structures, and key stakeholders that would need to be engaged.

Taken together, this SA should inform the Authority as to how best progress and fund the scheme.

2 Strategic Case

2.1 Overview and purpose of Strategic Case

This Case makes the Strategic Case for the NLCCP. The key elements that make this up are summarised in Figure 4 below.

Figure 4: Key Components of the Strategic Case

As set out above, this chapter sets out the strategic context against which the NLCCP is being developed; the issues that the Authority would face without a NLCCP and those drivers that make developing it attractive; a summary of the Strategic Objectives and critical success factors that will guide the NLCCP's development; details on the proposed intervention and options; and an overview of the key risks, dependencies and constraints that the NLCCP is likely to face.

2.2 Strategic context

This section sets out strategic context within which the proposed NLCCP is being developed. It has been split between international, national, regional and local levels.

2.2.1 International policy

The Paris Agreement in 2015 recognised carbon removal as essential for mitigating climate change and repairing environmental damage to limit global climate change to 1.5°C. Since then, the annual Conferences of the Parties (COP) under the United Nations Framework on Climate Change have acknowledged the importance of CCS.

At the most recent COP28 in 2023, CCUS was featured in the Paris Agreements' first Global Stocktake outcome as a zero and low emissions technology for Parties to take action on and accelerate[7]. Further, according to the Intergovernmental Panel on Climate Change (IPCC) in its AR6 Synthesis Report: Climate Change 2023, based on current trajectories, most countries will be unable to hit their climate commitments without the utilisation of some form of CC.[8]

Beyond these global conferences and reports, major economies around the world are investing in CCS and recognising its importance in their domestic climate change efforts – including the United States, the European Union, China, Australia, Norway, and Indonesia.[9] [10]

2.2.2 National policy

2.2.2.1 Legal framework

In 2019, the UK legislated for a binding target of reaching net zero emissions by 2050.[11] This increased the reduction of greenhouse gas emissions to at least 100% of 1990 levels, relative to the 80% committed in the UK's Climate Change Act 2008 (2008 Act).[12] This legal obligation provides a clear and stable regulatory framework that should instil confidence in those considering investing in low carbon technology, such as CCS.

In addition, under the 2008 Act, the government must set five-yearly carbon budgets, twelve years in advance, from 2008 to 2050, with consideration made to the Climate Change Committee's (CCC) independent Carbon Budget Report.[13] Carbon budgets set a cap on the maximum level of the net UK carbon account for each five-year budgetary period.

The 6th such carbon budget, published in 2020, set the 2033-2037 cap at 965,000,000 tonnes of CO_2 equivalent, reflecting a 77% reduction below 1990 levels. For comparison, the 4th carbon budget for the years 2023 to 2027 set the cap of 1,950,000,000 tonnes of CO_2 equivalent, which reflects a 52% drop on 1990 levels.[14]

In addition, the budget's supporting report advised the government in setting the legislative and policy measures in relation to this budget. This included emphasis on "waste prevention, re-use and recycling, and over time […] via carbon capture and storage. Government policy could also focus on EfW emissions, either through carbon taxation or inclusion in a UK ETS, and/or providing incentives for CCUS to be installed."[15] As will be discussed in further in Section 2.3.1.2, the proposal for the inclusion of waste in the ETS was indeed adopted by the government, being applied from 1 January 2028.[16]

This is further supported by the Energy Act 2023, which received royal assent in October 2023. The Energy Act outlines a framework for scaling CCS in the UK, including introducing a new economic licencing framework for T&S, confirming the Gas and Electricity Markets Authority of Ofgem as the CCS regulator, and providing guidance on commercial arrangements required for CCS.[17]

2.2.2.2 Policy and guidance

In addition to legislative changes, the government has published a range of strategies, commitments, policies and funding packages that detail the UK's green transition plans, and emphasise the key role

[7] Six Key COP28 Outcomes for CCS, Global CCS Institute, 2023: link here.
[8] AR6 Synthesis Report: Climate Change 2023; link here.
[9] CCUS, International Energy Agency (IEA), 2023: link here.
[10] Five countries leading the way in carbon capture and storage, Energy Industries Council (EIC), 2023: link here.
[11] The Climate Change Act 2008 (2050 Target Amendment) Order 2019; link here.
[12] The Climate Change Act (2008); link here.
[13] UK Carbon Budgets, 9 July 2019; link here,
[14] Climate Change Committee: Advice on reducing the UK's emissions, accessed 15 March 2024; link here.
[15] The Climate Change Committee: The Sixth Carbon Budget: Waste, 2020; link here.
[16] Department for Energy Security & Net Zero: Policy Paper: The long-term pathway for the UK Emissions Trading Scheme, 18 December 2023; link here.
[17] The Energy Act (2023); link here.

CCS will have in enabling this. A sample of relevant government publications and their commitment to CCUS are seen below:

Publication
Ten Point Plan for a Green Industrial Revolution (November 2020)[18] This document set out plans to mobilise £12 billion of public money and incentivise further private capital to advance the development and roll out of green technologies, including CC. It also set out the government's intention to support the industry's development via a series of CCUS clusters. *We will establish CCUS in two industrial clusters by mid 2020s, and aim for four of these sites by 2030, capturing up to 10 Mt of carbon dioxide per year.*
Spending Review (November 2020)[19] The 2020 Autumn Statement announced that funding for the CCS Infrastructure Fund would be increased to £1 billion. *To push the limits of what is currently possible, SR20 also invests in innovative clean energy technologies, building on existing UK strengths and venturing into exciting new industries. This includes £1 billion for a Carbon Capture and Storage Infrastructure Fund[.]*
Net Zero Strategy (October 2021)[20] The 2021 Net Zero Strategy set out a series of policies and commitments designed to enable the UK to reach net zero by 2050. It includes measures to deliver emissions reductions to meet targets set out in the sixth carbon budget (which covers the period between 2033 and 2037). *Decarbonisation of smaller and more dispersed sites will […] be needed, placing demands on associated infrastructure […] New CO_2 transport and storage infrastructure is needed for the use of CCUS which will require investment of around £15 billion from now to the end of the Carbon Budget 6 period, 2033 – 2037.*
Powering Up Britain: Energy Security Plan (March 2023)[21] This plan sets out the steps the government is taking to ensure the UK is more energy independent, secure, and resilient. *[The government is] committed to further development of industrial carbon capture, waste, CCUS-enabled hydrogen, power CCUS, and engineered greenhouse gas removals. [The government will] work with stakeholders to set out a vision for the UK CCUS sector, […] provide clarification on the future of CCUS, how it will support our net zero ambitions, and crucially provide the confidence and certainty developers, investors, and other stakeholders are looking for in the long run.*
Net Zero Growth Plan (March 2023)[22] The Net Zero Growth Plan sets out how the government will enhance the country's energy security, seize the economic opportunities of the transition, and deliver on legislated net zero commitments. *Carbon Capture, Usage and Storage (CCUS) is an emerging sector that is of central importance to decarbonising the UK's economy. It will enable the decarbonisation of hard to abate industrial sectors and enable low-carbon hydrogen production and flexible low carbon electricity generation to complement other forms of low carbon power, along with engineered greenhouse gas removals.*

[18] HM Government: 10 Point Plan for a Green Industrial Revolution, 18 November 2020; link here.
[19] HM Treasury: Spending Review 2020, November 2020; link here.
[20] HM Government: Net Zero Strategy: Build Back Greener, October 2021; link here.
[21] Department for Energy Security & Net Zero: Powering Up Britain: Energy Security Plan 2023; link here.
[22] Department for Energy Security & Net Zero: Net Zero Growth Plan, March 2023; link here.

CCUS Net Zero Investment Roadmap (March 2023)[23] The Roadmap lays out two sets of industrial CCUS clusters, as well as sets out the government's plans to create a supportive regulatory and policy environment to encourage private capital. *CCUS will play a critical role in the transition to net zero by 2050. The UK is well placed to lead in CCUS globally with: A worldwide reputation as an international centre of engineering excellence; Extensive experience from the oil, gas, and petrochemicals sector; Substantial* CO_2 *storage potential and industrial infrastructure.*
Autumn Statement (November 2023)[24] This Statement sets out the estimated impact of changes to tax, welfare and public service spending policy that carry a direct, quantifiable impact. *Funding of £4.5 billion will be made available starting in 2025-26 lasting for five years for eight manufacturing sub-sectors: automotive (particularly zero emission vehicles, their batteries and supply chains), aerospace, life sciences, and clean energy (carbon capture, utilisation and storage, electricity networks, hydrogen, nuclear and offshore wind).*

Table 1: UK government climate change policy and guidance

2.2.2.3 Policy and guidance: CCUS Vision

The government's most recent CCUS policy document, the CCUS Vision, was published by the DESNZ in December 2023.[25] This sets out the government's vision for the UK sector from the 2030s and is envisaged to be realised through three key phases:

- **Phase 1: CCUS market creation by 2030:** Led by UK government through policy and regulatory interventions and financial support. This aspect aims to have four CCUS industrial clusters – which were described in Section 1.2.2 and explored in more detail in Section 2.3.2.1 – operational by 2030.26 The government will also work with regulatory bodies to develop and enable a fit-for-purpose regulatory framework.
- **Phase 2: CCUS market transition by 2035:** This is characterised by reduced and diminishing government financial support and increased development of a competitive market driven by commercial dynamics. This transition period envisages innovation and market developments to progress existing CCUS business models and create cost reductions, competitive allocation of capture contracts to be operational, non-pipeline transportation to be operational, and streamlined leasing, licensing, and permitting process and fit-for-purpose regulation in place.
- **Phase 3: CCUS self-sustainability by 2050:** This envisages a mature CCUS system incorporating different transport modes, while offering storage services to international emitters. It also anticipates different ownership structures emerging within transport and storage and envisages a process for making new connections to be market led.

2.2.3 Regional policy

The section sets out the policies covering London and North London waste and carbon management which are impacting and influencing the Authority's approach to the NLCCP.

[23] HM Government: CCUS Net Zero Investment Roadmap, March 2023; link here.
[24] HM Government: Autumn Statement 2023; link here.
[25] Department for Energy Security & Net Zero: CCUS Vision, December 2023; link here.
[26] CCUS Net Zero Investment Roadmap, DESNZ (2023): link here.

Publication
The London Plan (2021)[27] The London Plan is the overall strategic plan for London, setting out an integrated economic, environmental, transport and social framework for the development of London over the next 20–25 years. *London will be a zero waste city. Resource conservation, waste reduction, increases in material re-use, and recycling, and reduction in waste going for disposal will be achieved by the Mayor, waste planning authorities, and industry working in collaboration to […] ensure that there is zero biodegradable or recyclable waste to landfill by 2026, [and to] meet or exceed the municipal waste recycling target for 65 percent by 2030.*
The North London Waste Plan (2022)[28] The North London Waste Plan (NLWP) outlines the priorities and requirements for the successful management of waste requirements for the London Boroughs of Barnet, Camden, Enfield, Hackney, Haringey, Islington, and Waltham Forest. This aligns to the national and local requirements on sustainability and decarbonisation, and identifies the ownership and accountability of each target area. *The NLWP aims to deliver effective waste and resource management which make a positive and lasting contribution to sustainable development and to combating climate change. In particular this includes reducing the reliance on disposal to landfill sites […] ensuring new waste facilities generating energy meet the Mayor's Carbon Intensity Floor [and] directing new development to the most appropriate sites.*

Table 2: Relevant regional policy

2.2.4 Local policy

The local authorities that use and govern the Authority are all committed to tackling climate change, and key documents in this respect are set out in Table 3. Taken together, this demonstrates that local policy makers should be expected to strongly support initiatives such as the NLCCP

[27] Mayor of London: The London Plan, 2021; link here.
28 The North London Waste Plan, 2022; link here.

Local Council	Policy or Statement
BARNET LONDON BOROUGH	**Creating a Net Zero Council by 2030:** BarNET ZERO is Barnet Council's journey to reach net zero carbon as a council by 2030 and as a borough by 2042. Barnet Council has eight key themes to deliver their sustainability goals, one of which is to reduce the use of fossil fuels where possible, which can be supported by the NLCCP.[29]
Camden	**Camden's Climate Action Plan 2020-2025:** Originally published in 2020 after Camden held the UK's first Citizens' Assembly on the climate crisis. The Plan responded to the recommendations of the Citizens' Assembly and community, and since its adoption in 2020 has seen Camden take action to tackle the climate crisis. The council has committed to reducing CO_2 emissions from the borough to net zero by 2030.[30]
ENFIELD Council	**Enfield Climate Action Plan 2020:** The Council has committed to becoming a carbon neutral organisation by 2030, reducing Scope 1 & 2 emissions by 73% with residual emissions offset locally.[31]
Hackney	**Greener Hackney:** Sets out an integrated approach for tackling the climate and ecological crisis. It provides a framework for everyone to take action to reduce emissions and adapt climate change driven by a vision for a greener Hackney in 2030.[32]
Haringey LONDON	**Haringey Climate Change Action Plan:** The Action Plan will enable Haringey to become a net zero-carbon borough by 2041. References how waste is part of the carbon footprint for the borough and the importance of reducing this in reaching its emissions goals.[33]
WE SERVE ISLINGTON	**Waste Reduction and Recycling Plan:** The Waste Reduction and Recycling Plan 2023-25 sets out how Islington will meet waste and recycling goals as part of its work to tackle the climate emergency. They created 4 objectives, one of which being to "reduce the environmental impact of waste activities (greenhouse gas emissions and air pollutants)". [34] **Vision 2030:** Islington's Vision 2030 sets out Islington's broader goal's to be net zero by 2030. [35]

[29] London Borough of Barnet: Creating a Net Zero Council by 2030, 2024; link here.
[30] London Borough of Camden: Camden Climate Action Plan, 2020; link here.
[31] London Borough of Enfield: Enfield Climate Action Plan, 2023; link here.
[32] London Borough of Hackney: Greener Hackney, 2023; link here.
[33] London Borough of Haringey: Haringey Climate Change Action Plan, 2021; link here.
[34] London Borough of Islington: Waste Reduction and Recycling Plan, 2023, link here.
[35] London Borough of Islington: Vision 2030, 2022, link here.

Waltham Forest	**Climate Action Plan:** This Climate Action Plan sets out 20 actions to help Waltham Forest be net zero by 2030. This references the importance of reducing emissions from waste, from collection to disposal. [36]

Table 3: Relevant local authority policy

[36] London Borough of Waltham Forest: Climate Action Plan, 2023, link here.

2.3 Case for change

This section sets out the case for change, and is made up of two key elements:

- Firstly, the existing arrangements at the Authority's Edmonton EcoPark, and the challenges these will pose to the operation of the ERF if the NLCCP is not implemented; and
- Secondly, the market enablers and investment drivers, which cover the technological and socio-economic developments that will make investing in a NLCCP attractive in the long-term.

2.3.1 Existing arrangements and challenges

2.3.1.1 Unabated CO_2 emissions from the new ERF

As noted in Section 1.2.1, the Authority is currently in the process of constructing a new ERF at the Edmonton EcoPark, which will replace the current EfW facility. The new, world-class facility will be operational from the end of 2026.

The key objective of the new facility is to build the greenest waste hub of its kind in the country, treating non-recyclable waste as a resource instead of sending it to landfill.

Until recently, landfill has been the most common method of disposal for municipal waste in the UK, but it is now widely recognised as the least sustainable method of disposal and is at the bottom of the 'waste hierarchy' that underpins UK waste policies.[37]

However, while the new ERF could be fitted with CC capability in future, this is not part of the current project. As a result, if the NLCCP is not taken forward to remedy this, any CO_2 emissions from the facility will be released into the atmosphere, in contravention of international, national, regional and local policy objectives and plans and net zero legislation.

The new ERF is being built to process 700,000 tonnes of waste per year. The combustion of one tonne of residual municipal solid waste is assumed to generate approximately 1 tonne of CO_2. Assuming a 95% instantaneous capture rate, and including additional plant downtime for both planned and unplanned events, the NLCCP is expected to capture approximately 632,000 tonnes of CO_2 per year.

As noted in Section 1.2, the ERF will treat both biogenic and non-biogenic waste, and IPCC publications estimate that non-biogenic waste makes up 33 to 50% of the average unit of residual municipal solid waste.[38]

As such, a significant portion of the CO_2 emitted each year will stem from sources outside of the earth's natural carbon cycle. By removing not only human-origin emissions, but emissions that would have happened naturally, the plant can be understood to be net negative.

2.3.1.2 Integration of waste within UK ETS

The UK ETS is designed to reduce greenhouse gas emissions across energy-intensive industries. The scheme works by assigning a maximum level, or 'cap', for total emissions in a year, with each unit of emissions up to this point being a tradable commodity between emitters. The cap will be reduced each year to encourage industry, through financial penalties, to reduce their individual emissions to avoid the cost of the carbon levy.

In addition, a certain quantity of emissions are currently considered 'free allocation' before organisations have to start paying the carbon levy. The UK ETS's intended approach is to incrementally reduce the free allocations to encourage further reductions in emissions.

It is expected that free allocation will no longer be issued at the point at which the NLCCP becomes operational, and this is reflected in more detail within the Section 3.2 in the Economic Case.

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37 Department for Environment, Food & Rural Affairs: Guidance on applying the waste hierarchy; June 2011, link here.
38 IPCC Publications – link here.

It is also important to note that, at present, only non-biogenic emissions will qualify for trading, and as such, emitters that capture biogenic emissions will currently not be able to make a return on this. However, as will be set out in Section 4.4, the government has signalled an interest in exploring the sale of negative emissions to incentivise the growth of the negative emissions market, as well as reduce government costs and increase affordability.

Currently the UK ETS applies only to EfW systems where the thermal input exceeds 20MWth across heating systems that are 3MW or over.[39] However, from 1 January 2028, the scheme will apply fully to all EfW facilities.

Based on the estimate of the Authority producing approximately 700,000 tonnes CO_2 per year, of which around 50% are non-biogenic derived, and a forecast UK ETS cost of between £50 and £160 per tonne of CO_2, it can be estimated that the Authority would have to pay between £17.5 million and £56 million per year if all emissions fell under the ETS scheme. This is the basis of the Do Nothing option explored in the Economic and Financial Cases.

This would pose a major financial strain to the Authority if emissions are not curtailed. As the total budget for the Authority was £75 million for the 2023-2024 financial year, the implementation of ETS at current costs could increase the Authority's expenditure by up to 75%, depending on the market price of CO_2 at the time.

2.3.1.3 EfW operators will have no option but to pursue CCS

It is incumbent on EfW operators like the Authority to explore CCS due to the very limited range of alternative options to achieve any largescale reductions in CO_2 emissions from their facilities.

Unlike other power generators – such as those that have converted coal-fired power stations to use biomass – the Authority cannot change its fuel. In addition, improvements in recycling rates have stalled in recent years, particularly in London, with the result that a significant portion of waste processed by the Authority remains non-biogenic.

Given that no other technology is available to substantially reduce emissions from such facilities, the CCC recognised that EfW operators will have to deploy CCS, with their 6th Carbon Budget assuming that this will be fitted to 100% of plants from 2040.[40] As such, pursuing the NLCCP is both essential and in line with plans at similar plants across the UK.

2.3.2 Market enablers and investment drivers

2.3.2.1 Maturity of CCS value chain

Given the increased prominence of CCS's role in global efforts to combat climate change, the sector has grown significantly in recent years. These developments represent important market enabler for the NLCCP.

At a global level, the efficiency, commercial viability, and economic performance of CC technology has seen steady improvement. There has been a steadily increasing amount of finance being put towards CCS research & development across the value chain, both investigating new methods of capture, and enhancing the capture rate of existing methods to increase the quantity and quality of carbon captured.

In parallel to the development of CC technology, a range of existing energy companies have begun to develop capabilities in the T&S of captured CO_2, both within the UK and internationally.

As set out in Section 1.2.2, four major industrial clusters have received (or will receive) funding from the CCS Infrastructure Fund (CIF) and Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS). These have been split into two tracks, with Track 1 made up of two clusters that are deemed as suitable for deployment in the mid-2020s:

[39] Norton Rose Fulbright: Energy from waste facilities, August 2023; link here.
[40] The Climate Change Committee: The Sixth Carbon Budget: Waste, 2020; link here.

- HyNet North West is an industrial cluster based in Liverpool Bay, developing both low carbon hydrogen and CCS infrastructure; and
- The East Coast Cluster is made up of Net Zero Teesside, Zero Carbon Humber and the Northern Endurance Partnership.

Track 2 is made up of two further clusters that are deemed suitable for deployment around 2030:

- Acorn CCS is located in northeast Scotland and is looking to re-utilise the existing oil and gas infrastructure at St Fergus gas terminal; and
- Viking CCS will deliver an onshore pipeline from the Humber region to the old Theddlethorpe Gas Terminal, and from there utilise an existing offshore pipeline to the Viking storage site.

These are complemented by further clusters – that have developed outside of the government's cluster sequencing process – and intermediate nodes – points at which captured CO_2 will be transferred from one mode to another for onward transport to a T&SCo's permanent storage site.

This range of clusters – including those in Track 1 and 2 process and those being established outside of this – are set out in Figure 5. Of these, the clusters at Bacton and Medway are nearest to the Edmonton EcoPark and are thus of interest to the NLCCP; these, and a number of smaller intermediate nodes on the Thames, are explored in Section 2.5.3.

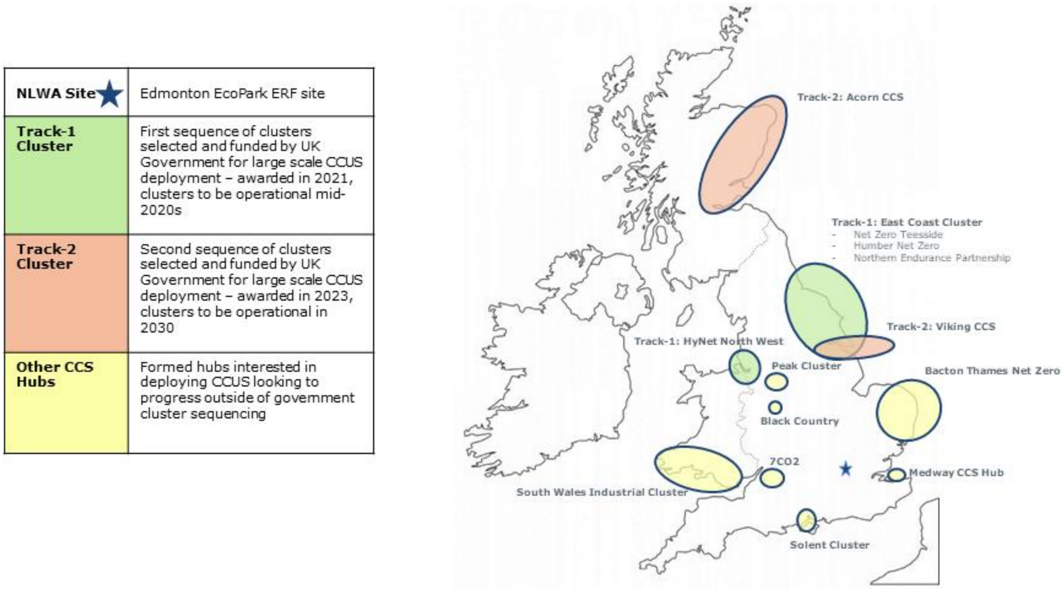

Figure 5: Map of UK clusters

The government have also facilitated the development of a range of permanent storage locations, with the North Sea Transition Authority (NSTA) obtaining powers to grant carbon storage licenses and permits in 2023. Fourteen T&SCos were awarded 21 licenses under the NSTA's first carbon storage licensing round in mid-September 2023, and the locations of these licenses are highlighted in Figure 6 below.[41]

41 North Sea Transition Authority: Net zero boost as carbon storage licences accepted, 15 September 2023; link here.

Figure 6: Map of NSTA September 2023 carbon storage licenses

As an indication of the expected growth in the UK's transport and storage market, the government's CCUS Vision has indicated that the current position – whereby funding is allocated to all applicants in the government-backed clusters that satisfy the assessment process – will evolve into a competitive allocation model, with an initial round expected to start in 2027. This is explored further in Section 4.4.2.

2.3.2.2 Green jobs for the local workforce

The government's Green Jobs Taskforce uses the term 'green job' to signify employment in an activity that directly contributes to – or indirectly supports – the achievement of the UK's net zero emissions target and other environmental goals, such as nature restoration and mitigation against climate risks. This includes roles in sectors including renewable energy, retrofitting homes and industries including CCS.[42]

As part of the global effort to tackle climate change, a significant number of new jobs have been created in areas such as renewable energy and energy efficiency. In 2010, the Greater London Assembly report into clean jobs in London found that 25,000 jobs were directly in the 'Green Sector'[43]. Within a decade to 2020, the number of green jobs reached 234,300, representing a significant increase.[44]

This growth is expected to continue over the coming decade, with projections suggesting that up to 725,000 new green jobs will be created UK-wide by 2030.[45] This will contribute towards the government's ambition to reach two million green jobs nationally by 2030.[46] Of those, the UK government expects that "up to 50,000 jobs that could be supported by 2030" as a consequence of the national approach to CCUS.[47]

At a local level, Enfield Council's Economic Development Strategy has already identified science and technology industries as key to the development of a wider employment offer.[48]

The NLCCP is expected to lead to a number of new job opportunities being created, both temporarily through construction and then in longer term through operation and maintenance. During the construction process specifically, these roles would be expected to be of a high quality, with apprenticeships and training for technical skills being made available to local residents. This will be

42 Department for Energy Security and Net Zero: Green Jobs Taskforce report, 14 July 2021; link here.
43 Greater London Authority: How big is London's green sector?, May 2010; link here.
44 London Councils: Green Jobs and Skills in London, 16 December 2021; link here.
45 The Climate Change Commission: A Net-Zero Workforce, May 2023; link here.
46 Department for Business, Energy & Industrial Strategy: Press release - UK government launches taskforce to support drive for 2 million green jobs by 2030, 12 November 2020; link here.
47 Department for Energy Security and Net Zero; Carbon Capture, Usage and Storage: A Vision to Establish a Competitive Market, December 2023, p.11, link here
48 London Borough of Enfield: Economic Development Strategy, January 2021, p.8; link here.

augmented by those involved in the transport and storage of CO_2, and others required for maintenance and through the broader supply chain.

2.4 Strategic Objectives and Critical Success Factors

The NLCCP is at an early stage in development, and a range of decisions will have to be taken to determine the NLCCP's scope, including in relation to the technology, transport and permanent storage used.

Guided by the Strategic Context – as set out in Section 2.2 – and Case for Change – as set out in Section 2.3, a framework has been developed to inform the longlisting, shortlisting and option selection process. This is split into two elements:

- **Strategic objectives** reflect the key outputs/outcomes the Authority would be expected to achieve. The spending objectives specify the Authority's business needs in terms of the improvements and changes required from the NLCCP. The spending objectives are aligned at the national, regional, local policies and to the Authority's business level plan; and
- **Critical success factors** are the attributes essential for successful delivery of the NLCCP. The CSFs must be crucial and not just desirable attributes, they should not be set at a level as to limit options at an early stage.

In conjunction with the Strategic objectives, the CSFs should be used as screening criteria (providing yes or no answers, rather than maybes) for shortlisting options. Typically, critical success factors reflect key criteria from each case of the Business Case.

Note that as part of the strategic objectives, a number of project **outputs** have been defined. The HM Treasury Green Book defines outputs as changes delivered by projects, which may consist of new products, new or improved services, or changes to business operations.[49]

The combination of strategic objectives and critical success factors will be used to convert a longlist of options to a shortlist for the SOC during Stage 1; it should also inform which of the shortlisted options is assumed as the NLCCP's preferred way forward. This framework should then be used again to reassess the shortlist options and then determine a clearly defined preferred option during the OBC at Stage 2.

The strategic objectives and outputs identified by the Authority are set out below in Table 4, and the critical success factors are set out in Table 5. It is important to stress that these should be treated as indicative at this stage, and will be reviewed prior to their use during each project stage. This reflects the fact that the understanding of how the NLCCP will address its strategic and technical challenges should mature as it progresses, and it is appropriate to ensure that its option assessment framework is updated to reflect this.

Strategic Objective		Output
Strategic objective 1	95% instantaneous CC rate	Operationally net negative status for ERF
Strategic objective 2	Minimising whole-life carbon	Operationally net negative status for ERF
Strategic objective 3	Creating opportunities for apprenticeships, jobs, and skills	Transition to a Low Carbon Economy
Strategic objective 4	Ensure end-to-end value chain resilience	Integrated T&S Value Chain

Table 4: Strategic objectives and outputs

[49] HM Treasury: The Green Book, updated 27 October 2023; link here.

Critical Success Factor		CSF Criteria
Critical success factor 1	The NLCCP demonstrates alignment to national, regional and local policy objectives	Strategic fit and business need
Critical success factor 2	The NLCCP represents Value for Money	Selected option delivers value for money
Critical success factor 3	The market is capable of delivering the NLCCP using commercially mature technologies	Supplier capacity and capability
Critical success factor 4	The NLCCP is affordable	Selected option is affordable by the Authority
Critical success factor 5	The NLCCP can be delivered and operational by around the mid-2030's	Selected option is deliverable within the required timeframe

Table 5: Critical success factors

The following sections set out a brief explanation for each of the strategic objectives and critical success factors.

2.4.1 Strategic Objectives

2.4.1.1 ***Strategic objective 1:*** *95% instantaneous carbon capture rate*

Aligning to what the Environment Agency (EA) currently considers Best Available Technique (BAT) for amine-based and hot potassium technologies of EfW facilities, the ERF will seek an average capture rate of at least 95% of the CO_2 in the flue gas. In the absence of other technology specific capture rates, the specified capture level will be considered the benchmark for all CC technologies.

As stated previously in Section 2.3.1.2, the ERF will emit up to 700,000 tonnes of CO_2 per year. Assuming a 95% instantaneous capture rate, with an ERF guaranteed availability of 8,000 hours per year and the CC plant able to operate at 95% of the ERF plant's operational hours, the CC plant could capture up to circa 632,000 tonnes per year of CO_2. This includes both biogenic and non-biogenic emissions.

2.4.1.2 ***Strategic objective 2:*** *Minimising whole-life carbon*

Aligning to the Authority's commitment to ensure the ERF is as environmentally responsible as possible, minimising whole-life carbon will ensure that through the conception, construction, operation, and maintenance phases of the facility's lifespan the upmost effort will be made to minimise its carbon footprint.

Due to the highly functional nature of much of the CC plant, it is likely an internal workshop with structural engineers and CCS engineers and product engineers would be needed to understand which materials or building elements are applicable for material specification changes or alternative construction approaches to reduce CO_2.

A holistic view is essential, considering the overall function of the NLCCP is to abate CO_2 emissions. Therefore, any carbon savings need to be assessed against any trade-offs to plant efficiency and subsequent carbon removal efficiency.

2.4.1.3 ***Strategic objective 3:*** *Creating opportunities for apprenticeships, jobs, and skills*

The NLCCP is expected to lead to a number of new job opportunities being created, during both construction and operation. While the expected number of jobs created from the NLCCP itself is expected to be modest, this will be augmented by those involved in the T&S of carbon, and others required for maintenance and through the broader supply chain.

2.4.1.4 ***Strategic objective 4:*** *Ensure end-to-end value chain resilience*

The NLCCP should ensure that the providers selected are able to provide a resilient service to transport and permanently store the captured CO_2, and that the operation of the CC plant is not unduly impeded by the availability of transport and storage services.

2.4.2 Critical Success Factors

2.4.2.1 ***Critical success factor 1:*** *The NLCCP demonstrates alignment to national, regional and local policy objectives*

To obtain the requisite planning and other consents (such as an environmental permit) required to allow the NLCCP to be constructed and operated, all decisions made by regulatory authorities and their associated statutory and non-statutory consultees will be made in the context of prevailing national, regional, and local policy requirements.

2.4.2.2 ***Critical success factor 2:*** *The NLCCP represents Value for Money*

The NLCCP should provide a net positive effect to the Authority and its members, which outweighs the total cost of building, operating, and maintaining the CC plant. The benefits of the NLCCP should include avoided CO_2, environmental, health, socioeconomic and monetary gains over the lifetime of the NLCCP. This will determine the scheme's Net Present Value (NPV), which is the total benefits of the scheme minus its total costs, with both calculated over the 25 year appraisal period and discounted to reflect the time value of money. These values are then used to determine the BCR, which is the total benefits divided by the total costs.

2.4.2.3 ***Critical success factor 3:*** *The market is capable of delivering the NLCCP using commercially mature technologies*

Commercial mature technologies refer to 'bankable' grade at scale deployed asset class with known standards and performance expectations. Currently the amine-based technology is the most mature CC technology and ready to deploy, with several technology suppliers and potential EPC contractors. For the HPC technology, there is no commercial operating CC plant, but a single project (Stockholm Exergi) which is approaching financial investment decision and potential deployment, and an EPC contractor has been selected. Considering the rapid pace of advancements in the CC technologies space, the aim is to keep the options open and the commercial maturity of CC technologies under close monitoring as the NLCCP is developed.

2.4.2.4 ***Critical success factor 4:*** *The NLCCP is affordable*

This Critical Success Factor will assess the affordability of the NLCCP, which will involve comparing the total cost of delivering and operating the scheme compared to not doing so and instead being subject to the UK ETS, where the Authority would be required to buy allowances for the ERF's non-biogenic carbon emissions.

2.4.2.5 ***Critical success factor 5:*** *The NLCCP can be delivered and operational by around the mid-2030s*

The existing EfW facility will be decommissioned and demolished when the new ERF is fully operational (expected to be around end of 2026). The existing EfW facility is expected to be fully decommissioned and demolished by mid-2031, freeing up space in the centre of the Edmonton EcoPark for other uses such as CC. Subject to the availability of an appropriate transport solution and T&SCo, it has been assumed that the CC plant could commence construction early 2032 with the CC plant becoming operational by around the mid-2030s, assuming the establishment of a viable T&S network.

2.5 North London Carbon Capture Project scope and options

As set out in the Sections 2.2 and 2.3, both the Strategic Context and the Case for Change make a strong case for the development of the NLCCP at the Edmonton EcoPark, and validate the Authority's decision to progress the NLCCP. This section sets out the various elements that make up the NCLPP and highlights the various options that will be considered as the scheme progresses.

2.5.1 Carbon Capture plant location and equipment

As noted in Section 1.1, the CC plant is set to be delivered on the Authority's Edmonton EcoPark. This site is within the Upper Lea Valley Opportunity Area and is bounded by industrial uses to the north, the River Lea Navigation Channel and the Lea Valley Regional Park to the east, Advent Way to the south and Salmons Brook and Ely Industrial Estate to the west.

The site is accessed from Advent Way, which leads to the A406 North Circular Road, part of the Transport for London Road Network. The site lies some 1.5km from the nearest section of the Strategic Road Network at the A1010 Fore Street.

Figure 7: Indicative layout of ERF and CCS plant

The new CC plant would be designed to extract flue gas from the ERF, including both biogenic and non-biogenic emissions. The equipment required is expected to include flue gas path ducting, direct contact cooler, absorber, stripper, water-wash, pumps, blowers, CO_2 handling equipment, exchangers, auxiliary equipment, piping and access-ways. The CC plant would be powered directly from the ERF, and any additional heat will be used for district heating energy demands where appropriate.

Estimates produced in support of this SA suggest that the total footprint required for the NLCCP will be between 10,950 m^2 and 24,550 m^2, which would require between 33% and 47% of the free space available on the Edmonton EcoPark site. This variance reflects the fact that pipeline transport would not be expected to require the same volume of initial storage facilities as non-pipeline transport, and this is illustrated in Figure 8.

As noted in Section 1.2, CC technology is still developing, and a limited number of full-scale CC plants have been commissioned globally. As such, it is important to emphasise that these high-level assumptions are subject to development work.

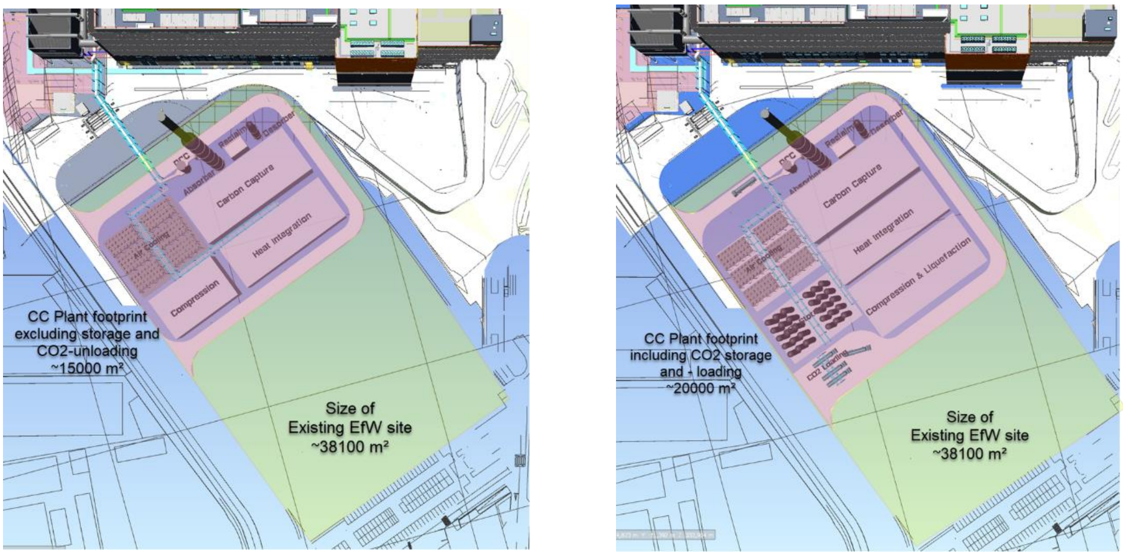

Figure 8: Illustrative spatial layouts of CCS plantwith and without truck loading facilities

2.5.2 Carbon Capture technology choices

In preparing this SA, an assessment of a range of possible CC technologies was undertaken. This considered health and safety, technical considerations, financial and commercial considerations, and planning and permitting. The results are set out in Figure 9 and explained in more detail below.

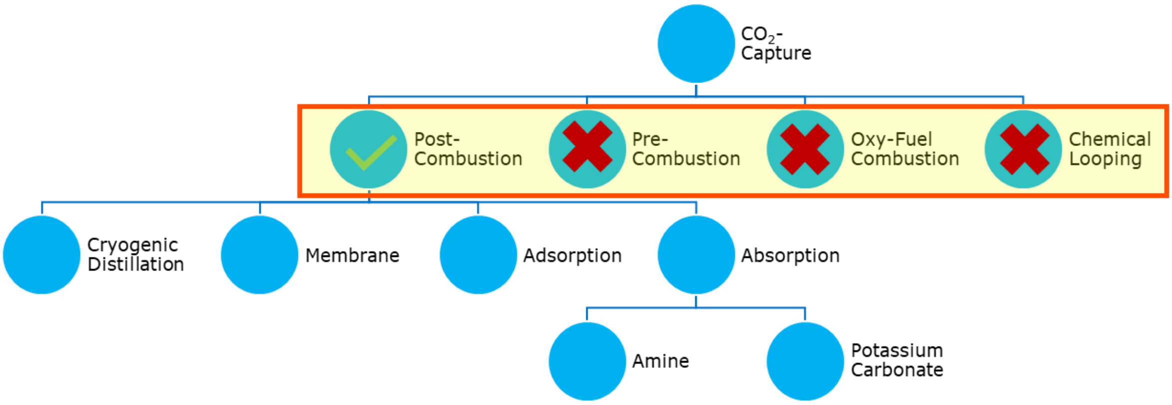

Figure 9: Carbon capture technology assessment

CC technologies relevant for power generation facilities are generally divided into four separate sub-categories: pre-combustion capture, oxy-fuel combustion, chemical looping combustion, and post-combustion capture. Post-combustion capture is the most mature technology for the proposed NLCCP, and the most viable in terms of construction, complexity, operations and costs.

Within post-combustion, there are a number of options and sub-options, and a preliminary screening exercise was carried out that assessed the various technologies. Of these, two – amine-based and HPC – scored the highest in this exercise, primarily due to achieving higher scores in the planning/permitting criteria and the commercial/financial criteria. As such, these technologies are potentially the most viable at this stage are briefly summarised below. The screening exercise will be revisited in the next stage.

2.5.2.1 Amine

Amine CC technologies have been used for more than 60 years to remove CO_2 from natural gas, and while the processes would differ if used in an EfW setting, this still represents the most technologically mature and cost-effective solution.

The process works by scrubbing the flue gas with a solvent that absorbs the CO_2 at relatively low temperature, with this typically taking place in a packed bed tower known as an absorber column.

This is then directed to a stripper column where it is heated with steam, which causes the absorbed CO_2 to be released or desorbed from the solvent. After the CO_2 is released, it is typically compressed and liquefied for transportation.

The solvents and degradation products used in this process would need to be safely managed, and this would be informed by the strict environmental permitting processes set out in Sections 6.7.2 and 6.7.3; this is reflected in this option's scoring under the health and safety element of the assessment.

A disadvantage of amine-based CC is the high amount of energy required for the solvent regeneration or CO_2 desorption. This could be addressed by the use of other newer modern chemical solvents, which require less energy to heat relative to the monoethanol-amine typically used, but further work will be required before any decision on this can be taken.

2.5.2.2 Hot Potassium Carbonate

The HPC process is very similar to amine-based technologies, with the solvent used to absorb the CO_2 being an aqueous solution of potassium carbonate rather than amines. These are less expensive and utilise more environmentally friendly chemicals.

However, HPC technology still needs to mature relative to amines – in both technological and commercial terms – and there are currently no HPC CC plants fitted to ERF plants. As such, HPC is treated as a sensitivity test in the options appraisal in both the Economic and Financial Cases.

2.5.3 Transport and Storage

Following the capture of the CO_2 at Edmonton EcoPark, the next stage in the value chain is to transport CO_2 – either directly or via an intermediate node for further onward transportation – to a T&SCo. This is set out below in Figure 10.

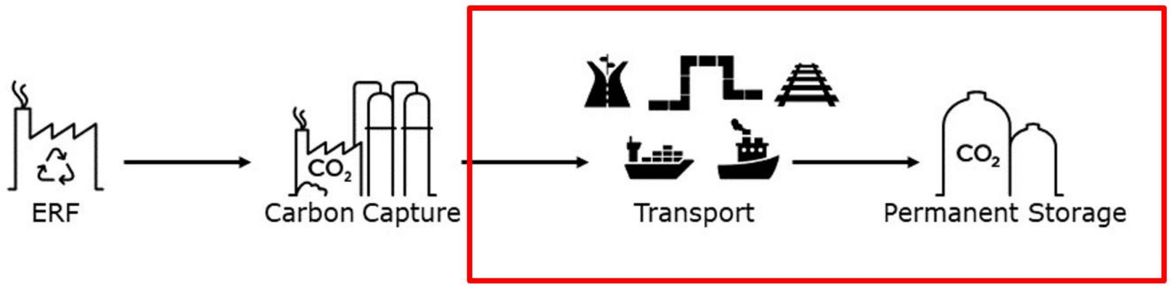

Figure 10: CCS value chain with transport and storage highlighted

T&S is one of the most challenging aspects of the NLCCP. This is due to the Edmonton EcoPark being what is referred to as a 'dispersed emitter', which is defined as an emitter that is inland and more 'isolated' relative to clusters of emitters.

As a result, the Authority will need to transport captured CO_2 over greater distances and at greater cost in order to reach a T&S network, relative to emitters that are part of, or located nearer, the Track 1 or 2 clusters. This can be seen in Figure 11 below.

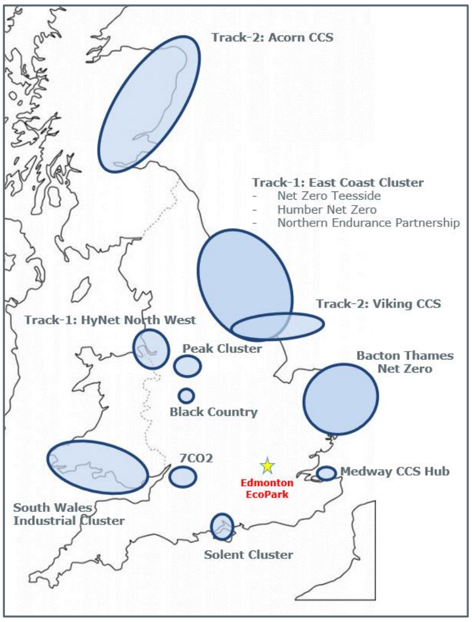

Figure 11: Map of UK clusters and intermediate nodes

This is further compounded by the fact that – based on market and stakeholder engagement to date – the NLCCP is not seen as an 'anchor emitter', which is a large emitter that provides a significant proportion of the CO_2 in a CCS cluster or hub.

While the Edmonton EcoPark represents a significant and stable load for a T&SCo – with an annual captured volume of approximately 632,000 tonnes of CO_2– this is less than what would be expected of an anchor emitter – which would likely be over 1,000,000 tonnes of CO_2 per year.

As a result of these challenges and confirmed through engagement with T&Scos and emitters to date, it is unlikely that a T&SCo would develop and offer an end-to-end transport solution for the Authority. Therefore, the onus will most likely be on the Authority to procure its own transport for the movement of captured CO_2 to a cluster or T&SCo network.

2.5.3.1 *Direct vs intermediate transport*

Transportation of the CO_2 from the Edmonton EcoPark can occur in two main ways:

- **Directly** from 'source to sink'. An example of this would be if a pipeline was built from the Edmonton EcoPark to a T&S network. Direct transportation would consist of only one 'transport leg'.
- From source to an **intermediate node** to sink. An example of this would be if trucks were used to transport CO_2 from the Edmonton EcoPark to a port, followed by ships taking the CO_2 from this port to a T&SCo's T&S network. Intermediate transport would therefore consist of more than one 'transport leg', with potentially numerous transport modes involved. The additional transport leg may need to be pursued by the Authority independently of a T&SCo – for example the Authority may contract this work directly to a shipping firm – or it could be provided by either the eventual T&SCo or the intermediate node operator.

All things being equal, direct transport of the CO_2 would be more efficient, cost-effective and present a lower risk to the Authority. However, the challenges outlined above in Section 2.5.3 in relation to its location mean that this would be difficult to procure for the NLCCP. Therefore, intermediate transport through a number of transport modes and routes will need to be explored.

2.5.3.2 *Transport and storage companies*

As noted in Section 1.2.2, the intention of the transport stage is to enable a T&SCo to receive captured CO_2, and then take it to deep geological permanent storage by way of the T&SCo's own T&S Network, which could include its onshore transportation system, offshore transportation and deep geological storage system.

A number of T&SCos have entered the market in recent years, including a number of existing oil and gas companies. These have been supported by the government's cluster sequencing policy, which has seen funding allocated to four industrial clusters in the north-east and the north-west of England, and in Scotland.

2.5.3.3 *Emerging clusters and intermediate nodes*

As set out in Section 2.3.2.1, the four clusters funded in the Track 1 and Track 2 cluster sequencing process are expected to act as a catalyst for the broader transport and storage industry across the UK. As the industry matures and market drivers, such as carbon taxes, encourage more emitters to explore solutions such as CCS, further T&S networks, clusters and intermediate nodes are expected to develop over the next decade.

Market engagement and technical studies to date have identified the following locations as potentially key to the development of a viable transport solution for the NLCCP.

- **Bacton**, which is the site of an existing gas terminal on the north Norfolk coast; a range of companies are promoting the use of existing infrastructure – including onshore and offshore pipelines – to transport CO_2 from London and the south east to permanent storage offshore.
- **The Isle of Grain** is the location of the Medway CCS hub . There are a number of large emitters in this region – including three major coastal gas power stations – which are of interest to several T&SCos which have received storage licences from the NSTA.
- **The River Thames** has various intermediate nodes – such as Cory Riverside and Navigator Terminal Thames – which may allow for onward transport to a range of permanent storage sites.

These locations are highlighted relative to the Edmonton EcoPark in Figure 12 below.

Figure 12: Emerging clusters and intermediate nodes

2.5.3.4 *Emerging transport modes*

A range of transport options are currently being explored for the NLCCP across direct and intermediate transport. These are summarised below.

Mode	Descriptor	Transport type
Pipeline	This mode can involve use of newly built or re-purposed existing pipelines. Pipeline transport is the most 'developed' method currently available, and is currently the only mode approved by government in the Track 1 and 2 CCUS clusters. This option could lead to lower operating costs and lower interdependency risk as fewer parties would be expected to be involved. However, the capital cost in constructing a new pipeline would be significant, and there would be a high risk of delays due to the nature of the planning consents required. Delivering such infrastructure around the Edmonton EcoPark would be particularly challenging given that the local environment is made up of already heavily developed land and the Lee Valley contains a series of environmentally sensitive reservoirs and parks. If a pipeline were viable but – for the reasons set out above – would require an extended delivery period, it may be possible to utilise a non-pipeline mode for an initial period and then switch over to pipeline at the point at which the fleet of vehicles used have reached the end of their lease period.	• Direct transport may be possible, through a new-build or re-purposed pipeline from Edmonton EcoPark to a T&S Network • Intermediate transport is possible, through a new-build or re-purposed pipeline, from Edmonton EcoPark to an intermediate node • This could be used by a T&SCo within their T&S Network
Road	This would involve loading the carbon on to trucks which would transport it to a T&SCo or intermediate node. While this is likely to be best suited to the transport of low CO_2 volumes over relatively short distances[50], it can also be utilised for larger volumes and longer distances. While a range of sustainable options could be considered to fuel these vehicles (including electricity, hydrogen and biofuels), all would require varying degrees of technological development to become viable. In addition, adding traffic to the road network would not align to various national, regional and local policies.	• Direct transport is possible through trucking on road from Edmonton EcoPark to a T&S Network • Intermediate transport is possible through trucking from Edmonton EcoPark to an intermediate node
Rail	A single freight train can generally transport goods equivalent to over 30 HGVs, and as such, the daily number of train movements would not be significant. This mode would require dedicated railheads to load freight services, and discussions would need to take place with Network Rail and the rail freight industry to determine if capacity is available.	• Only intermediate transport is possible through running services from a transfer point on the West Anglia main line (which is near the Edmonton EcoPark) to an intermediate node

50 Department for Energy Security & Net Zero: CCUS Vision, December 2023; link here.

Inland freight barges 	This form of transport would require the use of the nearby River Lea Navigation canal, with dedicated loading facilities being provided. Captured CO_2 would then be transferred to a T&SCo or intermediate node. To make this solution viable, a range of challenges would need to be overcome, including the size of locks and conflicts with leisure users.	• Only intermediate transport is possible through running services on the River Lea Navigation from • Edmonton EcoPark to an intermediate node
Shipping 	The Edmonton EcoPark is inland - therefore, large-scale open water shipping can be used to transport captured CO_2 from an intermediate node to a T&SCo or, once received by a T&SCo, to transfer it from an onshore facility to permanent off-shore storage. This mode is likely to be best placed to transport large volumes of CO_2 over long distances.	• Only intermediate transport is possible through the intermediate node to a T&S Network • This could be used by a T&SCo within their T&S Network

Table 6: Emerging transport modes

2.5.3.5 Emerging transport and storage options

Following the identification of a number of potentially suitable T&S modes and intermediate nodes through market and stakeholder engagement, a screening exercise has been undertaken to identify a series of transport and storage options for the NLCCP.

These have been developed to assess the value for money the NLCCP represents and its affordability, which are explored in the Economic and Financial Cases respectively. It is important to emphasise that these are purely illustrative at this stage and not formal options; these will be developed further at the SOC Stage. The principles guiding this exercise were:

- Locations should be identified as part of a full CCS value chain (a 'source to sink' approach);
- Transport to intermediate nodes could make it more attractive for T&SCos to permanently store the ERF's CO_2, potentially mitigating the challenge posed by the Edmonton EcoPark's status as a dispersed emitter.
- There should be flexibility if the market becomes commercially driven, with competitive and cost advantages and choices of final destination accounted for.
- Solutions could be 'interim' and allow for potential flexibility in the future; for example, trucking would not preclude pipeline transport if a suitable UK-wide government supported CO_2 transport network emerged in future.
- It is assumed that the vehicles required for non-pipeline transport would be leased, albeit this would need be explored further in future stages if this option were pursued.
- Permanent storage is expected to occur in the southern North Sea due to proximity to the Edmonton EcoPark and concentration of storage licenses in this area, as highlighted in Section 2.3.2.1.

The options developed are set out below in Table 7. The point of transfer to a T&SCo is highlighted in the solid red boxes around the permanent storage stage. The additional dotted red box around the intermediate destination and ongoing transportation stages reflects the fact that while the Authority may have to procure these elements, market and stakeholder engagement has indicated that it may be feasible to reach alternative arrangements; for example, a T&SCo could procure these elements as part of their main storage contract, or the intermediate node operator could contract with a T&SCo. This is explored further in Section 4.2.4.2.

In order to clearly highlight the impacts of both the transportation modes and routes and the use of various intermediate nodes, all scenarios (apart from Do nothing) assume the use of amine technology and receipt by a T&SCo at Bacton.

#	Option description	Transportation Mode	Intermediate Destination	Ongoing Transportation	Permanent Storage entry point
1	Do Nothing	N/A	N/A	N/A	N/A
2	Direct Pipeline	Pipeline	N/A	N/A	Bacton
3	Direct Trucking	Trucking	N/A	N/A	Bacton
4	Intermediate pipeline to Isle of Grain	Pipeline	Isle of Grain	Ship	Bacton
5	Intermediate trucking to Isle of Grain	Trucking	Isle of Grain	Ship	Bacton
6	Intermediate pipeline to Thames Port	Pipeline	Thames Port	Ship	Bacton
7	Intermediate trucking to Thames Port	Trucking	Thames Port	Ship	Bacton
8	Intermediate barges to Thames Port	Barges	Thames Port	Ship	Bacton
9	Intermediate trains to Teesside Port	Trains	Teesside Port	Ship	Bacton

Table 7: Emerging transport and storage options

A range of sensitivity tests in the Financial Case explore a range of alternative assumptions:

- Impact on capital expenditure of sharing CO_2 transport with other parties (see Section 5.4.3);
- Impact on capital expenditure of using HPC (rather than amine) technology (see Section 5.4.3);
- Impact on operational expenditure of 20% higher carbon price under UK ETS (see Section 5.4.4);
- Impact on operational expenditure of 20% lower carbon price under UK ETS (see Section 5.4.4);
- Impact on operational expenditure of using HPC (rather than amine) technology (see Section 5.4.5);
- Impact on operational expenditure of using larger ships to transport CO_2 and share with other parties (see Section 0);
- Impact on operational expenditure of higher T&SCo costs (see Section 0);
- Impact on operational expenditure of 10% cost efficiencies (see Section 5.4.7).

2.6 Strategic risks, dependencies and constraints

This section sets out the strategic risks, dependencies and constraints associated with the NLCCP.

2.6.1 Strategic risks

Risks are defined as issues that are specifically related to the NLCCP, and may arise in its design, construction, implementation or operation. Once risks have been evaluated, they can be treated in one of the following ways:

- **Avoidance:** Eliminating the activity that generates the risk entirely;
- **Reduction:** Implementing controls or measures to lessen the likelihood of the risk occurring or reducing its impact;
- **Transfer:** Shifting the risk to a third party, typically through insurance or contracts ; and
- **Acceptance:** Accepting that the risk is beyond the control of the project or, in some cases, the cost of treating it may outweigh the benefits of reducing it.

Further information regarding the risk management process and mitigating risks are are set out in detail in Section 6.8.4 of the Management Case.

The top ten strategic risks facing the NLCCP are set out below, alongside how they are to be treated and the key mitigation measures. These are based on the NLCCP's Risk Register, which includes further details on the risks, their impact and their pre and post-mitigation scoring .

Note that those risks that are presented as accepted are broadly associated with government policy. Directly changing these policies is not within the NLCCP's control, and thus the focus will primarily be on monitoring these issues.

In addition, a small number of mitigations focussed on advocacy are set out for some of these risks. This reflects the fact that if the NLCCP's efforts are combined with other emitters facing similar challenges, it may be possible to collectively achieve positive policy change; however, the accepted designation is still deemed appropriate for these risks given that the NLCCP is not in a position to guarantee that such advocacy will prevent the risk being realised.

2.6.1.1 Commercially viable intermediate T&S

There is a risk that the NLCCP will not secure a commercially viable intermediate T&S solution, which results in an inability to transport carbon and the paying of UK ETS for a period of time. This risk can be reduced through the following mitigations:

- Establish strategic partnerships with transport & storage providers, potentially negotiating a long-term contract for favourable rates and availability during procurement;
- Investigate and assess alternative methods of transporting and storing carbon, such as utilising existing pipeline infrastructure, shipping to offshore storage or developing new solutions that may offer cost advantages;
- Engage with stakeholders on shared storage facilities, including engaging with other CC projects to explore the possibility of shared transport and storage, which would spread the costs among multiple stakeholders; and
- Use the MSD workstream to engage with DESNZ to mitigate this risk through policy change.

2.6.1.2 Negative emissions

There is a risk that if negative emissions are not included in the government's business models that provide support to CCS projects, this will adversely affect the project's financial viability. This risk is accepted, albeit the following mitigations will still be put in place:

- Monitor broadly and regularly to capture market and policy developments, including through horizon scans;
- Engage with government through consultation responses and directly with DESNZ and the Carbon Capture Storage Association (CCSA); and
- Pursue these mitigations in parallel with those related to other government policy risks.

2.6.1.3 Delayed approval of Town and Country Planning Act application

Under the TCPA planning route, there is a risk of delayed approval of a planning application by the Local Planning Authority (LPA), resulting in project delays and associated increased project costs. This risk can be reduced through the following mitigations:

- Build relationships with the officers, politicians and members of the LPA;
- Secure a planning performance agreement with the LPA;
- Appoint a specialist planning adviser to the NLCCP;
- Develop a comprehensive planning and community engagement strategy;
- Ensure the project design aligns closely with national and local planning policy objectives; and
- Consider the option to seek direction from the Secretary of State (SoS) on non-determination.

2.6.1.4 Lack of market appetite for project

There is a risk that a lack of market appetite for the NLCCP (due to its size, timelines and location) results in a failure to attract sufficient interest from key stakeholders, in particular T&S companies, which results in project delays (including to Business Case development) and associated increased project costs. This risk can be reduced through the following mitigations:

- Monitor the market through engagement and horizon scans;
- Engage broadly and regularly to capture market developments and stay on track, including participating in industry events;
- Raise the profile of NLCCP and of dispersed emitters;
- Continue to engage with the market throughout NLCCP's development and continue to prepare for delivery; and
- Keep exploring the potential for alignment of strategic and commercial interests with emitters.

2.6.1.5 Supply chain challenges or market restrictions

There is a risk that supply chain challenges or market restrictions for key equipment and contractors result in project delays and associated increased project costs. This risk can be reduced through the following mitigations:

- Learn about the rates of delivering post-combustion capture plants from industrial clusters, which will help build deployment capability in the UK;
- Monitor London and national pipelines of contractors in CCS and the broader construction and engineering market, particularly as construction approaches;
- Undertake early supplier engagement to foster collaboration and alignment with desired project outcomes;
- Undertake early market engagement to confirm the procurement strategy and ensure that the NLCCP is developed in a fully integrated manner, avoiding long lead times;
- Explore innovative post-combustion capture plant solutions, which have the potential to reduce costs and the time required to deliver the plant, but still have low technology readiness levels; and
- Make the NLCCP more attractive through certainty of financing, such as Public Works Loan Board (PWLB) financing.

2.6.1.6 Technically viable intermediate transport & storage

There is a risk that the NLCCP will not secure a technically viable intermediate T&S solution, which results in an inability to transport carbon and the paying of UK ETS for a period of time. This risk can be reduced through the following mitigations:

- Prepare a strategic plan for cluster formation and identify potential partners;
- Keep under consideration multiple options of transport routes and modes and avoid 'locking in' a long list of options too soon; and
- Consider the technical routes and options in more detail for the next stages.

2.6.1.7 Slow or delayed formation of a partnership with transport and storage company

There is a risk that the slow or delayed formation of a partnership with a permanent or ultimate T&SCo results in project delays and associated increased project costs. This risk can be reduced through the following mitigations:

- Regularly review market conditions and the availability of transport and storage options;
- Stay informed about market trends so as to anticipate and mitigate risks associated with partnership formations; and
- Require potential transport and storage providers to complete a pre-qualification questionnaire to reduce the number of potential bidders to a shortlist that meets the NLCCP's requirements, which will in turn speed up the selection process when the NLCCP is ready to form partnerships.

2.6.1.8 Government focus on Track 1 and 2 CCS clusters

There is a risk that the government's focus on Track 1 and 2 CCS clusters results in a lack of appropriate policy, business models and funding, which will adversely affect the NLCCP's financial viability. This risk is accepted, albeit the following mitigations will still be put in place:

- Monitor broadly and regularly to capture market and policy developments, including through horizon scans;
- Engage with government through consultation responses and directly with DESNZ and the CCSA, highlighting the challenges faced by dispersed emitters; and
- Pursue these mitigations in parallel with those related to other government policy risks.

2.6.1.9 Delayed approval of Development Consent Order application

Under the DCO consenting route, there is a risk that the delayed approval of a planning application by the consenting authority results in project delays and associated increased project costs. This risk can be reduced through the following mitigations:

- Build relationships with the officers, politicians and members of the LPA;
- Secure a planning performance agreement with the planning authority;
- Engage in early pre-application discussions with the Planning Inspectorate;
- Engage a specialist planning agent for the NLCCP;
- Engage a planning legal specialist;
- Develop a comprehensive planning and community engagement strategy; and
- Ensure the project design aligns closely with national and local planning policy objectives.

2.6.1.10 Uncertainty around the price of CO_2

There is a risk that uncertainty around the price of CO_2 within the UK ETS results in differing prices than assumed in the economics model, causing difficulties in ensuring the viability of the CC plant and an impact on securing funding. This risk is accepted, albeit the following mitigations will still be put in place:

- Monitor broadly and regularly to capture market and policy developments, including through horizon scans; and
- Ensure forecasting of future pricing is as up-to-date as possible.

2.6.2 **Strategic dependencies**

Dependencies are external factors, such as infrastructure that the NLCCP is reliant upon to be successful, but which are beyond its direct control. Where appropriate, an equivalent risk has been recorded for dependencies that are considered as posing a risk to the NLCCP. Dependencies should be managed regularly as the NLCCP progresses.

2.6.2.1 ERF being available to provide CO_2 to the CC plant

The operation of the new ERF is a pre-requisite for the CC plant operation. Should this scheme be delayed or paused, this would have a significant and material impact on the NLCCP.

2.6.2.2 Site remediation and vacant possession

The planning consent for the Authority’s new ERF requires the existing EfW site to be decommissioned and demolished, with the land to be returned to a cleared state and vacant possession provided. This is a pre-requisite before physical work can be begin on the NLCCP.

2.6.2.3 ERF Development Consent Order

Any future development of the site should consider the context of the DCO for the construction and operation of the new ERF at the Edmonton EcoPark, which was granted in February 2017 and then modified to enable a higher electricity output in 2018.

2.6.2.4 Integration between ERF and CC plant

Steam, electricity and utilities will need to be provided by the new ERF for the CO_2 capture process. This will require review due to the complexity and potential disruption of the ERF’s operation during construction and operation of the CC plant. By carefully establishing interface details through process and layout modelling, parameters can be assessed and integrated between the ERF and CC plant.

2.6.2.5 *Intermediate transport and permanent storage*

The NLCCP will need to secure an intermediate transport solution and an agreement with T&SCo to permanently store captured CO_2.

2.6.3 **Strategic constraints**

Constraints are external considerations that set limits, within which the NLCCP must work, such its social acceptability, timing, practicality and strategic fit with wider public policies and strategy. Constraints will be considered as part of shortlisting of the options and definition of the project scope and should be managed periodically.

2.6.3.1 *The CO_2 specification and quality demanded by T&S companies*

Captured CO_2 will need to be conditioned during the post-combustion process to meet T&S companies requirements on issues such as the levels of impurities and non-condensable fractions, particularly in pipeline transport options.

2.6.3.2 *Site capacity*

As noted in Section 2.5.1, the proposed CC plant will require a significant site footprint, but as CC technologies are still developing, the footprint for the proposed CC plant at Edmonton EcoPark will vary according to the specific location, and CC technology requirements. As such, while it is currently assumed that there will be sufficient space at the Edmonton EcoPark, this assumption will have to be reviewed regularly as the NLCCP progresses.

2.6.3.3 *Business model support*

As set out in Section 4.4.2, the constraints of the government's business model support will need to be identified in relation to dispersed emitters. This includes the fact that capital grants and the Waste ICC business models are currently only available to emitters connected to the Track 1 and 2 cluster processes.

2.6.3.4 *Green belt*

The site is adjacent to the Green Belt boundary. Local policy requires any development option to consider effects on the adjacent green belt such as on views and vistas. It also states that any development proposals will only be permitted where the height, scale and massing has been considered to reduce visual dominance.

2.6.3.5 *Planning policy*

The CC plant will need to demonstrate compliance with prevailing planning policy, which is detailed in Section 6.7.1.7.

2.6.3.6 *Environmental impacts*

The CC plant will need to comply with a range of environmental policies, which are detailed in Section 6.7.1.8.

2.7 Strategic Case conclusion

This Strategic Case has demonstrated there is a strong case to develop the NLCCP, with the scheme strongly aligning with policies to tackle climate change at international, national, regional, and local level.

As highlighted in the Case for Change, the NLCCP would address the challenges the Authority would otherwise face in terms of CO_2 emissions, charges under the UK Emissions Trading Scheme, and the fact it is unable to significantly alter the fuel (i.e. residual waste that cannot be recycled) for its ERF.

The development of CC technology and a UK T&S industry should be expected to make the scheme more attractive over the coming years, and the NLCCP should be expected to create a number of 'green jobs' for the local economy, particularly during the construction phase.

A number of CC technologies have been reviewed and post combustion absorption – specifically amine and hot potassium carbonate (HPC) – currently appear to be the most favourable technology option for the NLCCP. This will be kept under review as the NLCCP progresses.

- A range of emerging transport and storage options have been identified, which are assessed in the Economic and Financial Cases. For the purpose of the Strategic Assessment Bacton has been selected as the hypothetical location for a potential interface point with a T&SCo to allow options to be compared on a like for like basis. The modelled options are: Direct Pipeline to Bacton;
- Direct Trucking to Bacton;
- Intermediate pipeline to Isle of Grain and then Ship to Bacton;
- Intermediate trucking to Isle of Grain and then Ship to Bacton;
- Intermediate pipeline to Thames Port and then Ship to Bacton;
- Intermediate trucking to Thames Port and then Ship to Bacton;
- Intermediate barges to Thames Port and then Ship to Bacton; and
- Intermediate trains to Teesside Port and then Ship to Bacton.

The chapter then sets out a range of risks, with the most significant relating to finding a commercially viable transport and storage solution, not being able to trade in negative emissions, and delays in obtaining planning consent. However, the process of assessing the NLCCP's risks has not identified any show-stoppers, and mitigation measures have been proposed for all those identified.

2.7.1 Strategic Case recommendations

The SOC stage should explore the following key areas:

- What the optimal technology for the CC plant should be; this will require ongoing engagement with the supply chain; and
- What technically feasible, deliverable and commercially viable intermediate T&S solutions are available; this will require work to establish strategic partnerships with providers, investigate and assess alternative methods of transporting and storing carbon, and engage with stakeholders on shared storage facilities.
- What the preferred T&SCo or T&SCos should be.

The Authority should also engage with DESNZ with a view to securing a more supportive policy framework on negative emissions and support for Energy-from-Waste operators and dispersed emitters in developing T&S solutions.

[Continued in Part 2]