National Planning Framework 4

Research Project: Lifecycle Greenhouse Gas Emissions of NPF4 Proposed National Developments Assessment Findings

Scottish Government
Riaghaltas na h-Alba

Research Project:

LIFECYCLE GREENHOUSE GAS EMISSIONS OF NPF4 PROPOSED NATIONAL DEVELOPMENTS ASSESSMENT FINDINGS

October 2022

Report prepared by:
Land Use Consultants Ltd

Registered Office:
250 Waterloo Road
London
SE1 8RD

The opinions expressed in this report are those of the author.

Report commissioned by:

Planning and Architecture Division
Area 2H South
Victoria Quay
Edinburgh
EH6 6QQ
e-mail: DMprocedures@gov.scot
web: http://www.gov.scot/Topics/Built-Environment/planning

This report is published electronically to limit the use of paper, but photocopies will be provided on request to Planning and Architecture Division.

	Date	**Changes**
First published	October 2021	First published
Revision 1.0	October 2022	As per changes detailed below

This report has been updated to align with the amended National Developments as set out in the Revised Draft NPF4 submitted to the Scottish Parliament in November 2022. Where references are to the 'draft NPF4' or to 'NPF4' these should be read as referring to the Revised Draft NPF4 and the proposed National Developments referred to therein. Changes in the main report are listed first in the below table. Changes in the Annex are briefly summarised in this table, as changes have been initially described in the preceding description of changes to the main report text.

Change	**Location**	**Description**
1.1	Executive summary, paragraph 1	Clarifies status of report
1.2	Executive summary, paragraph 9	Clarifies national development presented in alphabetical order
1.3	Throughout report	Names of national developments updated to reflect name changes
1.4	Executive summary	Order of national developments updated to

		reflect name changes and alphabetical order
1.5	Chapter 1 (paragraph 1.2)	Clarifies status of report
1.6	Chapter 2 (paragraph 2.3)	Amendment to text describing which national developments refer to low carbon and renewable hydrogen. All national developments which refer to hydrogen now include both in scope
1.7	Chapter 2 (paragraph 2.6)	Minor amendments to text to reflect the above change
1.8	Chapter 2, (paragraphs 2.9 to 2.12)	Text added on carbon footprint of water use in hydrogen production comparing low carbon and renewable hydrogen production
1.9	Chapter 2 (paragraph 2.13)	Reference added to associated water use in hydrogen production
1.10	Chapter 2 (paragraph 2.16)	Reference to renewable hydrogen changed to reflect both low carbon and renewable hydrogen
1.11	Chapter 2, Aberdeen Harbour Table 2.4	Indirect effects for transport updated to minor positive Reference to renewable hydrogen changed to reflect both low carbon and renewable hydrogen Addition of text on uncertainty over the energy requirements of the hydrogen production and CCUS processes.
1.12	Chapter 2, Circular economy materials management facility:	Change of word in description from ‘re-processing’ to ‘circulation’
1.13	Chapter 2, Clyde Mission	Change of wording in description from ‘vacant and derelict’ to ‘brownfield’
1.14	Chapter 2, Digital Fibre Network	Minor clarity change to assumption wording
1.15	Chapter 2, Dundee Waterfront	Change of wording in description from ‘expansion to’ to ‘improvement of facilities at’
1.16	Chapter 2, Dundee Waterfront	Minor change of wording in assumption for clarity Deletion of ‘and land reclamation for port expansion’
1.17	Chapter 2, Industrial Green Transition Zones	Deletion of wording in description ‘as well as further industrial transition sites that are expected to emerge in the longer term’.
1.18	Chapter 2, Industrial Green Transition Zones	Change of wording of assumption to reflect inclusion of renewable hydrogen Change of wording of assumption from ‘near shore’ to ‘off shore’ Change of wording of assumption to delete reference to ‘passenger’
1.19	Chapter 2, Industrial Green Transition Zones	Table 2.24 change of indirect effects for electricity to minor positive, national, enabling, long term

1.20	Chapter 2, Industrial Green Transition Zones	Table 2.24 addition of wording in summary of GHG balance (direct effects) to reflect hydrogen production for use for heat
1.21	Chapter 2, Industrial Green Transition Zones	Table 2.24 addition of wording in summary of lifecycle GHG balance (indirect effects) and overall summary of effects to reflect renewable hydrogen
1.22	Chapter 2, Energy innovation Development on the Islands	Name change from Islands Hub for Net Zero in all relevant locations
1.23	Chapter 2, Energy innovation Development on the Islands	Addition of 'low carbon' hydrogen to description and assumptions for clarity
1.24	Chapter 2, Energy innovation Development on the Islands	Addition of 'This is aligned with low carbon energy projects within the Islands Growth Deal that have been developed with local partners such as the Islands Centre for Net Zero, and encompasses other projects that can facilitate net zero aims.'
1.25	Chapter 2, Energy innovation Development on the Islands	Deletion of 'in particular at the proposed Orkney Research and Innovation Campus' in the description Deletion of 'There may also be opportunity for ports in the islands'
1.26	Chapter 2, Energy innovation Development on the Islands	Addition of word 'expertise' to description
1.27	Chapter 2, Energy innovation Development on the Islands	Deletion of 'There may also be opportunity for ports in the islands.'
1.28	Chapter 2, Energy innovation Development on the Islands	Addition of new assumption 'Assuming carbon capture and storage facilitates carbon capture from a range of processes and locations.'
1.29	Chapter 2, Energy innovation Development on the Islands	Table 2.26 change to GHG balance (direct effects) for industrial, manufacture and construction processes from moderate negative to minor positive
1.30	Chapter 2, Energy innovation Development on the Islands	Table 2.26 summary of GHG balance (direct effects) change from low to medium level of confidence in minor positive effects for electricity and addition of wording Change to minor positive effects from industrial processes and inclusion of text
1.31	Chapter 2, Energy innovation Development on the Islands	Table 2.26 summary of lifecycle GHG balance (indirect effects) addition of text
1.32	Chapter 2, National Walking, Cycling and Wheeling Network	Change to description to include 'infrastructure'
1.33	Chapter 2, Pumped hydro storage	Minor amendment to assumption
1.34	Chapter 2, Strategic Renewable Electricity	Addition of wording in description 'on and' to off shore renewables

	Generation and Transmission Infrastructure	
1.35	Chapter 2, paragraph 2.37	Additional wording to clarify location
1.36	Chapter 3, paragraph 3.14	Addition of text on carbon capture
1.37	Annex A, Table A.3 Aberdeen Harbour	Addition of new assessment row for low carbon hydrogen
1.38	Annex A, Table A.4 Aberdeen Harbour	Update of effects for transport, electricity and industrial, manufacture and construction processes.
1.39	Annex A, Table A.7 Chapelcross Power Station Redevelopment	Minor edit of wording for consistency with sentence structure in other table cells.
1.40	Annex A, Table A.9 Circular Economy Materials Management Facilities	Change of development description to match edited text
1.41	Annex A, Table A.15 Dundee Waterfront	Change of development description to match edited text
1.42	Annex A, Table A.17 Edinburgh Waterfront	Change of text to reflect change in ND description
1.43	Annex A, Table A.19 High Speed Rail	Change to development sub category description to match edited text
1.44	Annex A, Table A.22 Hunterston Strategic Asset	Addition of text on confidence of indirect effects for consistency with structure of other tables.
1.45	Annex A, Table A.23 Industrial Green Transition Zone	Amendment to table for consistency
1.46	Annex A, Table A.24 Industrial Green Transition Zone	Minor edits to text
1.47	Annex A, Table A.25 Energy Innovation Development on the Islands	Addition of low carbon hydrogen Addition of carbon capture and storage
1.48	Annex A, Table A.26 Energy Innovation Development on the Islands	Amendment of table for consistency
1.49	Annex A, Table A.31 Stranraer Gateway	Change to development sub category description to match edited text
1.50	Annex A, Table A.33 Strategic Renewable Electricity Generation and Transmission Infrastructure	Change to development sub category description to match edited text

Contents

Executive Summary

1 This report provides findings from the assessment of lifecycle greenhouse gas emissions of the proposed national developments. The assessment is based on descriptions of the proposed national developments as set out in the Revised Draft National Planning Framework 4 (NPF4) submitted to the Scottish Parliament in November 2022, hereafter referred to as 'the Draft NPF4'.

2 The assessment of the proposed national developments considers direct effects and indirect effects on greenhouse gas emissions. Direct effects include, for example, the effects of construction of a development. Indirect effects include those which are enabled by the development, for example, electricity transmission infrastructure which supports renewable energy generation.

3 Many of the proposed national developments include multiple project elements. The assessment considers the greenhouse gas emissions from different elements of each proposed national development, before combining these effects.

4 The assessment is structured against the six emissions sectors of transport, electricity, buildings (heat), industrial, manufacturing and construction processes (including embodied carbon), waste, and land use, land use change and forestry (LULUCF). Negative Emissions Technologies (NETs) are included for the assessment of the Industrial Green Transition Zones, which is the only proposed national development for which this sector is relevant. The assessment considers greenhouse gas emissions against the baseline and from the project stages of construction, through operation to decommissioning.

5 The assessment provides initial separate conclusions on the overall direct effects and overall indirect effects, before combining these in an overall summary of effect. This concludes whether the effects of the proposed national development are net positive (decrease emissions) or net negative (increase emissions).

6 For some of the proposed national developments direct effects may increase emissions in the short term, but positive indirect effects may occur over the longer term. The overall summary provides a judgement on the balance of direct and indirect greenhouse gas emissions.

7 The proposed national developments are developments that the Scottish Ministers consider strongly support the draft NPF4 spatial strategy, i.e. are 'needed'. Designation as a proposed national development does not remove requirements for relevant consents to be obtained before development can begin and it follows that there is considerable uncertainty as to the detailed scale and location of development that

would occur and around the implementation of new technologies. The assessment has therefore drawn on a number of assumptions based on the descriptions in the draft NPF4. Consequently, the overall summary of effect for each proposed national development may include a range in the scale of potential impacts on greenhouse gas emissions.

8 The overall summary of effect is therefore based on the detail provided at the time of the assessment, and the conclusion may alter depending on the nature and detail of the projects taken forward.

9 Table 0.1 below provides an overview of the overall summary of effect of the proposed national developments lifecycle greenhouse gas emissions on achieving national greenhouse gas emissions reductions targets in alphabetical order.

Table 0.1 Overall summary of effects from each proposed National Development

National development	Overall summary of effect
Aberdeen Harbour	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Central Scotland Green Network	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Chapelcross Power Station Redevelopment	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Circular Economy Materials Management Facilities	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Clyde Mission	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net negative impact on achieving national greenhouse gas emissions reduction targets.

Digital Fibre Network	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall negligible impact on achieving national greenhouse gas emissions reduction targets.
Dundee Waterfront	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Edinburgh Waterfront	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Energy Innovation Development on the Islands	Depending on the nature of the projects taken forward and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
High Speed Rail	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Hunterston Strategic Asset	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Industrial Green Transition Zones	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
National Walking, Cycling and Wheeling Network	Depending on the nature of the projects taken forward and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction

	targets.
Pumped Hydro storage	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Stranraer Gateway	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Strategic renewable electricity generation and transmission infrastructure	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Urban Mass/Rapid Transit Networks	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.
Urban Sustainable Blue and Green Surface Water Management solutions	Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall net positive impact on achieving national greenhouse gas emissions reduction targets.

10 The assessment concludes that considering both direct and indirect effects, the lifecycle greenhouse gas emissions the proposed National Developments will make a positive contribution to the 2030 carbon reduction targets, helping to reduce emissions. Overall, the greatest contributions to sectoral emission reductions are likely to be in terms of electricity and, to a lesser extent, transport. While the Industrial, manufacture and construction processes sector is likely to experience the largest increase in direct emissions, it will enable direct and indirect emission reductions across other sectors.

1. Introduction

Introduction

1.1 This report sets out findings from the finalised assessment of lifecycle greenhouse gas emissions of the proposed National Developments.

1.2 The assessment of the scope of the proposed national developments is based on the information provided by the Scottish Government and informed by associated assessment assumptions. The development descriptions should be read alongside the information provided on the proposed national developments in the Revised Draft NPF4 submitted to the Scottish Parliament in November 2022, hereafter referred to as 'the Draft NPF4'.

Methodology overview

1.3 A detailed methodology was developed in consultation with the Scottish Government and project steering group and is provided in Annex B. To summarise the methodology, the assessment follows two main stages:

a. an assessment of all of the individual components of a development (some projects have multiple and diverse components which are assessed individually) to identify positive (decrease emissions) or negative (increase emissions) and the significance of these.

b. a summary assessment which draws the project components together and provides conclusions on net direct, indirect, and overall effect. The summary assessment relates the scale of effect on GHG emissions to a national benchmarking exercise, included in the methodology. This uses the scale of minor, moderate, major, or super in terms of positive or negative contributions to GHG emissions.

1.4 The assessment is structured against the six emissions sectors of transport, electricity, buildings (heat), industrial, manufacturing and construction processes (including embodied carbon), waste, and land use, land use change and forestry (LULUCF). Negative Emissions Technologies are included for the proposed Industrial Green Transition Zones, but is not relevant to the scope of the other proposed national developments included in the assessment. Agriculture sector emissions are also excluded as not relevant to the scope of the proposed national developments included in the assessment. The assessment considers construction/establishment impacts, operations (direct), operations (indirect) and decommissioning effects.

1.5 The assessment provides initial separate conclusions on the overall direct effects and overall indirect effects, before combining these in an overall summary of

effect. This concludes whether the effects of the proposed national development are net positive (decrease emissions) or net negative (increase emissions).

1.6 For some of the proposed national developments direct effects may increase emissions in the short term, but positive indirect effects may occur over the longer term. The overall summary provides a judgement on the balance of direct and indirect greenhouse gas emissions.

1.7 The proposed national developments are developments that the Scottish Ministers consider strongly support the NPF4 spatial strategy, i.e. are 'needed'. Designation as a proposed national development does not remove requirements for relevant consents to be obtained before development can begin and it follows that there is considerable uncertainty as to the detailed scale and location of development that would occur and around the implementation of new technologies. The assessment has therefore drawn on a number of assumptions based on the descriptions in NPF4. Consequently, the overall summary of effect for each proposed national development may include a range in the scale of potential impacts on greenhouse gas emissions.

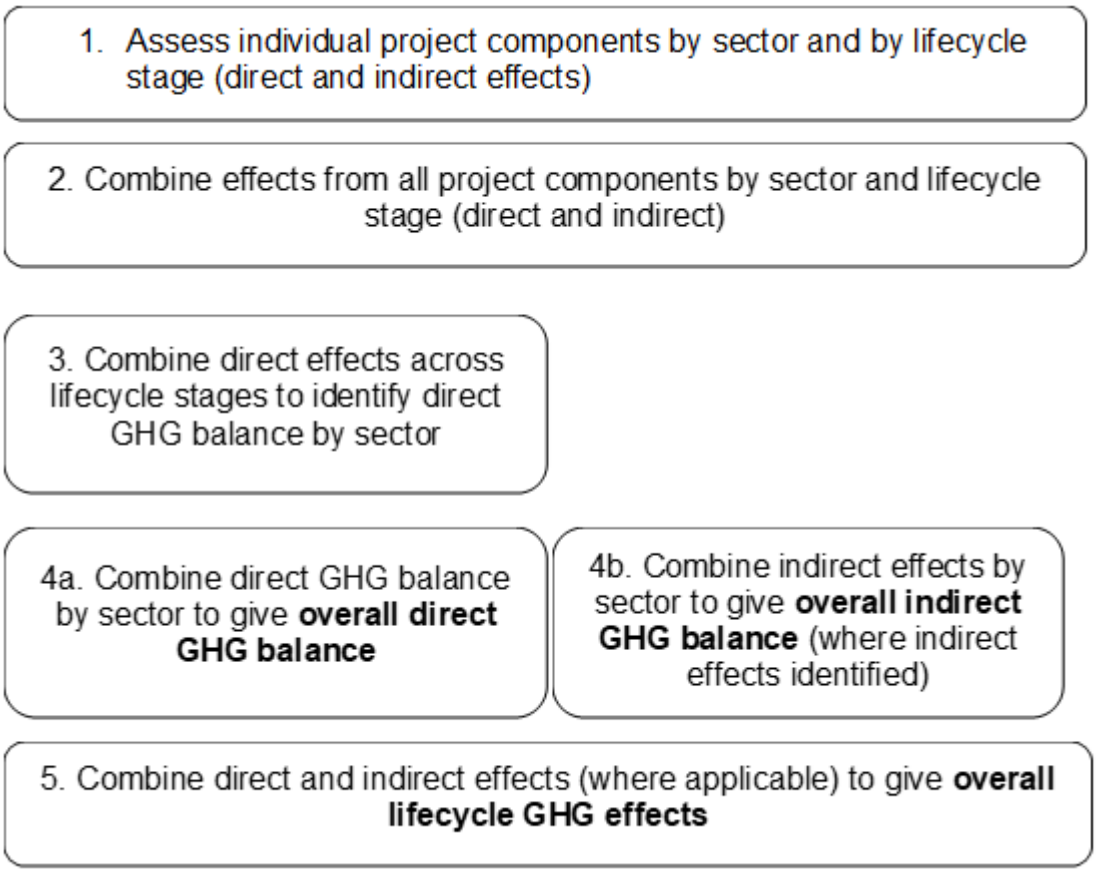
1.8 The overall summary of effect is therefore based on the detail provided at the time of the assessment, and the conclusion may alter depending on the nature and detail of the projects taken forward.

1.9 Additional mitigation and enhancement included in the assessment has been identified by LUC.

Summary of methodology

1.10 This section provides an overview of the methodology applied to the assessment process. The stages in this process are summarised in Figure 1.1 and described in more detail in the following sections. The assessment is based on the proposed national development description and supported by assessment assumptions.

Figure 1.1: Assessment Stages



Overview of methodology stages

Stage 1

1.11 The assessment firstly identifies the nature and scale of the effect for each project element, by sector and lifecycle stage. This is scored using the following system, shown in Table 1.1:

Table 1.1: Project element scoring

Key
Significant negative (increases emissions)
Minor negative (increases emissions)
Negligible negative (increases emissions, several negligible effects could combine in the summary table)
Negligible positive (increases emissions, several negligible effects could combine in the summary table)
Mixed negligible (both increases and reduces emissions at a negligible scale)
Mixed (both increases and reduces emissions at a minor scale)
Minor positive (reduces emissions)
Significant positive (reduces emissions)
No effect

1.12 An example of the assessment table which applies this scoring system is illustrated in Table 1.2 overleaf:

Table 1.2: Example assessment table

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
NAME	SUB CATEGORY	**Transport**		*Explanatory text for positive or negative effect and scale of effect*	*Explanatory text*	*Explanatory text*	*Explanatory text*	*Explanatory text*
		Electricity			*Explanatory text*	*Explanatory text*		
		Buildings/Heat						
		Industrial, manufacture and construction processes		*Explanatory text*				
		Waste		*Explanatory text*	*Explanatory text*		*Explanatory text*	
		LULUCF						
		Negative Emissions Technologies						

1.13 Table 1.2 is repeated for as many sub-categories of the proposed or alternative proposed national development as required.

Stage 2

1.14 This is then followed by a summary table which combines all project components to identify the balance of effect by sector, by lifecycle stage. The main body of the summary table is illustrated in Table 1.3 overleaf:

Table 1.3: Example summary table (excluding final column)

Summary of significant effects from all project components including cumulative effects.	**Baseline**	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**
Transport		*Overall combined transport **construction/establishment** GHG emissions for **all project components***	*Overall combined transport **operation (direct)** GHG emissions for **all project components***	*Overall combined transport **operation (indirect)** GHG emissions for **all project components***	*Overall combined transport **decommissioning** GHG emissions for **all project components***
Electricity					
Buildings (heat)					
Industrial, manufacture and construction processes					
Waste					
LULUCF					
Negative Emissions Technologies					

Stage 3

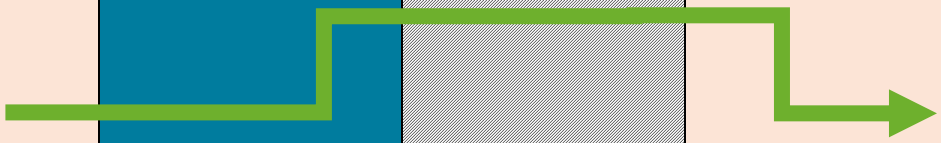
1.15 Combining the direct effects by sector, the overall GHG balance is identified, as positive or negative, (see the final column of Table 1.5), and the scale of that effect is related to the benchmarking for that sector using the colour coding shown in Table 1.4 below. The benchmarking relates to the quantity of 2021 emissions reductions by 2032, and is explained in more detail in the separate method document:

Table 1.4: Benchmarking score colour codes

Overall effect colour codes (positive)	Overall effect colour codes (negative)
Minor	Minor
Moderate	Moderate
Major	Major
Super	Super
Neutral	Neutral

Table 1.5: Process for identifying GHG balance by sector (direct effects)

Summary of significant effects from all project components including cumulative effects.	**Baseline**	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector (direct)**
Transport						*Overall judgement on direct GHG balance by sector related to benchmarking.*
Electricity						
Buildings (heat)						
Industrial, manufacture and construction processes						
Waste						
LULUCF						
Negative Emissions Technologies						



Stages 4a, 4b and 5

1.16 Following the sector-by-sector combination of effects, summary text is provided for direct effects, indirect effects and the overall summary of effects, as shown in Table 1.6.

Table 1.6: Process for identifying summary GHG balance for direct, indirect and overall effects

Summary of direct lifecycle GHG effects	Describes the overall **direct** lifecycle GHG effects, noting the confidence level related to effects for each sector. The overall effect is identified as net positive or negative.
Summary of indirect lifecycle GHG effects	Describes the overall **indirect** lifecycle GHG effects. The overall effect is identified as net positive or negative.
Summary of overall lifecycle GHG effects	Describes the overall effect, **combining direct and indirect effects**. Identifies the scale of the effect, which may be a range depending on uncertainties associated with the proposed national development. Attributes a confidence level to the scale and / or nature of the effect.
Additional mitigation and enhancement	Describes suggested mitigation and enhancement.

2. Lifecycle GHG Emissions of Proposed National Developments

Introduction

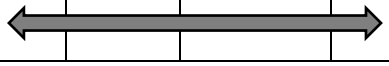
2.1 This chapter provides individual summaries of the lifecycle GHG emissions of each of the proposed national developments. The developments are ordered alphabetically. The key for the colour coding of the significance of effects is shown in Table 2.1.

Table 2.1: Key for colour coding significance of effects

Overall effect colour codes (positive)	Overall effect colour codes (negative)
Minor	Minor
Moderate (1-5%)	Moderate (1-5%)
Major (5-10%)	Major (5-10%)
Super (more than 10%)	Super (more than 10%)
Neutral	Neutral

2.2 A summary table of range of effects is provided for each development (see example in Table 2.2), with the relevant word indicting the score for direct and indirect effects, and an arrow indicating the range for the overall summary of effects.

Table 2.2: Example of a summary table with the range of effects

Proposed National Development	**Positive**				**Negative**			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**N/A**				**N/A**			
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
								

2.3 The Scottish Government Hydrogen Policy Statement (2020) defines low carbon (or blue) hydrogen as produced from reforming of natural gas, in conjunction with carbon capture and storage which captures most of the CO_2 produced, whereas renewable (or green) hydrogen is produced through electrolysis of water. The process of electrolysis is powered by renewable energy. For the purposes of this assessment all of the proposed National Developments which refer to hydrogen production assess both low carbon and renewable hydrogen. These proposed National Developments are:

- Aberdeen Harbour;
- Energy Innovation Development on the Islands;
- Industrial Green Transition Zone (covering both the Scottish Cluster Carbon Capture and Storage Network and the Grangemouth Investment Zone);
- Chapelcross; and
- Hunterston.

2.4 Low-carbon hydrogen production is reliant on natural gas which has associated upstream production GHG emissions which are ongoing throughout the low carbon hydrogen production process. Carbon capture and storage is not 100% efficient, and incurs an energy penalty requiring additional natural gas input, which is continuous throughout the production process.

2.5 Carbon capture and storage is assumed to reuse existing oil and gas infrastructure, however there will be some new construction associated with hydrogen production and upgrades and maintenance to existing infrastructure which will result in GHG emissions associated with industrial processes.

2.6 Renewable hydrogen production is considered to result in increased GHG emissions (relative to low-carbon hydrogen) related to industrial processes from construction and maintenance of the renewable energy sources. These structures are reliant on materials with high levels of embodied carbon. However, the carbon payback period for wind turbines is typically less than a year as manufacturing and construction emissions are then offset by the production of renewable electricity.

2.7 Both methods of hydrogen production are likely to result in some fugitive hydrogen emissions.

2.8 Where both renewable and low carbon hydrogen are produced the profile of GHG emissions will vary according to the mix of each. Renewable hydrogen will result in higher emissions during manufacture and construction than low carbon hydrogen, but low emissions during operation. Conversely, low carbon hydrogen is likely to result in lower emissions during construction, but higher emissions than renewable hydrogen during operation. Renewable hydrogen produced using surplus electricity from existing established renewable generation assets will have a lower profile of GHG emissions than new build dedicated renewable hydrogen production facilities.

2.9 The carbon footprint of water use in hydrogen production is a consideration in the assessment, however, there is some uncertainty over which processes will be used, and the scale of production which will be taken forward under the proposed national developments.

2.10 Low carbon hydrogen is produced by steam methane reforming which is the high temperature reaction of methane with steam (water) to produce hydrogen and carbon dioxide. Water is also required for cooling purposes.

2.11 Renewable hydrogen produced by electrolysis requires high purity water and energy from renewable sources. The treatment of the water supply to provide high purity demineralised water has an additional carbon footprint due to the energy requirements of this process. Renewable hydrogen production in on or offshore locations may rely on the desalinisation of seawater which is an energy intensive process, but which would be powered by renewable energy.

2.12 A range of values for water use for each form of hydrogen production are identified. A range of 6.4kg – 32.2kg of water per kg of hydrogen for steam reforming of methane, is identified when considering both the water for the process and for cooling (with 4.5kg water required for the reaction only). For renewable hydrogen values are in the range of 18kg -24kg of water per kg of hydrogen produced by electrolysis (with 9kg of water required per kg of hydrogen for the reaction only), with higher estimates to 25.7kg – 30.2kg[1].

2.13 As hydrogen production is only one element of a proposed national development, and in the context of other uncertainties associated the assessment conclusions, the GHG emissions associated with entirely renewable hydrogen production, entirely low carbon hydrogen production, or a mix of the two (and the associated water use) do not affect the overall conclusion.

[1]Blanco, H. (2021) Hydrogen production in 2050: how much water will 74 EJ need? Energypost.eu [online] Accessed 16/09/22. Available at: https://energypost.eu/hydrogen-production-in-2050-how-much-water-will-74ej-need/

Aberdeen Harbour

Description

2.14 This proposed national development supports the continued relocation and repurposing of Aberdeen Harbour.

2.15 The south harbour can act as a cluster of port accessible offshore renewable energy research, manufacturing and support services. The facilities are important for international connections.

2.16 At the south harbour the focus should be on regenerating existing industrial land and reorganising land use around the harbour in line with the spatial strategy of the local development plan. By focusing future port activity here, parts of the existing harbour in the city centre will become available for mixed use development, opening up development land to help reinvigorate Aberdeen city centre.

Assumptions

- Assuming the delivery of significant new port infrastructure, including development at South Harbour.
- Assuming the development will increase shipping capacity and will enable larger vessels to visit Aberdeen. Larger vessels are more fuel efficient.
- Assuming cruise ships will use the harbour.
- Assuming infrastructure required for renewable and low carbon hydrogen production.
- Assuming that carbon heavy materials will be required for construction and operation phases.
- Assuming a significant number of jobs will be created within the development.
- Assuming onshore elements of harbour infrastructure will require an electricity supply – including for the operation of lighting, offices, security etc.
- Assuming that buildings will require heating.
- Assuming that development will include brownfield and greenfield land, whilst recognising that brownfield will be prioritised as far as possible.
- Assuming that this activity is going to support oil and gas decommissioning and to support offshore renewables.
- Assuming potential for transport structure upgrades including road and rail.
- Assuming development will enhance access and improve the quality of green space.
- Assuming active travel options will be designed-in.

- Assuming environmental sensitivities are addressed through careful planning, assessment and implementation.
- Assuming that, as part of the consenting process, consideration through all relevant statutory assessment regimes such as Environmental Impact Assessment (EIA) and Habitats Regulations Appraisal (HRA) will be required, where applicable at project level.
- Assuming the development will have a lifetime of at least 40 years.
- Assuming that some hydrogen leakage may occur during distribution and transportation.
- Assuming that recycled materials will be used where possible.

Table 2.3: Aberdeen Harbour summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)					**Negative**			
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
		⟷						

Table 2.4: Aberdeen Harbour summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor negative	Minor positive Scotland wide, long term
Electricity	Minor negative	Minor to major positive Scotland wide, long term, multiplier effect
Buildings (heat)	Minor negative	Minor positive National, enabling, long term
Industrial, manufacture and construction processes	Minor negative	Minor to major positive Scotland wide, long term,

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
		multiplier effect
Waste	Minor negative	N/A
LULUCF	Minor negative	N/A
Summary of direct lifecycle GHG effects	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Low confidence in minor negative effects from transport as it is uncertain how much additional marine and road traffic this development is likely to generate, and how much of the hydrogen produced will be used for **transport** purposes. ▪ Medium confidence in minor negative effects from **electricity** as it is expected that this development will require electricity for operation, and it is uncertain if energy demands will be met from renewable sources. ▪ Low confidence in minor negative effects for **buildings** due to uncertainty if hydrogen will be used as a heat source. It is assumed there is a small increase in heat demand. ▪ Medium confidence in minor negative effects in relation to **industrial processes** as this development will require a significant amount of carbon heavy materials for construction and operational phases, and it is uncertain how much hydrogen will be used for industrial purposes and uncertainty over the energy requirements of the hydrogen production and CCUS processes. ▪ Medium confidence in minor negative effects from **waste** due to uncertainty over the quantity of waste generated by the operations. ▪ Medium confidence in minor negative effects arising from **LULUCF** as it is assumed that the development would be delivered on both brownfield and greenfield land.	
Summary of indirect direct lifecycle GHG effects	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. This development is likely to enable increased generation of renewable electricity through research, manufacturing and support services. This could displace higher carbon fuel sources across Scotland. The research elements are likely to have a multiplier effect for renewable energy development over the medium to long term. In addition, it is likely to facilitate the more efficient use of renewable energy by using surplus electricity to produce renewable hydrogen. Renewable and low carbon hydrogen may be used for transport, heat and industry. Low confidence in indirect positive effects due	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	to uncertainty over the use of surplus electricity for hydrogen production, the scale of hydrogen production and deployment across different sectors.	
Summary of overall lifecycle GHG effects	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the facilitation and enabling of renewable energy development across Scotland, and the production of renewable and low carbon hydrogen over long timescales. The scale of this effect could range from low to high. A low scale of effect would result from higher levels of increased transport emissions from the site operations using high carbon fuels, but with a lesser contribution by the development to enabling renewable energy and a lesser quantity of renewable and low carbon hydrogen produced. Conversely, if the additional site transport emissions are lower overall and use low carbon fuels, and the proportion of renewable energy development enabled and renewable and low carbon hydrogen produced is higher, this could result in a high positive effect. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means there is low confidence in this conclusion.	
Additional mitigation and enhancement	Prioritise the use of renewable / low carbon energy to power the development. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled. Provide low carbon transport options for the site to reduce car dependency.	

Central Scotland Green Network

Description

2.17 The proposed national development is to support delivery of green infrastructure in Central Scotland.

Assumptions

- Assuming expansion of active travel paths will increase journeys taken on foot/cycling.
- Assuming Central Scotland Green Network will not be decommissioned.
- Assuming the only electricity use will be safety lighting.
- Assuming construction equipment will be powered by fossil fuels.
- Assuming trees will need protection when young for up to 5 years by tree guards.
- Assuming waste is limited to associated infrastructure found in green space.
- Assuming some soil/vegetation will be cleared as part of upgrades. Assuming to be reused/repurposed elsewhere within development.
- Assuming tree protection removed after 5 years.
- Assuming some carbon in soil will be released during construction works.
- Assuming large scale tree planting and peatland regeneration across Central Scotland.
- Assuming green infrastructure will be created on brownfield land where possible.
- Assuming green infrastructure uses may include food growing, nature-based solutions for climate adaptation and biodiversity enhancement, and water management.

Table 2.5: Central Scotland Green Network summary of the range of effects

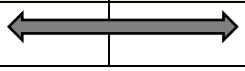
	Positive				**Negative**			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**N/A**				**N/A**			
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
								

Table 2.6: Central Scotland Green Network summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Super positive (more than 10%)	N/A
Electricity	Minor negative	N/A
Buildings (heat)	Neutral	N/A
Industrial, manufacture and construction processes	Minor positive	N/A
Waste	Minor negative	N/A
LULUCF	Major positive (between 5 and 10%)	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in super positive effects for **transport** related to the assumed greater uptake of active modes of travel displacing emissions from transport over a long time period and at a national scale, however there is uncertainty over the uptake of active travel. ▪ Medium confidence in major positive effects for **LULUCF** from greater carbon sequestration from creation of new greenspace and large-scale planting of trees. However, there is uncertainty surrounding the scale of green network enhancements. ▪ Medium confidence in minor positive effects for **industrial, manufacture and construction processes** due to reduced flood risk and impacts on property and infrastructure. ▪ High confidence in minor negative effects for **electricity**, **and waste** due to assumed limited emissions associated with these sectors.	
Summary of lifecycle GHG balance (indirect effects)	No indirect effects identified.	
Overall summary of effect	This proposed national development is likely to have a **net positive** effect on lifecycle GHG emissions due to reduced transport emissions from higher uptake of active travel, reduced flood risk and greater rates of carbon sequestration due to the creation of new greenspace and large-scale planting of trees.	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	The scale of this effect is likely to be in the range of **medium to high** as it is likely to encourage a change in behaviour around active travel in central Scotland over a long time period. A medium scale of effect would result from higher embodied carbon in construction infrastructure, lower levels of active travel and lower levels of flood risk reduction. Conversely, lower embodied carbon in construction infrastructure, higher levels of active travel and higher levels of flood risk reduction would result in a higher scale of effect. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. However there is considerable uncertainty and this could be within the range of medium to high positive impact. Uncertainty about the scale of these effects means there is medium confidence in this conclusion.	
Additional mitigation and enhancement	Maximise the scale of expansion, number of trees and type of development, whilst protecting existing high carbon soils. Ensure low carbon materials are used for associated infrastructure (seating, lighting, tree protective equipment etc). Consider the use of the green network for providing renewable heating. Ensure that green network is well linked with other active travel routes and public transport modes to further reduce potential emissions from transport.	

Chapelcross Power Station Redevelopment

Description

2.18 The proposed national development is to redevelop the former nuclear power station site. The development may include for example business development with a particular focus on energy and energy supply chain; energy generation from solar; electricity storage; generation of heat; production and storage of low carbon and renewable hydrogen.

Assumptions

- Assuming most vehicles are powered by fossil fuels. Over time vehicles are likely to transition to lower carbon alternatives such as electric vehicles or hydrogen fuelled HGV.
- Assuming that this development will provide opportunities for active and sustainable travel.
- Assuming a proportion of electricity demand will be low carbon in nature and provided from elsewhere within the development.
- Assuming that the land is potentially contaminated and that some ground remediation works will be required, although the nature of these is unknown.
- Assuming that wherever possible existing infrastructure will be reused.
- Assuming some landscaping and greenspace will be incorporated into the development.
- Assuming heat generation is surplus or low carbon.
- Assuming that renewable energy, including solar energy, will displace emissions from some of the current fossil fuel-based energy. Energy storage will enable more efficient use of renewable energy.
- Assuming that electricity storage will be developed in the medium to long term.
- Assuming low carbon hydrogen production.
- Assuming renewable hydrogen production.
- Assuming large scale hydrogen production, over at least 30 years' time scales.
- Assuming hydrogen produced supports the transition to net zero and could be used for transport, heat and energy storage.
- Assuming the development includes infrastructure for chemicals production associated with hydrogen, including ammonia production, for the purpose of energy storage or transportation.

- Assuming some hydrogen may leak to the atmosphere. Assuming hydrogen distribution and storage will be a part of this development.

- Assuming that distribution of hydrogen and ammonia for vehicular/transport use will rely on shipping and road transport, which is assumed to be fuelled by fossil fuels.

Table 2.7: Chapelcross Power Station Redevelopment summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)					**Negative**			
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
				⟷				

Table 2.8: Chapelcross Power Station Redevelopment summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor negative	Minor positive Regional to national, enabling, medium to long term
Electricity	Minor positive	Minor positive Regional to national, enabling, medium to long term
Buildings (heat)	Neutral	Minor positive National, enabling, long term
Industrial, manufacture and construction processes	Minor negative	Minor positive effects Regional to national, enabling, medium to long term
Waste	Minor negative	N/A
LULUCF	Minor negative	Negligible positive

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Low confidence in minor positive effects arising from **electricity** because of the uncertainty around the amount of renewable electricity generated versus the amount of electricity required for hydrogen generation. ▪ Medium confidence in minor negative effects arising from **transport** as this development is assumed to generate additional transport. ▪ Medium confidence in minor negative emissions from **industrial processes** as it is assumed that this development is likely to require carbon heavy materials for its construction and also it is likely to lead to hydrogen leakage during its operation. ▪ Low confidence in minor positive effects on **LULUCF** due to the assumed limited scale of landscaping potential at this site.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is likely to support and provide a catalyst for low carbon energy generation, storage and distribution which will help displace emissions from current fossil fuel-based energy, including for transport, heat and industrial processes. The indirect positive effects could range from minor to moderate positive due to uncertainty over how much the development supports hydrogen for fuel or supports renewable energy development elsewhere. Negligible positive effects are also identified in relation to LULUCF, as this development is likely to avoid using a greenfield site which could have led to more significant soil carbon and vegetation loss	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the production of renewable and low carbon energy and support for energy related business development. The scale of effects could range from low negative to low positive. A low negative effect would result from a lower level of renewable / low carbon energy produced or stored, and lower levels of enabling support for renewable energy related development which could be insufficient to balance against the embodied energy of	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	construction and on site energy demands and increase in transport emissions, Conversely, if the levels of renewable/low carbon energy production and storage are higher and the enabling effect of the development for renewable energy is greater a low positive effect could be achieved. An overall net positive effect is concluded based on the assumption of a higher level of renewable/low carbon energy production and storage. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects means there is low confidence in this overall conclusion	
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or at least recycled. Consideration of the type and scale of green energy generation and whether it can be used to provide electricity to the businesses forming the development. Consideration should be given to potential restoration of the development site (or individual components) upon decommissioning. Ensure public transport connections and links to active travel routes.	

Circular Economy Materials Management Facilities

Description

2.19 The proposed national development is to deliver a range of facilities required to manage waste streams and their circulation back to the economy, where sites and facilities will enable retaining the value of waste materials to maximise the use of materials and minimise the use of virgin materials to reduce GHG emissions.

Assumptions

- Assuming that even without these facilities materials would have to be transported for some processing or landfilling. Assuming the facilities will be in place for at least 30 years.
- Assuming that new supply chains will need to be developed and this may increase the overall transport emissions.
- Assuming that electricity would be required for the processing activities.
- Assuming that reprocessing of some materials will require at least some heat.
- Assuming that if these facilities are not constructed, there would be a need to construct other facilities that would process similar volume of waste. This would also require materials for construction.
- Assuming most materials will remain in the loop once this network is implemented.
- Assuming brownfield sites will be prioritised for these facilities.

Table 2.9: Circular Economy Materials Management Facilities summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
		⟷						

Table 2.10: Circular Economy Materials Management Facilities summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor negative	N/A
Electricity	Minor negative	N/A
Buildings (heat)	Minor negative	Minor positive Local, long term
Industrial, manufacture and construction processes	Minor negative	Minor positive Scotland wide, long term
Waste	Major positive	Minor positive Enabling, medium to long term
LULUCF	Neutral	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects arising from **transport** as it is assumed that more complex supply chains may be developed which may increase the transport, but it is uncertain how such vehicles will be fuelled in the future. ▪ Medium confidence in minor negative effects from **electricity** and **heat** as materials processing will require additional electricity and heat, but there is uncertainty over the source of electricity or heat. ▪ Medium confidence in minor negative effects from **industrial, manufacture and construction processes** as it is assumed this development will lead to limited additional emissions compared to existing processing facilities. ▪ High confidence in significant positive effects in relation to **waste** as this development has the potential to reduce waste from a range of waste streams by keeping them in the loop, repurposing and reusing them.	
Summary of lifecycle	This proposed national development is likely to result in	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
GHG balance (indirect effects)	a **net positive** effect on indirect lifecycle GHG emissions. This development may potentially encourage more innovation and may enable some businesses to use new materials that is likely to reduce the demand for virgin materials, with positive effects for industrial, manufacture and construction processes. Potential for positive effects where surplus by-products can be utilised, for example surplus heat. The indirect positive effects could range from minor to moderate due to uncertainty over the role of the development in reducing emissions from production and processing of raw materials and the quantity of electricity or heat produced.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have **net positive** effects on lifecycle GHG emissions due to increased efficiency in waste management and use of raw materials. The scale of the positive effects could range from low to high positive depending on the volume of waste reprocessed. If the amount of waste reprocessed is relatively minor, vehicle movements are higher, energy demands of reprocessing are higher and waste heat is not utilised the overall positive effect is likely to be minor. However, if this development enables reprocessing at a significant scale, uses low carbon transport, utilises waste heat and supports energy production, it is likely to lead to high positive effects. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects mean that there is medium confidence in this conclusion.	
Additional mitigation and enhancement	Ensure that where possible transport is decarbonised to reduce the overall emissions from this development and also from transport sector. Ensure use of waste heat where possible.	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	Support on site low carbon or renewable energy generation. Support local processing and reuse where possible. Ensure development on brownfield land where possible.	

Clyde Mission

Description

2.20 The proposed national development is to deliver an ambitious redevelopment programme to bring forward sites which are ready for redevelopment to sustain a range of uses.

2.21 This development will repurpose and reinvigorate brownfield land tackling contamination, and supporting local living as well as adapting the area to the impacts of climate change.

Assumptions

- Assuming that sustainable transport modes and active travel routes will be linked with the development to reduce emissions from resident's commute.
- Construction over 20 years. Assuming the development will have a lifetime of at least 40 years.
- Assuming that energy efficiency and low carbon solutions will be installed.
- Assuming for the purposes of assessment that heat efficiency and low carbon solutions will be installed to provide net zero heating, to meet the net increase in heating demand from the development.
- Assuming for the purpose of assessment that the land is potentially contaminated and that some ground remediation works will be required, although the nature of these is unknown.
- Assuming that new and/or upgraded infrastructure for climate adaptation, including nature-based, green and blue solutions will be embedded in the development.
- Assuming the upgrading of existing ports and harbour assets.

Table 2.11: Clyde Mission summary of the range of effects

	Positive				**Negative**			
Summary of GHG balance (direct effects)					**Negative**			
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
					⟷			

Table 2.12: Clyde Mission summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor negative	N/A
Electricity	Minor negative	N/A
Buildings (heat)	Minor negative	N/A
Industrial, manufacture and construction processes	Minor negative	N/A
Waste	Minor negative	N/A
LULUCF	Minor positive	Negligible positive, local, long term
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects related to **industrial, manufacture and construction processes** based on an assumption that this development will require a significant amount of carbon heavy materials, although there is uncertainty over the use of low carbon construction materials. ▪ Medium confidence in minor negative effects related to **transport**, **electricity** and **waste**, based on assumptions that the development will encourage an increase in travel, electricity demand and waste production. ▪ Low confidence in relation to minor negative effects for **buildings (heat)** based uncertainty over the use of sustainable heating sources. ▪ Low confidence in minor positive effects from **LULUCF** based on an assumption that the impact of development of the site and implementation of green and blue infrastructure are unknown.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is taking place on previously developed land, and it is assumed that the development reduces pressure on greenfield land and reduces potential transport emission generated from equivalent development on greenfield land with fewer sustainable transport connections and LULUCF associated emissions. The scale of this effect is likely to be minor, due to the regional effect of this development.	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net negative** effect on lifecycle GHG emissions due to increased emissions from transport, electricity, heat, industrial, manufacture and construction processes and waste. This development is likely to be delivered on vacant or derelict land which is assumed to protect greenfield sites from being developed. The scale of this effect is likely to be low depending on the uptake of sustainable transport modes and low carbon/energy efficiency solutions, and LULUCF benefits. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net negative** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects mean that there is medium confidence in this conclusion.	
Additional mitigation and enhancement	Ensure that electricity and heat demand and supplied from renewable or low carbon sources to reduce potential emissions. Exploit the potential for green and blue infrastructure to ensure climate resilience and adaptation, and also potential for active travel. Ensure requirement for high energy efficiency of new and retrofitted buildings. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or at least recycled.	

Digital Fibre Network

Description

2.22 The proposed national development is to deliver enhanced digital connectivity providing high speed broadband or equivalent mobile service, prioritising those areas with weaker networks across Scotland.

Assumptions

- Assuming that increased connectivity will support a reduced need to travel. The lifetime of the development is assumed to be about 10 years based on the rate of change associated with this technology.
- Assuming that the network equipment will include cables and masts (the quantity is uncertain which may have a significant impact on the potential GHG emissions).
- Assuming potential creation of green data centres.
- Assuming mix of brownfield and greenfield land.

Table 2.13: Digital Fibre Network summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)					**Negative**			
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
				⟺				

Table 2.14: Digital Fibre Network summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor negative	Minor positive Supra regional, enabling, short to medium term
Electricity	Minor negative	N/A
Buildings (heat)	Neutral	Negligible negative, Scotland wide, long term
Industrial, manufacture and construction processes	Minor negative	N/A
Waste	Minor negative	N/A
LULUCF	Minor negative	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects arising from **transport** related to the assumed more frequent maintenance travel. ▪ Medium confidence in minor negative effects from **electricity** due to an assumed increase in the number of devices and internet use. ▪ Medium confidence in minor negative effects related to **industrial, manufacture and construction processes** from the embodied carbon in the materials. ▪ Medium confidence in minor negative effects for **waste** reflecting uncertain energy requirements for processing waste or loss of embodied carbon in waste materials. ▪ Medium confidence in minor negative GHG balance for **LULUCF**, due to uncertainty over extent of loss of sequestered carbon in soils and vegetation.	
Summary of lifecycle GHG balance (indirect	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
effects)	emissions. The development will support digital connectivity in less well-connected areas of the Highlands and Islands. There is low confidence over the scale of impact of indirect positive effects on transport. The indirect positive effects may only be minor due to uncertainty over reductions in travel for work, as increased connectivity may also encourage an increase in travel in the medium to long term. Increased home working may result in minor indirect negative effects on heat demand, however this is likely to be limited in scale.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have **negligible** effects as the potential increases in maintenance travel and electricity use, and to industrial, manufacture and construction processes should be counterbalanced by reduced journeys from improved connectivity. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **negligible** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty over the balance between reductions in travel and increases in travel means there is low confidence in this conclusion.	
Additional mitigation and enhancement	Avoid development in areas with high carbon soil. Development of best practice guidance/regulation to ensure that fibre cables and tower construction do not impact on high carbon soils. Ensure cable laying utilises conduits or existing infrastructure for lower carbon future cable replacement.	

Dundee Waterfront

Description

2.23 This proposed national development supports the continued delivery of the waterfront transformation securing the role of the city as a location for investment in the net zero economy. Further projects associated with this include: the Michelin Scotland Innovation Parc which will become an innovation hub for net zero emission mobility; the Eden Project; and an improvement of facilities at Dundee Port. This proposed national development includes reusing land on and around the Dundee Waterfront to support the lifelong health and wellbeing of communities, deliver innovation and attract investment. As the development progresses it will be important to support sustainable and active transport options and to build in adaptation to future climate risks.

Assumptions

- Assuming that the development will have a lifetime of at least 40 years.
- Assuming that the development will be served by sustainable transport modes and will be linked with active travel routes but will result in overall net increase in travel demand of all types.
- Assuming that at least some of the electricity will come from renewable sources.
- Assuming for purposes of assessment that a proportion of low carbon heating sources will be in place.
- Assuming for purposes of assessment that waste minimisation will be sought across the development.
- Assuming that green and blue infrastructure will be part of the development.
- Assuming a significant number of people will use sustainable and active transport modes. Assuming in the longer-term greater numbers of people will use them as these will become the most convenient transport mode.
- Assuming active travel routes will include a green infrastructure.
- Assuming activity to support oil and gas decommissioning and off-shore renewables.
- Assuming that recycled materials will be used where possible.
- Assuming redevelopment of brownfield land.
- Assuming new or upgraded ports facilities .

Table 2.15: Dundee Waterfront summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)					**Negative**			
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
				⟺				

Table 2.16: Dundee Waterfront summary GHG balance

Sector emission source	**GHG balance (direct effects)**	**GHG balance (indirect effects)**
Transport	Minor negative	N/A
Electricity	Minor negative	Minor positive Scotland wide, long term, multiplier effect
Buildings (heat)	Minor negative	N/A
Industrial, manufacture and construction processes	Minor negative	N/A
Waste	Minor negative	N/A
LULUCF	Negligible	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects in relation to **transport** based on an assumption that this development will increase overall journeys but will also enable sustainable and active transport. ▪ Medium confidence in minor negative effects arising from **electricity** and **heat** due to increased demand and uncertainty over extent of renewable or low carbon electricity or heat incorporated into	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	the development. ▪ Medium confidence in minor negative effects arising from **industrial processes** as it is Assuming that carbon heavy materials will be required for the construction phase of the development. ▪ High confidence in minor negative effects from **waste**, as the development will increase overall levels of waste generated. ▪ Medium confidence in negligible GHG balance from **LULUCF** due to Assumed use of previously developed land and incorporation of green and blue infrastructure.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is likely to support the decommissioning of the oil and gas industry and also off-shore renewables. The scale of indirect effects is likely to be minor, however there is low confidence over the scale of indirect positive effects on electricity due to uncertainty over the quantity of renewables that will be supported by this development.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the transport emissions being partly balanced by indirect support for renewable energy development. The scale of this effect is likely to be low positive to negligible, depending on the level of renewable energy supported by the development and the level of travel generated by the development. If a relatively small amount of renewable energy generation supported by this development negligible effects are expected, whereas if this development supports a significant amount of renewable energy generation then minor positive effects are expected. However, it is assumed that a significant amount of renewable energy capacity will be supported considering the location of the harbour in relation to off-shore renewables and the relatively large-scale expansion of the harbour. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty over the scale of effects means there is low confidence in this conclusion.	
Additional mitigation and enhancement	Ensure that public transport connections are frequent and convenient to offer an effective alternative to private vehicles. Ensure that the site is connected with active travel network. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled. Implement district heating. Ensure renewable energy generation is incorporated into the development. Ensure requirements for high energy efficiency buildings.	

Edinburgh Waterfront

Description

2.24 This proposed national development supports regeneration that will include high-quality mixed-use proposals that optimise the use of the strategic asset for residential, community, commercial and industrial purposes, including support for off-shore energy relating to port uses.

Assumptions

- Assuming good public transport provision and links to active travel network will be ensured. Based on travel generated by additional homes and jobs. Development will have a lifetime of at least 40 years.
- Assuming a proportion of energy efficiency solutions will be implemented in the new homes.
- Assuming that support for offshore energy relates to renewable energy and not oil and gas.
- Assuming that recycled materials will be used where possible.
- Assuming that green and blue infrastructure will be a part of the development.
- Assuming the majority of the area is redevelopment of brownfield land.

Table 2.17: Edinburgh Waterfront summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)					**Negative**			
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
				⟺				

Table 2.18: Edinburgh Waterfront summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor negative	N/A
Electricity	Minor negative	Minor positive, regional, long term
Buildings (heat)	Minor negative	N/A
Industrial, manufacture and construction processes	Minor negative	N/A
Waste	Minor negative	N/A
LULUCF	Negligible	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects related to the assumed increased **transport**, due to uncertainty over the potential for the greater uptake of sustainable travel. ▪ Medium confidence related to the assumed increase in the overall **electricity** and **heat** demand. ▪ Medium confidence in minor negative emissions from **industrial processes** as it is assumed that this development will require carbon heavy construction materials. ▪ High confidence in minor negative effects related to the assumed increased amount of **waste** produced.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is likely to support the increasing capacity of off-shore renewables. The scale of indirect effects is likely to be minor, however there is low confidence over the scale of indirect positive effects on electricity due to uncertainty over the quantity of renewable energy that will be supported by this development.	
Overall summary of effect	It is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the indirect positive effect from the support for the renewables industry which is judged to outweigh the negative direct	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	effects of the development from the provision of housing, employment and industry leading to increased GHG emissions from transport, electricity and heat demand. The scale of this effect could range from low positive to negligible positive depending on the uptake of sustainable travel, energy efficiency measures, potential blue and green infrastructure, the nature of industries based within the development and their potential emissions, and the scale of support for the renewable sector. There is considerable uncertainty over the scale of renewable energy enabled by this development. If the scale is significant then this development could have low positive effects, whereas if the amount of renewable energy enables is relatively minor it would lead to negligible positive effects. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty over the scale of these effects means there is low confidence in this conclusion.	
Additional mitigation and enhancement	Ensure that active travel routes are provided to the site and across the site. Ensure that good public transport connections are secured and delivered pre-completion of the development. Ensure that high levels of renewable energy and heat are installed. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or at least recycled. Ensure that green infrastructure opportunities are implemented across the development. Ensure that low carbon heating is installed for residential heating and ensure requirement for high energy efficiency buildings.	

High Speed Rail

Description

2.25 The proposed national development is to support the implementation of increased infrastructure to improve rail capacity and connectivity on the main cross-border routes, the east and west coast mainlines.

Assumptions

- Assuming this development will be powered by renewable energy, according to decarbonisation of Scottish transport strategy.
- Assuming new infrastructure will be required, for example new track, passenger facilities and fuelling infrastructure.
- Assuming for the purposes of assessment that this development will avoid impacting areas of rich carbon soils and areas that contain woodlands and forests.
- Assuming creation of multi-modal stations and depot facilities.

Table 2.19: High Speed Rail summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
								

Table 2.20: High Speed Rail summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Major positive	Minor positive National, long term.
Electricity	Negligible	
Buildings (heat)	Minor negative	
Industrial, manufacture and construction processes	Minor negative	
Waste	Minor negative	
LULUCF	Minor negative	
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence for major positive effects in relation to **transport** as this development could divert emissions from private cars and aircraft to trains reducing the overall emissions, although there is uncertainty over the level of this modal shift, it is likely to occur over a long timeframe. ▪ High confidence in minor negative effects in relation to **industrial, manufacture and construction** processes as due to the nature of this development significant quantities of carbon heavy materials will be required. ▪ Medium confidence in minor negative effects from **buildings** and **waste** as electricity is Assuming to be from renewable sources and limited waste will be generated. ▪ Medium confidence in minor negative effects in relation to **LULUCF** as this development will require land take and vegetation maintenance.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. This development will provide high speed rail which has	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	the potential to reduce domestic air travel to the UK and Europe and the associated transport GHG emissions. The indirect positive effects are likely influence travel across the UK and occur over the long term. There is low confidence in indirect positive effects as there is uncertainty to how much air travel will be reduced.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to displacement of emissions from private cars and air travel over a long time period The scale of this effect could range from negligible to high positive depending on the level of uptake of train travel. If this development enables a significant amount of modal shift from private car and aeroplane to train, then a high positive effect is expected. Whereas, if this development enables to only a relatively small modal shift, negligible effects are expected. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects means there is low confidence in this conclusion.	
Additional mitigation and enhancement	Ensure that renewable energy is provided for running of the train services. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or at least recycled. Ensure that the development avoids high carbon soils or areas important for carbon sequestration. Ensure limitations on comparable air routes and competitive pricing to support use of rail.	

Hunterston Strategic Asset

Description

2.26 This proposed national development will support an increased mix of opportunities including port, electricity and hydrogen generation including servicing for offshore energy, carbon capture, aquaculture, business, commercial and industrial uses. Flood risk management, access, and biodiversity impacts will also be considered.

Assumptions

- Assuming electricity generation from renewable sources. Electricity generation will be of at least 50 megawatts.
- Assuming the development is on previously developed land.
- Assuming the plant will be operational for at least 20-30 years.
- Assuming this development will produce low carbon and renewable hydrogen.
- Assuming hydrogen produced supports the transition to net zero and could be used for transport, heat and energy storage.
- Assuming the development includes infrastructure for chemicals production associated with hydrogen, including ammonia production, for the purpose of energy storage or transportation.
- Assumes some leakage of hydrogen, and scope for captured carbon and methane leakage in the process.
- Assuming that some leakage may take place from the pipeline during distribution.
- Assuming that the land is potentially contaminated and that some ground remediation works will be required, although the nature of these is unknown.
- Assuming potential for upgraded access arrangements including to support active travel.
- Assume potential for works to mitigate risk of flooding, including through sustainable flood risk management measures.
- Assuming commercial and industrial activity on site.
- Assuming most vehicles travelling to/from the site will be powered by fossil fuels in the short term. Over time vehicles are likely to transition to lower carbon alternatives such as electric vehicles or hydrogen fuelled HGV.

Table 2.21: Hunterston Strategic Asset summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
								

Table 2.22: Hunterston Strategic Asset summary GHG balance

Sector emission source	**GHG balance (direct effects)**	**GHG balance (indirect effects)**
Transport	Minor negative	Minor positive National, enabling, multiplier, long term.
Electricity	Minor positive	Minor positive National, enabling, long term.
Buildings (heat)	Minor negative	Minor positive National, enabling, long term.
Industrial, manufacture and construction processes	Minor negative	Minor positive National, enabling, long term.
Waste	Minor negative	N/A
LULUCF	Minor positive	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	arising from **transport** as it is assumed that there will be an increase in transport movements and vehicles will be fossil fuel powered. ▪ High confidence in minor positive effects in relation to **electricity** as it is assumed that more electricity will be produced than consumed by other processes at the site, although there is uncertainty over the scale of production of renewable energy in excess of 50 megawatts. ▪ High confidence in minor negative effects from **heat** due to assumed increase in heat demand. ▪ Low confidence in minor negative effects in relation to **industrial processes** as it is uncertain how much low carbon and renewable hydrogen respectively will be produced and uncertainty generally regarding the deployment of new and emerging technology. ▪ Low confidence in minor positive effects from **LULUCF** as the development will enable carbon sequestration through sustainable flood management as it is assumed it will include green infrastructure, although the scale is uncertain.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is likely to support renewable energy and renewable and low carbon hydrogen production which will enable displacement of GHG emissions from fossil fuel-based energy sources with and without carbon capture for **electricity**, **transport** and **heat**.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to support for renewable and low carbon hydrogen production, and electricity generation from renewable energy, increasing the renewable energy supply and security of supply over a long time period. The scale of these effects could range from low to high positive depending on the scale of electricity generation and storage, and the scale of use of fossil fuels. This development can deliver high positive effects if it will generate and store a significant amount of renewable and lower carbon energy displacing emissions from current fossil fuels. However, if this development delivers only a small amount of renewable or lower carbon	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	energy then low positive effects are expected. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects means there is medium confidence in this conclusion.	
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled. Ensure that heat is renewable or low carbon.	

Industrial Green Transition Zones

Description

2.27 Industrial Green Transition Zones will support the generation of significant economic opportunities while minimising carbon emissions. Technologies that will help Scotland transition to net-zero will be supported at these locations, with a particular focus on low carbon and zero emissions technologies including renewables and the generation, storage and distribution of hydrogen.

2.28 Industrial Green Transition Zones are the Scottish Cluster and Grangemouth Investment Zone.

2.29 The Scottish Cluster encompasses a Carbon Capture, Utilisation and Storage (CCUS) projects network and is a key strategic vehicle for industrial decarbonisation, energy generation, and the transportation and storage of captured carbon. The designation relates to projects that form a Scottish Cluster in the first instance specifically Peterhead, St Fergus and Grangemouth. The creation of hydrogen and deployment of negative emissions technologies, utilising CCUS, at commercial scale.

2.30 Grangemouth Investment Zone will be a focus for transitioning the petro-chemicals industry and associated activities into a leading exemplar of industrial decarbonisation.

2.31 Decarbonisation could include opportunities for: renewable energy innovation; bioenergy; hydrogen production with carbon capture and storage; and repurposing of existing strategic and critical infrastructure such as pipelines.

Assumptions

- Assuming that low carbon hydrogen production plant will be operational for 20-30 years.
- Assuming low carbon and renewable production of hydrogen and bioenergy.
- Assuming that some biomaterials (for bioenergy production) will be transported from within the UK, and some will be imported from overseas.
- Assuming that bioenergy will only be used where other more sustainable alternatives are unavailable.
- Assuming that majority of the emissions from burning bio fuels will be captured, however there is a scope for carbon leakage as CCUS can typically capture 95% of emissions.
- Assuming hydrogen produced supports the transition to net zero and could be used for transport, heat and energy storage.

- Assuming the development includes infrastructure for chemicals production associated with hydrogen, including ammonia production, for the purpose of energy storage or transportation.

- Assuming some hydrogen may leak to the atmosphere. Assuming that oil and gas only used in combination with CCUS. Hydrogen when leaked, acts as an indirect GHG by reducing hydroxide and thus increasing methane abundance. Some emissions are not captured via CCUS.

- Precise location of development unknown and whether this is brownfield or greenfield sites, therefore assumption of early focus on brownfield and partly greenfield.

- Assuming the application of Carbon Capture and Storage technology to existing or replacement thermal power generation.

- Assuming there will be some reuse of existing pipework at existing sites for CCUS purposes.

- Assuming on or off shore geological storage of hydrogen.

- Assuming long-term offshore storage of captured carbon. Assuming that improvements to utilities infrastructure will be delivered.

- Assuming greater freight movement within the Forth. Assuming these vessels will be diesel powered but over the long-term transition to lower carbon alternatives such as LNG and new or upgraded ports facilities.

- Assuming the use of carbon capture on existing emissions sources or implementing energy efficiency measures.

- Assuming deployment of negative emissions technologies.

- Assuming that net negative emissions technologies could include burning biomass (trees, willows, grasses) or could involve direct air carbon capture.

- Assuming timeframe for carbon storage will be long term (>100 years).

- Assuming Grangemouth Flood Protection Scheme (FPS) will include development of footpaths. This will encourage active travel.

- Assuming Grangemouth FPS will comprise 25km of flood defences (including walls and embankments).

- Assuming flood defences will not be decommissioned.

- Assuming people will travel to Grangemouth via a mix of private vehicle and public/active transport modes (linked to transport improvements).

- Assuming new or upgraded green and blue infrastructure.

- Assuming vehicles are fuelled by current fossil fuels (petrol/diesel).

- Assuming existing buildings will be repurposed where possible though some new buildings may be required.

Table 2.23: Industrial Green Transition Zones summary of the range of effects

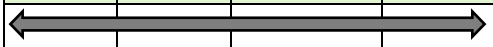
	Positive				Negative			
Summary of GHG balance (direct effects)					**Negative**			
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
								

Table 2.24: Industrial Green Transition Zones summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Moderate negative	Minor positive National, enabling, long term.
Electricity	Minor positive	Minor positive National, enabling, long term
Buildings (heat)	Minor positive	Minor positive National, enabling, long term
Industrial, manufacture and construction processes	Minor negative	Minor positive National, enabling, long term
Waste	Minor negative	N/A

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
LULUCF	Minor negative	N/A
Negative Emissions Technologies	Minor positive	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Low confidence in moderate negative effects from **transport** due to the uncertainty on how majority of hydrogen and captured carbon will be transported for storage and distribution domestically and for export and the potential for leakage. ▪ Low confidence in minor positive effects for **electricity**, as this development supports low carbon energy generation but may increase electricity demand for some processes. ▪ Medium confidence in minor positive effects for **heat**, as this development supports heat networks but the scale is unknown, and also supports hydrogen production which can be used for heat. ▪ Low confidence in minor negative effects from **industrial processes**, due to high levels of embodied carbon and as the long-term reliability of carbon capture is untested. ▪ High confidence in minor negative GHG balance from **waste** due to assumed low levels of waste generated. ▪ High confidence in minor negative GHG balance from **LULUCF**, from land use disturbance from biomass harvesting releasing soil carbon. ▪ Low confidence in minor positive GHG balance from **NETs** due to uncertain scale of development.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. This development is likely to enable renewable and low carbon hydrogen production as a lower carbon fuel for **transport, heating** and **industry** compared to use of fossil fuels without carbon capture and storage. Moreover, it is likely to displace the emissions from current energy sources and will enable carbon capture. The development also indirectly supports renewable energy innovation, enabling further improvements in carbon reductions. A minor negative GHG balance is identified from LULUCF, from land use disturbance from biomass harvesting releasing soil carbon, but this is	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	likely to be small scale. There is a low confidence in the scale of indirect positive effects due to uncertainty over the scale of renewable and low carbon hydrogen production and extent to which the hydrogen will displace higher carbon energy sources in transport, industry and heating.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have **net positive** effects on lifecycle GHG emissions due to support for the transition to hydrogen from direct fossil fuel dependency using low carbon hydrogen production with carbon capture, utilisation and storage, and from renewable hydrogen production. The scale of positive effect could range from low to very high. A low scale of effect would result from higher levels of increased transport emissions, lower levels of low carbon electricity generation, higher levels of fugitive emissions, smaller scale heat networks, and smaller scale NETs development. Conversely, if a greater amount of low carbon energy and hydrogen is produced, there are lower levels of fugitive emissions, more widespread heat networks and larger scale NETs development and wider deployment and use of hydrogen, this could result in a very high positive effect. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty over the scale of these effects means there is low confidence in this conclusion.	
Additional mitigation and enhancement	Prioritise use of existing infrastructure on and offshore which can be refurbished, ensure that technologies for minimising leakage are in place. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled.	

Energy Innovation Development on the Islands

Description

2.32 This proposed national development supports proposed developments in the Western Isles, Shetland and Orkney island groups, for renewable energy generation, renewable and low carbon hydrogen production, infrastructure and shipping, and associated opportunities in the supply chain for fabrication, research and development. Any strategy for deployment of these technologies must enable decarbonisation at pace and cannot be used to justify unsustainable levels of fossil fuel extraction or impede Scotland's just transition to net zero. The use of low and zero emission fuels will play a crucial role in decarbonising island and mainland energy use, shipping, strengthening energy security overall and creating a low carbon energy economy for the islands and the islanders. This is aligned with low carbon energy projects within the Islands Growth Deal that have been developed with local partners such as the Islands Centre for Net Zero, and encompasses other projects that can facilitate net zero aims. The developments will add value where they link into national and international energy expertise, learning and research and development networks.

Assumptions

- Assuming that this development will have a lifetime of at least 30 years.
- Assuming that this development will increase marine vessel movements.
- Assuming infrastructure to support renewable energy generation will include a mix of renewable energy technologies both on and offshore, and energy from low carbon fuels with abatement as appropriate.
- Assuming carbon intensive materials, including metal for cabling.
- Assuming large scale renewable energy generation will have a negative impact on LULUCF and will include loss of marine carbon sequestering habitats.
- Large scale renewable hydrogen production, over at least 30 years' time scales.
- Assuming low carbon fuel produced supports the transition to net zero and could be used for transport, heat and energy storage.
- Assuming the development includes infrastructure for chemicals production associated with hydrogen, including ammonia production, for the purpose of energy storage or transportation.
- Assuming carbon capture and storage facilitates carbon capture from a range of processes and locations.
- Assumes some leakage of hydrogen, and scope for captured carbon and methane leakage in the process.
- Assuming low carbon and renewable hydrogen production.

- Assuming that the lower emissions fuels for shipping will include Liquified Natural Gas (LNG) distribution and storage. Marine vessels will travel to the island to refuel. Fuels include marine gas, oil and hydrogen.

- Assuming most vessels will be fuelled by oil/gas. Assuming for the purposes of assessment at least some of the LNG will be imported from Middle East or North America.

- Assume brownfield and greenfield land utilised for developments though brownfield will be prioritised.

- Assuming that R&D will also require premises to carry out the work. Assume R&D will lead to further renewable energy generation in the future.

- Assuming that supply chain for fabrication will enable the roll out of renewable energy because parts will be produced locally.

- Assuming that R&D will increase innovation and efficiency enabling net zero emissions.

Table 2.25: Energy Innovation Development on the Islands summary of the range of effects

	Positive				**Negative**			
Summary of GHG balance (direct effects)					**Negative**			
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
		⟷						

Table 2.26: Energy Innovation Development on the Islands summary GHG balance

Sector emission source	**GHG balance (direct effects)**	**GHG balance (indirect effects)**
Transport	Moderate negative	Minor positive National, enabling, medium to long term.
Electricity	Minor positive	Minor positive National, enabling,

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
		multiplier, medium to long term.
Buildings (heat)	Minor negative	Minor positive National, enabling, medium to long term.
Industrial, manufacture and construction processes	Minor positive	Minor positive National, enabling, multiplier, medium to long term.
Waste	Minor negative	N/A
LULUCF	Minor negative	Negligible positive Regional, enabling, medium to long term
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: • Medium confidence in moderate negative effects arising from **transport** related emissions, due to an overall increase in emissions but uncertainty over the amount of hydrogen produced for transport, or levels of use of low carbon fuel. • Low confidence in minor positive effects in relation to **electricity** as it is uncertain how much electricity demand there will be for the development, and what proportions of the development's electricity needs will be met by renewable and non-renewable sources and how much renewable electricity will be generated. • High confidence in minor negative effects from **heat** due to limited heat requirements. • Low confidence in minor positive effects from **industrial processes**, due to the facilitation of carbon capture and storage, and renewable hydrogen production but taking into account the amount of carbon heavy materials required for this development, use of fossil fuels and fugitive emissions. • Medium confidence in minor negative effects from **waste** due to assumed low levels of waste and high levels of recycling. • Medium confidence in minor negative effects in relation to **LULUCF** as such scale of development will lead to disturbance of soil, vegetation and	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	marine areas, although there is uncertainty over the scale of this effect.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development includes renewable and low carbon hydrogen production. Hydrogen can provide low carbon fuel for **transport, heating and industry** compared to use of fossil fuels without carbon capture and storage. Low confidence in indirect positive effects due to uncertainty over the scale of hydrogen production. The development is likely to support R&D activities which have the potential to enhance innovation and efficiency for net zero developments at a national scale, both enabling further development and supporting new developments over the long term. Delivering developments on already developed land is likely to lead to reduced emissions from LULUCF as it is likely to avoid disturbance of soil and vegetation.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to uncertainty of the scale and type of renewable energy production, hydrogen production, distribution and storage, supporting infrastructure, supply chain for fabrication and R&D, the scale of carbon capture and storage and the use of lower emission fuels for shipping. It is assumed that these developments will be large scale and long-term and would outweigh the negative effects from the embodied carbon in the infrastructure. Indirect positive effects from the support for the renewables industry and production of hydrogen are judged on balance to outweigh the negative direct effects identified due to relatively minor nature of these direct effects, which during the construction and decommissioning phases would be short term in nature. The positive indirect effects identified would be experienced throughout the operational phase of the development. The scale of this effect could range from low to high positive, depending on the scale of renewable energy and low carbon fuels produced over time. For example, smaller scale renewable energy and hydrogen production will likely have low positive effects. However, if this is deployed at a large scale, and is utilised across	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	sectors, it could have high positive effects. **Conclusion:** Depending on the nature of the projects taken forward and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is medium confidence in this overall conclusion	
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled. Provide low carbon transport options to the sites to reduce car dependency.	

National Walking, Cycling and Wheeling Network

Description

2.33 Proposed national development for upgrading and provision of additional active travel infrastructure.

Assumptions

- Assuming the network is delivered across Scotland.
- Assuming that a significant amount of people especially in urban areas will use active travel for their daily commute.
- Assuming that the active travel network will not be decommissioned.
- Assuming no additional waste generated overall from operation.
- Assuming increased vegetation along travel corridors.
- Assuming that majority of the electricity for street lighting will come from renewable sources.
- Assuming that majority of materials will be recycled.

Table 2.27: National Walking, Cycling and Wheeling Network summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**N/A**				**N/A**			
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
	⟷							

Table 2.28: National Walking, Cycling and Wheeling Network summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Super positive (more than	N/A

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	10%)	
Electricity	Minor negative	N/A
Buildings (heat)	Neutral	N/A
Industrial, manufacture and construction processes	Minor negative	N/A
Waste	Minor negative	N/A
LULUCF	Minor positive	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in super positive effects for **transport** related to the assumed greater uptake of active and sustainable modes of travel facilitated by the construction and enhancement of the walking and cycling network across Scotland, in addition to better linkages with public transport and delivery of multi-modal hubs. However, there is uncertainty over levels of uptake of active and sustainable travel, and the extent and scale of the active travel network. Super positive effects would only arise with a high level of journeys made by active or sustainable modes of travel. ▪ Medium confidence in minor negative effects for **electricity, heat, industrial processes and waste**, due to assumed low levels of demand for electricity and heat, low generate of waste and quantity of materials required. ▪ Medium confidence in positive effects for **LULUCF** from increased carbon sequestration, assuming there is increased vegetation planted along active travel routes, partly balanced by some negative effects during construction and decommissioning phases.	
Summary of lifecycle GHG balance (indirect effects)	No indirect effects identified.	
Overall summary of effect	It is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the support for low carbon and active travel. The scale of this effect could range from high to very high positive assuming a high level of uptake and a long timeframe for the benefits. If this development facilitates a shift in travel behaviour, with a significant amount of people travelling through the network via active modes, very high positive effects are expected. These very high	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	positive effects is likely to be further enhanced by opportunities for carbon sequestration linked to the provision of green and blue infrastructure. However, if uptake of active travel is less, and there are fewer opportunities for carbon sequestration this may reduce to high positive. **Conclusion:** Depending on the nature of the projects taken forward and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is low confidence in this overall conclusion.	
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled. Ensure that waste is minimised during the construction phase.	

Pumped Hydro Storage

Description

2.34 The proposed national development is to deliver additional capacity at existing sites as well as new sites. It will include expansion of the capacity of the Cruachan.

Assumptions

- Assuming removal of surface infrastructure and restoration to natural state on decommissioning.
- Assuming that if new or expanded hydro power plant capacity is not built there will be a continued requirement for rapid capacity power generation to provide electricity when there is a surge in demand. This is currently provided by fossil fuel sources, although it is assuming that future technologies will provide low carbon alternatives.
- Based on the lifetime of existing Cruachan, the period of operation of enhanced capacity at Cruachan is assumed to be 50-100 years.
- Assuming that the new power station will generate significant additional capacity.
- Assuming construction of a second turbine hall, additional turbines, transformers, new or enlarged tunnels and new or enlarged reservoir.
- Assuming majority of sub surface infrastructure would be left in situ.
- Due to the upland location, assuming that reservoir construction will impact on high carbon soils. Sediment build up in the dam will cause release of carbon dioxide and methane on release of the water during operation.
- Assuming upgraded grid capacity will be required, including sub-stations, transformers and transmission cables.

Table 2.29: Pumped Hydro Storage summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
	⟷							

Table 2.30: Pumped Hydro Storage summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor negative	N/A
Electricity	Super positive (more than 10%)	Minor positive National, enabling, long term.
Buildings (heat)	N/A	N/A
Industrial, manufacture and construction processes	Minor negative	N/A
Waste	Minor negative	N/A
LULUCF	Minor negative	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: • Medium confidence in minor negative effects in relation **transport**, due Assuming transport impacts during construction and high volumes of construction material. • Medium confidence in super positive effects in relation to **electricity** assuming that the energy required for pumping water will be renewable, and the development will operate over a long time period. • Medium confidence in minor negative effects from **industrial processes** as this development will require a significant amount of carbon heavy materials, but the scale of new hydroelectric development and potential releases of carbon dioxide and methane from operation is uncertain. The scale of effects will be dependent on whether the development relates to upgrades to existing facilities or construction of new infrastructure. • Low confidence in minor negative effects from **waste** as it is unknown whether materials would be left in place after decommissioning or removed. • Medium confidence in minor negative effects from **LULUCF** as the locations of a new reservoirs are unknown and may lead to a significant loss of vegetation and soil.	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development indirectly enables further renewable energy development across Scotland in the medium to long term by increasing storage capacity, and displacing fossil fuel emissions. There is low confidence in the scale of indirect positive effects due to uncertainty over the scale of other storage capacity for renewable energy, and the scale of increased pumped hydro-electric storage capacity.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the facilitation and enabling of renewable energy development across Scotland from the provision of energy storage and rapid capacity during demand peaks. The scale of this effect could range from medium to very high depending on the project details, the location and frequency of use. If the development enables significantly more renewable electricity to be generated, whilst minimising energy associated with construction and decommissioning, and effects on soil carbon, a very high positive effect will be expected. However, if renewable electricity generation provided by the development is lower, and there are more significant amounts of energy and carbon intensive materials used during construction, this positive effect might reduce to medium. Furthermore, significant disturbance to soils and release of soil carbon is likely to reduce the effect to medium. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is low confidence in this overall conclusion.	
Additional mitigation and enhancement	Ensure that the design of the extension of the hydro power plant and extensions of other existing facilities will have minimal impacts on LULUCF. Ensure that sediment creation and build up is managed to reduce emissions. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	decommissioning waste materials are reused again or recycled.	

Stranraer Gateway

Description

2.35 The proposed national development is to deliver a high-quality place-based regeneration to support the wider population of southwest Scotland and provide a platform for future investment, including commercial, residential and industrial development.

Assumptions

- Assuming use of fossil fuels by the marina.
- Assuming for purposes of assessment sustainable transport connectivity refers to rail for freight and passengers.
- Assuming for purposes of assessment potential for transport infrastructure upgrades including road and rail.
- Assuming new or upgraded infrastructure to support the distribution and use of low carbon fuels.
- Assuming that this development will be operational for at least 30 years.
- Assuming that heat will come from lower carbon sources such as hydrogen.
- Assuming that majority of materials will include concrete and steel.
- Assuming that this development will be delivered on a brownfield site.
- Assuming that energy efficiency measures will be in place.
- Assumes electricity to power sustainable transport will be renewable.
- Assuming that heat will come from lower carbon sources.

Table 2.31: Stranraer Gateway summary of the range of effects

	Positive	Negative
Summary of GHG balance (direct effects)	**Negligible**	**Negligible**

Summary of GHG balance (indirect effects)	Positive							
Overall summary of effects	Very high	High	Medium	Low	Low	Medium	High	Very High
				⟺				

Table 2.32: Stranraer Gateway summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor positive	Negligible positive
Electricity	Minor negative	N/A
Buildings (heat)	Minor negative	N/A
Industrial, manufacture and construction processes	Minor negative	Negligible positive
Waste	Minor negative	N/A
LULUCF	Minor negative	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negligible** effect on direct lifecycle GHG emissions. This is based on: ▪ Low confidence in minor positive effects from **transport** due to uncertainty over the scale of the development and impact on journeys generated, balanced by some assumed increase in rail transport and scale of use of low carbon fuels. ▪ Medium confidence in increased **electricity and heat demand** due to assumed low levels of increased demand and uncertainty over the extent of renewable energy or heat generation. ▪ Low confidence in **industrial, manufacture and construction processes** due to uncertainty over the scale of development. ▪ Medium confidence in emissions from **waste** due to assumed net increase in waste but uncertainty over quantity of waste generated. ▪ Medium confidence in minor negative effects from **LULUCF** due to assumed net loss of soil carbon from development, despite assumed development on brownfield land.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **negligible positive** effect on indirect lifecycle GHG emissions. The development is likely to support low carbon fuels distribution. The scale of indirect effects is likely to be negligible, however there is low confidence	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	as it is uncertain how much low carbon fuel will be distributed via this development.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that the development will have a **net positive** effect on lifecycle GHG emissions due positive effects from use and distribution of low carbon fuels, increased transport efficiency from new rail facilities and transportation which is judged to outweigh the negative effects from increased transport emissions. The scale of this effect is likely to be low. **Conclusion:** Depending on the nature of the projects taken forward and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is low confidence in this overall conclusion.	
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled. Ensure that energy efficiency solutions are in place within the developments. Support low carbon fuel for marine vessels. Minimise disturbance to marine sediments.	

Strategic Renewable Electricity Generation and Transmission Infrastructure

Description

2.36 This proposed national development supports renewable electricity generation (of or exceeding 50MW), repowering, and expansion of the electricity grid for domestic consumption and export to the UK and beyond. This development will include new infrastructure to support on and off-shore renewables.

Assumptions

- Assuming that not all infrastructure will be decommissioned but there will be the potential to repower or install lifetime extensions for all kinds of renewable energy technologies.
- Assuming a range of different renewable energy technologies.
- Assuming that the development of the electricity generation and transmission infrastructure improves resilience and capacity in the energy network and could support the development of a range of renewable energy generation and storage technologies.
- Assuming battery storage is used for electricity storage purposes.
- Assuming that this infrastructure will be in place for at least 25 years.
- Carbon footprint of development materials is high due to extensive metal component. Transmission energy losses are from renewable energy derived sources and therefore although they reduce the efficiency of the power generation, they do not increase the GHG emissions.
- Assuming that redundant cables will remain in the ground after decommissioning.
- Assuming that actions will be taken to reinstate the surrounding ground in order to ensure that carbon sequestration will be possible when development is operating.
- Assuming disturbance to high carbon soils.
- Assuming that this development is necessary to enable the full potential of renewable energy.
- Assuming that this includes both subsea cables and land-based transmission lines.
- Assuming that this infrastructure includes converter stations and substations and switching stations.

Table 2.33: Strategic Renewable Electricity Generation and Transmission Infrastructure summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
	⟷							

Table 2.34: Strategic Renewable Electricity Generation and Transmission Infrastructure summary GHG balance

Sector emission source	**GHG balance (direct effects)**	**GHG balance (indirect effects)**
Transport	Minor negative	Minor positive National, enabling, long term.
Electricity	Major positive	Significant positive National, enabling, long term
Buildings (heat)	Neutral	Negligible positive National, enabling, long term
Industrial, manufacture and construction processes	Moderate negative	Minor positive National, enabling, long term
Waste	Minor negative	N/A
LULUCF	Neutral	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in major positive effects arising from **electricity**, as this development will deliver large scale renewable energy generation displacing emissions from current fossil fuel energy	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	sources, however there is uncertainty how many such developments will be delivered. ▪ Medium confidence in minor negative effects from **transport**, as it is uncertain how many transport journeys will be generated. ▪ Medium confidence in minor negative effects from **waste** due to assumed low levels of waste produced. ▪ Low confidence in moderate negative effects in relation to **industrial processes** due to uncertainty over the extent and GHG emissions of the materials required, although high confidence in the carbon intensity of the materials.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The proposed national development facilitates renewable energy generation which may support hydrogen production and provide low carbon fuel for **transport**, **heating** and energy for **industrial processes** compared to use of fossil fuels. The indirect effect is judged to be of super scale, but with medium confidence due to uncertainty on the actual scale of renewable energy and hydrogen production.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to potential for substantial generation and transmission of renewable electricity. The scale of positive effect is assumed to be between medium and very high positive, depending on the scale of renewable energy generation and the role of the development in facilitating further renewable energy development. A medium scale of effect would result from higher embodied carbon in construction infrastructure, and lower levels of renewable energy generation and use. Conversely, lower embodied carbon in construction infrastructure, and higher levels of renewable energy generation would result in a very high scale of effect. **Conclusion:** Depending on the nature and scale of renewable projects taken forward and associated electricity infrastructure, and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Greater certainty about the nature and scale of these effects means that there is medium to high confidence in	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	this overall conclusion.	
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled. Ensure that cabling and supporting infrastructure avoids carbon rich soils and vegetation that store or absorb significant amounts of carbon.	

Urban Mass/Rapid Transit Networks

Description

2.37 The proposed national development is to deliver low carbon transport solutions to support reduction in private car use in Aberdeen, Edinburgh and Glasgow and their associated regions providing better access to employment and supporting investment.

Assumptions

- Assuming 7 million journeys annually on the Edinburgh tram network (7.4m in 2019).
- Over 12.7 million journeys annually on the Glasgow Metro.
- Assuming trams, buses and light rail will be powered from low carbon fuel or electricity.
- Assuming electricity will be low carbon/ renewable.
- Assuming new infrastructure will be required, for example new track, road, passenger facilities, depots and fuelling infrastructure.

Table 2.35: Urban Mass/Rapid Transit Networks summary of the range of effects

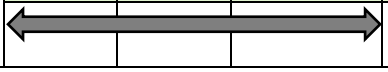
	Positive				Negative			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**N/A**				**N/A**			
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
								

Table 2.36: Urban Mass/Rapid Transit Networks summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Major positive	N/A
Electricity	Neutral	N/A
Buildings (heat)	Neutral	N/A
Industrial, manufacture and	Minor negative	N/A

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
construction processes		
Waste	Minor negative	N/A
LULUCF	Minor negative	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. ▪ Medium confidence in significant positive effects from **transport** related to the assumed greater uptake of sustainable travel and journeys facilitated by the construction and enhancement of the light rail network across Scotland's main cities over the long term. However, there is uncertainty over levels of future passenger use, and the full extent of the networks. ▪ Medium confidence in minor negative effects during construction and decommissioning phases in relation to **industrial, manufacture and construction processes**. ▪ High confidence in minor negative effects from **waste** during construction and decommissioning due to assumed low levels of waste produced. ▪ Medium confidence in minor negative from **LULUCF** during construction and decommissioning due to assumed new infrastructure required.	
Summary of lifecycle GHG balance (indirect effects)	No indirect effects identified.	
Overall summary of effect	It is likely that this proposed national development will have a **net positive** effect on lifecycle GHG emissions as the long-term positive effects of three of Scotland's major cities using sustainable transport powered by low carbon electricity is likely to outweigh the short-term negative effects. The scale of this effect could range from medium to very high positive depending on the network extent and level of uptake. If this development facilitates a shift in travel behaviour, with a significant amount of people travelling via the mass/rapid transit networks very high positive effects are expected. However if uptake is less, positive effects may reduce to medium positive. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is medium confidence in this overall conclusion.	
Additional mitigation and enhancement	Commitment to the use of low carbon/renewable sources of energy to power the trams and light rail developments. Ensure integration of the mass transit networks with active travel networks. Increase the roll out of mass transit networks to other major towns and cities in Scotland.	

Urban Sustainable, Blue and Green Surface Water Management Solutions

Description

2.38 The proposed national development will deliver drainage infrastructure in the Glasgow and Edinburgh City and wider catchment areas.

Assumptions

- Assuming that this development will deliver water and drainage infrastructure.
- This development enables managing flood risk, which includes infrastructure development.
- Assuming some built engineered structures but with priority for nature-based solutions.
- For the purposes of the assessment, assuming development will largely be on previously developed land.
- Assuming that this project will deliver green infrastructure.

Table 2.37: Urban Sustainable, Blue and Green Surface Water Management Solutions summary of the range of effects

	Positive				Negative			
Summary of GHG balance (direct effects)	**Positive**							
Summary of GHG balance (indirect effects)	**Positive**							
Overall summary of effects	**Very high**	**High**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Very High**
			⟷					

Table 2.38: Urban Sustainable, Blue and Green Surface Water Management Solutions summary GHG balance

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Transport	Minor negative	N/A
Electricity	Neutral	N/A

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
Buildings (heat)	Neutral	N/A
Industrial, manufacture and construction processes	Minor negative	Minor positive Supra regional, medium to long term
Waste	Minor negative	N/A
LULUCF	Minor positive	N/A
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: • Medium confidence in minor positive effects in relation to **transport** due to minor levels of maintenance travel. • Low confidence in minor negative effects from **industrial, manufacture and construction processes** due to uncertainty over the carbon intensity of the materials used. • Medium confidence in minor negative effects from **waste** due to assumed limited waste produced. • Medium confidence in minor positive effects in relation to **LULUCF** as this development is likely to enhance carbon sequestration, although the scale of the effect is uncertain.	
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The proposed national development reduces flood risk, and there is medium confidence in minor positive effects due to reduced flood damage and embodied carbon in replacement materials due to uncertainty on the scale of flood damage avoided.	
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to reduced flood risk and delivery of more green spaces that will enhance carbon sequestration. The scale of effects could range from low to medium positive depending on how much flood damage is avoided and how many green spaces are delivered. A low scale of effect would result from minimal use of nature-based drainage solutions and the greater use of materials which contain higher embodied carbon. Conversely, if the drainage solutions are widespread and	

Sector emission source	GHG balance (direct effects)	GHG balance (indirect effects)
	deliver green infrastructure, they will reduce greenhouse gas emissions due to limiting flood damage, with a medium positive effect. **Conclusion:** Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Greater certainty about the nature and scale of these effects means that there is medium confidence in this overall conclusion.	
Additional mitigation and enhancement	Ensure that green infrastructure is fully exploited to enhance carbon sequestration. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled.	

3. Conclusions: Assessment of Effects by Emissions Sector

Introduction

3.1 This section of the report explores the cumulative impacts of the proposed national developments on the transference of emissions by sector and carbon reduction targets.

Transport

3.2 In relation to emissions from transport, direct negative effects are identified from a number of proposed national developments that generate a large amount of travel or an increase in journeys. Increases in transport emissions also include some developments that are large scale construction projects and will generate construction related transport movements, although overall there is medium certainty that these negative effects are typically minor due to their short term duration.

3.3 Direct positive effects are identified from a smaller proportion of the proposed national developments, but these typically support sustainable travel on a national or regional scale and for a significant proportion of the population. This includes both active travel and rail or mass transit networks proposed national developments.

3.4 Indirect effects on transport emissions are positive where they are identified. These effects typically result from support for low carbon fuel (an element of several developments), travel reductions and modal shift.

3.5 There is considerable uncertainty over the scale of the emissions reduction for transport, due to reliance on modal shift to sustainable transport. However, it is assumed that the cumulative effect of a number of transport improvements will support the overall ease of use of the sustainable travel network and encourage further uptake. The developments are in the most densely populated areas of Scotland, impacting a larger proportion of the population and therefore effects are likely to be more significant.

Electricity

3.6 For emissions from electricity, the majority of developments are likely to result in a minor increase in demand for electricity with potential minor negative effects at a project level. There is high level of certainty over the impact of increased electricity demand. This is balanced by the positive direct effects from a number of developments which support low carbon or renewable electricity production at varying scales, including projects with large scale or national impact over a long time period. However, there is lower certainty over the scale of renewable energy directly resulting from the developments.

3.7 Indirect positive effects include renewable energy related research, innovation and support for wider roll out, including support for offshore renewables, energy storage and electricity transmission infrastructure. These indirect effects have potential to impact at a national scale, over a long time period, although there is a higher level of uncertainty over the scale of the multiplier and enabling effect,

3.8 For electricity the emissions reductions identified result from increased support for renewable energy generation and transmission infrastructure, energy storage, and research and development. It is recognised that due to the high proportion of renewable energy generation currently within Scotland that these emissions savings will be less significant compared to the baseline but that they relate to electricity storage and also supporting the role of electricity in decarbonising emissions from other sectors.

Buildings (heat)

3.9 Direct negative effects on buildings and demand for heat are largely limited to minor and project specific increases in heat demand, reflecting the nature of the proposed national developments which are largely infrastructure projects not directly related to heat. Increased heat demand is only identified for developments with a larger residential component, for which there is uncertainty over the heating source for these developments.

3.10 Only positive indirect effects are identified, and these are also limited to the potential use of waste heat or production of low carbon fuels with potential for use for domestic heat or cooking at a minor scale, although there is low certainty over how these fuels will be deployed in the long term, and the level of widespread use.

3.11 The impact on emissions from buildings (heat) is likely to be negligible, mainly due to the scope of the proposed national developments which are not strongly related to this emissions sector and particularly in relation to the uncertainty around the use of sustainable or low carbon heating for the majority of the proposed national developments.

Industrial, manufacture and construction processes

3.12 Direct effects on greenhouse gas emissions related to industrial, manufacture and construction processes are typically negative across the proposed national developments, reflecting high certainty over the carbon intensity of the materials required for the construction and maintenance of the proposed developments, and the large scale of these developments.

3.13 Positive indirect effects are identified for those developments that enable the production of low carbon fuel for use in industrial, manufacture and construction processes, although there is a higher level of uncertainty over the scale of these developments.

3.14 The impact on emissions from industrial, manufacture and construction processes is balanced between the high carbon intensity of materials required for a number of the proposed national developments, and the enabling effects of

the proposed national developments on providing low carbon fuels for use in industry or carbon capture. Due to the levels of uncertainty around the role of the proposed national developments in providing low carbon fuel, and the lack of proposed national developments which support innovation in reducing emissions from this sector, particularly construction, and uncertainty over the scale of carbon capture the balance is likely to be marginally negative.

Waste

3.15 Direct negative effects on emissions from waste largely relate to the potential for increased waste generation from new developments, however this is likely to be minor in scale, due to the nature of the developments and there is high confidence in this conclusion. Positive direct effects on emissions are identified from the circular economy materials management facilities, and these are likely to be national, over a long time period. However, the balance between the baseline and the emissions savings from materials reprocessing is uncertain. The only indirect effects identified are in relation to this same proposed national development, where further positive effects are identified through support for other businesses to reuse new materials.

3.16 For waste the proposed focus on materials management facilities to support a circular economy is likely to support waste management in Scotland, reducing emissions from waste and also from industrial, manufacture and construction processes based on reduced extraction of virgin materials. There is considerable uncertainty over the extent to which emissions from waste will be reduced overall, due to the impact of emissions from the movement and reprocessing of waste materials.

LULUCF

3.17 Direct negative effects on emissions from LULUCF relate primarily to emissions from disturbance to soil and vegetation from construction. Minor positive effects relate to construction on brownfield sites, and the associated avoidance of effects on greenfield sites, and the inclusion of landscaping or green infrastructure within a development. The most widespread positive effects from new planting relate to the development of the National Walking, Cycling and Wheeling Network and the Central Scotland Green Network. The level of positive effect is uncertain, as the scale of effects is sub-national.

3.18 No indirect effects are identified in relation to LULUCF.

3.19 The impact on emissions from LULUCF relates to the scale of the proposed national developments, and significant use of previously developed land. The majority of the proposed national developments are local in scale or involve previously developed land. The positive effects from the proposed national developments which support enhanced green infrastructure over a much larger land area are likely to result in a net positive effect on emissions from this sector. Due to uncertainty over any increase in carbon sequestration or reduction in emissions from land as a result of management changes, this positive effect is likely to be marginal.

Negative Emissions Technologies (NETs)

3.20 Only the Industrial Green Transition Zone includes NETs and there is uncertainty of the scale of this development. However NETs will achieve direct emissions reductions.

Summary

3.21 The proposed national developments are likely to result in a net reduction in emissions for transport, electricity and waste overall. Effects on LULUCF are likely to be a marginal net reduction in emissions. Effects on industrial, manufacture and construction processes are likely to increase emissions overall, and effects on buildings (heat) are likely to be negligible.

Contribution to Scotland's carbon reduction targets

Direct emissions

3.22 Considerable uncertainties underpin the assessment of lifecycle greenhouse gas emissions associated with proposed national developments. As a result, it is not possible to quantify precisely the contribution that individual National Developments, or the entire suite of National Developments, will make to the carbon reduction targets set out in Scotland's Climate Change Plan. However, reference to the sectoral benchmarking exercise used to guide the assessment makes it possible to draw some broad conclusions about the possible impacts of National Developments on these targets.

3.23 National Developments making the largest contributions to direct emission reductions are likely to include Pumped Hydro Storage, Strategic Renewable Electricity Generation and Transmission Infrastructure, the Central Scotland Green Network, National Walking, Cycling and Wheeling Network, High Speed Rail and Urban Mass/Rapid Transit Networks. National Developments resulting in the largest increases in direct emissions are likely to include Energy Innovation Development on the Islands, Industrial Green Transition Zones, Clyde Mission, Aberdeen Harbour, Dundee and Edinburgh Waterfronts and Stranraer Gateway, largely as result of the construction works involved. Many will deliver indirect emissions savings.

3.24 Taken together, it is estimated that the total direct emissions associated with proposed national developments could be positive or negative and are likely to lie in a range between an increase in emissions equivalent to up to 7% of the 2030 emissions reduction target, and a reduction in emissions equivalent to up to 15% of the target. The total direct contribution of National Developments to sector targets are likely to be greatest for transport (between 7.5% and 33% of the sector target) and electricity (between 5% and 25% of the sector target). In total, National Developments are likely to result in net increases in direct emissions for industrial manufacturing and construction processes, buildings and waste sectors.

Indirect effects

3.25 The indirect effects of National Developments on greenhouse gas emissions are even more uncertain, reflecting the inherent uncertainty as to the detailed scale

and location of development that will be realised and changes in behaviour that will be enabled by National Developments and the influence of factors such as investment, technological advances and consenting mechanisms. Reflecting these uncertainties, indirect effects have only been qualitatively assessed at a broad scale. However, the assessment concluded that the Strategic Renewable Electricity Generation and Transmission Infrastructure National Development is likely to deliver the greatest indirect emission reductions.

Overall effects

3.26 The assessment concludes that it is most likely that, considering both direct and indirect effects, the lifecycle greenhouse gas emissions of the proposed national developments will make a positive contribution to the 2030 carbon reduction targets, helping to reduce emissions. Overall, the greatest contributions to sectoral emission reductions are likely to be in terms of transport and electricity. While the Industrial, manufacture and construction processes sector is likely to experience the largest increase in direct emissions, it will enable direct and indirect emission reductions across other sectors.

Annex A Proposed National Development Assessment Tables

The summary of the methodology outlined in Section 1 provides an explanation of the colours used in the detailed assessment tables, which are also included here for reference. The initial stage of assessment focuses on identifying if effects are positive or negative, and the significance of this on a negligible, minor or significant scale.

Table A.1: Key for project element scoring

Key
Significant negative (increases emissions)
Minor negative (increases emissions)
Negligible negative (increases emissions, several negligible effects could combine in the summary table)
Negligible positive (increases emissions, several negligible effects could combine in the summary table)
Mixed negligible (both increases and reduces emissions at a negligible scale)
Mixed (both increases and reduces emissions at a minor scale)
Minor positive (reduces emissions)
Significant positive (reduces emissions)

The initial assessment is followed by a summary table which uses the scales of effect related to the benchmarking process for direct effects. Indirect effects reflect the scales of effect in Table A.1.

Table A.2: Key for overall direct effects scoring

Overall effect colour codes (positive)	**Overall effect colour codes (negative)**
Minor	Minor
Moderate	Moderate
Major	Major
Super	Super

Table A.3: Aberdeen Harbour

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Aberdeen Harbour	Upgraded port facilities	**Transport**	Existing vessel emissions Most marine vessels and vehicles are fuelled by diesel	Negligible negative effects from transportation of machinery and materials required for the construction of manufacturing and support services and renewable energy development.	Mixed effects from the development. It will enable larger vessels, including cruise ships, to visit Aberdeen. These larger vessels may therefore travel more often to Aberdeen, however they will be more efficient. Enhancements to the harbour may reduce journey length for larger vessels by providing an additional harbour. It may also increase the number of larger vessels which have to make longer journeys to access ports which can berth vessels of this size. In addition, GHG emissions will arise from port workers commuting to/from work and maintenance activities.		Negligible negative effects from decommissioning related transport of resources and waste for processing.	Unsure of the number of marine vessel journeys which will be made to/from the harbour.
		Electricity			Negligible negative effects from electricity requirements for the operational phase of the development.			.
		Buildings/ Heat	Heating is dependent on fossil fuels		Negligible negative effects from heating for buildings.			
		Industrial, manufacture and construction processes	Existing facilities/buildings at the harbour. Carbon embodied within existing infrastructure	Minor negative effects from embodied carbon in new infrastructure and materials to be used in the development. Energy required for construction.	Negligible negative effects from energy requirements for the operation of businesses for renewable energy research, manufacture and support services. Materials used during the operations of the development.		Negligible negative effects from decommissioning of development infrastructure. Energy required for decommissioning.	
		Waste		Negligible negative	Negligible negative effects		Negligible negative	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				effects from waste material generated during the construction phases.	from operational waste.		effects from waste material generated during the decommissioning phases.	
		LULUCF	Previously developed land	Negligible negative effects from disturbance to soil and vegetation during the construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	A cluster of port accessible renewable energy research, manufacture and support services, regeneration of existing employment land and reorganisation of land use around the harbour , with sustainable and active travel and green infrastructure	**Transport**	Existing vessel emissions Most marine vessels and vehicles are fuelled by diesel	Negligible negative effects from transportation of machinery and materials required for the construction of development associated with the south harbour.	Negligible negative effects from additional journeys generated from workers commuting to/from site, partly balanced by sustainable and active travel. Transport related to the operation of businesses based at the harbour.		Negligible negative effects from decommissioning related transport of resources and waste for processing.	Uncertain on the types of development that will be located here, and associated transport needed. Uncertain of the number of jobs to be provided.
		Electricity			Negligible negative effects from electricity requirements for land based operations (e.g., offices, security, lighting etc).	Minor positive effects from renewable energy generation enabled by research, manufacturing and support services		Uncertain if electricity will be from a low carbon source
		Buildings/ Heat			Negligible negative effects from buildings (e.g., offices) will require heating			
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in new infrastructure to be developed at South Harbour. Energy required for construction.	Negligible negative effects from energy requirements for harbour operations and buildings.		Negligible negative effects from energy required during the decommissioning phases.	
		Waste		Negligible negative effects from waste	Negligible negative effects from operational waste of		Negligible negative effects from waste	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				material generated during construction phases	the harbour.		material generated during the decommissioning phases	
		LULUCF		Negligible negative effects from Disturbance to soil and vegetation during the construction.	Negligible positive effects from potential for carbon sequestration through green infrastructure during the operational phase of the development.		Negligible negative effects from disturbance to soil and vegetation during the decommissioning.	Uncertain how much greenfield land will be developed Uncertain as to any restoration plans for the site.
	Renewable hydrogen production and hydrogen production related chemicals including ammonia	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development.	Negligible negative effects from transportation of hydrogen.	Minor positive effects as renewable hydrogen provides low carbon fuel for transport.	Negligible negative effects from transportation of staff, materials and equipment during decommissioning.	It is uncertain how much renewable hydrogen will be produced and how it will be transported.
		Electricity				Minor positive effects as renewable hydrogen will facilitate greater efficiency of renewable electricity via renewable energy storage.		Impact will depend on the scale; how much renewable hydrogen will be produced
		Buildings/ Heat				Minor positive effects from production and use of a renewable hydrogen as a low carbon heating source		Will depend on the scale of the activities.
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of renewable hydrogen	Negligible negative effects from potential for hydrogen leakage. Fugitive emissions from transport of hydrogen.	Minor positive effects as renewable hydrogen provides a low carbon fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the activities.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				facilities.				
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative effects from loss of and disturbance of soil and vegetation on brownfield and greenfield site .			Negligible negative effects from the disturbance to soil and vegetation during the decommissioning.	
	Low carbon hydrogen production	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development	Negligible negative effects from energy requirements for transportation of oil and gas, hydrogen and captured carbon.	Minor positive effects from hydrogen which provides low carbon fuel for transport.	Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	
		Electricity			Minor negative effects from electricity required for carbon capture and storage.			It is uncertain how much low carbon hydrogen will be produced.
		Buildings/ Heat				Negligible positive effects from production of lower carbon heating source		Impact will depend on the scale; how much hydrogen will be produced
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen and ammonia production	Minor negative effects from energy required for hydrogen production; energy required for carbon capture, storage and utilisation. Use of oil and gas only in combination with CCUS. Potential for fugitive emissions from hydrogen,	Minor positive effects from hydrogen which provides a low carbon fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the activities. Low carbon hydrogen production dependent on oil and gas production.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				and storage facilities.	ammonia, oil and gas and CCUS (from production, distribution and storage).			
		Waste		Negligible negative effects from construction waste.		.	Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative because of the potential disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning	

Table A.4: Aberdeen Harbour

Aberdeen Harbour					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of machinery and materials required for the construction of manufacturing and support services, hydrogen facilities and renewable energy development.	Negligible negative effects from commuting of workers to/from site, partly balanced by use of sustainable and active transport, transport related to the operation of businesses based at the harbour and maintenance related transport.	Minor positive effects from hydrogen which provides low carbon fuel for transport	Negligible negative effects from decommissioning related transport of resources and waste for processing.	Minor negative GHG balance from transport. Low confidence as it is uncertain how much additional marine and road traffic will be generated by this development, and how much hydrogen produced will be used for transport.
Electricity	Negligible negative effects from energy required for the construction.	Negligible negative effects from electricity requirements for the operational phase of the development.	Minor positive effects from use of surplus renewable energy for hydrogen production and from renewable energy research, manufacturing and support services which will enable	Negligible negative effects from energy required for decommissioning.	Minor negative GHG balance from electricity. Medium confidence as it is uncertain if energy demands will be met by renewable sources.

Aberdeen Harbour					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
			innovative and more efficient solutions and will support the transition to renewable energy and supporting renewable energy generation. Partly balanced by electricity required for carbon capture and storage for low carbon hydrogen.		
Buildings (heat)		Negligible negative effects from heating for buildings and offices.	Minor positive effects from the production and use of a renewable hydrogen as a low carbon heating source		Minor negative GHG balance from buildings (heat), low confidence due to assumed small increase in heat demand.
Industrial, manufacture and construction processes	Minor negative effects from embodied carbon in new infrastructure and materials to be used in the development and energy required for construction.	Minor negative effects from energy requirements for the operation of businesses and the materials used. Fugitive hydrogen, oil and gas and carbon emissions will have negative effects, and energy required for hydrogen production carbon capture and storage.	Minor positive effects as renewable hydrogen provides a low carbon fuel for industrial purposes.	Negligible negative effects from decommissioning of development infrastructure. Energy required for decommissioning.	Minor negative GHG balance from industrial processes. Medium confidence as it is assumed that carbon heavy materials will be required for construction and operation phases and that some hydrogen, oil and gas and carbon will be leaked during production, storage and transportation.
Waste	Negligible negative effects from waste material generated during the construction phases.	Negligible negative effects from operational waste from the mixed-use development. Operational waste of the harbour, including from cruise ships.		Negligible negative effects from waste materials generated during the decommissioning phases.	Minor negative GHG balance from waste, medium confidence due to uncertainty over quantity of waste produced by the operations.
LULUCF	Negligible negative effects from using some areas of currently vegetated land for development.	Negligible positive effects from the potential for carbon sequestration through green infrastructure during the operational phase of the development.		Negligible negative effects from the disturbance to soil and vegetation during the decommissioning.	Minor negative GHG balance from LULUCF. Medium confidence as it is assumed that the development would be partly delivered on both brownfield and greenfield land.
Summary of direct lifecycle GHG effects	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Low confidence in minor negative effects from transport as it is uncertain how much additional marine and road traffic this development is likely to generate, and how much of the hydrogen produced will be used for **transport** purposes. ▪ Medium confidence in minor negative effects from **electricity** as it is expected that this development will require electricity for operation, and it is uncertain if energy demands will be met from renewable sources. ▪ Low confidence in minor negative effects for **buildings** due to uncertainty if hydrogen will be used as a heat source. It is assumed there is a small increase in heat demand.				

Aberdeen Harbour					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	▪ Medium confidence in minor negative effects in relation to **industrial processes** as this development will require a significant amount of carbon heavy materials for construction and operational phases, and it is uncertain how much hydrogen will be used for industrial purposes. ▪ Medium confidence in minor negative effects from **waste** due to uncertainty over the quantity of waste generated by the operations. ▪ Medium confidence in minor negative effects arising from **LULUCF** as it is assumed that the development would be delivered on both brownfield and greenfield land.				
Summary of indirect direct lifecycle GHG effects	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. This development is likely to enable increased generation of renewable electricity through research and support services. This could displace higher carbon fuel sources across Scotland. The research elements are likely to have a multiplier effect for renewable energy development over the medium to long term. In addition, it is likely to facilitate the more efficient use of renewable energy by using surplus electricity to produce renewable hydrogen. Renewable and low carbon hydrogen may be used for transport, heat and industry. Low confidence in indirect positive effects due to uncertainty about the scale of the renewable energy production of the use of surplus electricity for hydrogen production, the scale of hydrogen production and deployment across different sectors. This development is likely to also enable renewable electricity energy development				
Summary of overall lifecycle GHG effects	When direct and indirect effects are combined, it is likely that this development will have **net positive** effects on lifecycle GHG emissions due to the facilitation and enabling of renewable energy development across Scotland, and the production of renewable hydrogen over long timescales. The scale of this effect could range from low to high. A low scale of effect would result from higher levels of increased transport emissions from the site operations using high carbon fuels, but with a lesser contribution by the development to enabling renewable energy and a lesser quantity of renewable hydrogen produced. Conversely, if the additional site transport emissions are lower overall and use low carbon fuels, and the proportion of renewable energy development enabled and renewable hydrogen produced is higher, this could result in a high positive effect. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means there is low confidence in this conclusion.				
Additional mitigation and enhancement	Prioritise the use of renewable / low carbon energy to power the development. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled. Provide low carbon transport options for the site to reduce car dependency.				

Table A.5: Central Scotland Green Network

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Central Scotland Green Network	Expansion of green infrastructure network.	**Transport**	Existing green network enables active travel including walking/cycling, but is not fully connected	Negligible negative effects from transport emissions from construction activities related to the development of new greenspace	Significant positive effects from expansion will enable more journeys to be made by sustainable modes (walking, cycling). The focus of expanding green infrastructure in relation to development will support sustainable transport in new developments.			Uncertain as to the scale of expansion. Uncertain extent to which new active travel opportunities will reduce vehicular journeys.
		Electricity			Negligible negative effects from limited electricity to be used to provide a safer environment (for example, providing lights in parks and along green corridors).			
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from energy use associated with growth of new trees, construction and development of new green space, access routes, lighting and other infrastructure	Mixed effects. Negligible negative effects from creation and installation of protective structures once trees are planted until they reach some level of maturity (e.g., fences, stakes, tree tubes). Minor positive effects from improvements to surface water management and drainage, and reduction in impacts of flood risk on infrastructure and property.			
		Waste		Negligible positive effects from removal and reuse of excess soil/vegetation for creation of paths	Negligible negative effects from removal of protective structures once trees reach maturity			
		LULUCF	Soil carbon stored in soil	Mixed effects from creating greenspace from previously developed land. Disturbance of soil and	Significant positive effects from enhancing carbon sequestration though woodland planting and peatland regeneration.			Uncertainty about level of expansion, habitat types, rate of carbon sequestration How much green

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				release of carbon.				space will be created as opposed to enhanced Uncertainty over type of tree/species and their sequestration value

Table A.6: Central Scotland Green Network

Central Scotland Green Network					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transport emissions arising from construction activity (materials and machinery) and transport of trees for planting	Significant positive effects due to more journeys made by sustainable modes of transport			Super positive GHG balance from transport due to more active travel. Medium level of confidence depending on the scale of network expansion, uptake of sustainable travel and rate of expansion of active travel network.
Electricity		Negligible negative effects on electricity used to power lighting etc.			Minor negative GHG balance from electricity use. High confidence due to assumed level of use for lighting only.
Buildings (heat)					Neutral GHG balance from heat. High confidence as no heating requirements.
Industrial, manufacture and construction processes	Negligible negative effects from energy use associated with construction and development of new green space/corridors, and associated infrastructure (lighting, seating etc), including carbon embodied in materials.	Minor positive effects from improvements to surface water management and drainage, and reduction in impacts of flood risk on infrastructure and property assumed to outweigh negligible negative effects from protection of new planting .			Minor positive GHG balance from positive effects of reduced flood risk assumed to outweigh negligible negative effects from infrastructure and protection of new planting . Medium confidence due to assumed low carbon content of infrastructure and construction work.
Waste	Negligible negative effects from removal and reuse of soil materials during construction	Negligible negative effects relating to disposal of protective structures for young trees			Minor negative GHG balance from waste. High confidence - limited waste expected.
LULUCF	Minor positive effects from creation/enhancement of new green space on previously developed land.	Significant positive effects from enhancing carbon sequestration though woodland planting and peatland regeneration.			Major positive GHG balance from LULUCF. Medium confidence depending on scale of the tree planting, peatland restoration and expansion of green space.

Central Scotland Green Network					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in super positive effects for **transport** related to the assumed greater uptake of active modes of travel displacing emissions from transport over a long time period and at a national scale, however there is uncertainty over the uptake of active travel. ▪ Medium confidence in major positive effects for **LULUCF** from greater carbon sequestration from creation of new greenspace and large-scale planting of trees. However, there is uncertainty surrounding the scale of green network enhancements. ▪ Medium confidence in minor positive effects for **industrial, manufacture and construction processes** due to reduced flood risk and impacts on property and infrastructure. ▪ High confidence in minor negative effects for **electricity**, **and waste** due to assumed limited emissions associated with these sectors.				
Summary of lifecycle GHG balance (indirect effects)	No indirect effects identified.				
Overall summary of effect	This proposed national development is likely to have **net positive** effects on lifecycle GHG emissions due to reduced transport emissions from higher uptake of active travel, reduced flood risk and greater rates of carbon sequestration due to the creation of new greenspace and large-scale planting of trees. The scale of this effect is likely to be in the range of medium to high as it will encourage a change in behaviour around active travel in central Scotland over a long time period. A medium scale of effect would result from higher embodied carbon in construction infrastructure, lower levels of active travel and lower levels of flood risk reduction. Conversely, lower embodied carbon in construction infrastructure, higher levels of active travel and higher levels of flood risk reduction would result in a higher scale of effect. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. However there is considerable uncertainty and this could be within the range of medium to high positive impact. Uncertainty about the scale of these effects means there is medium confidence in this conclusion.				
Additional mitigation and enhancement	Maximise the scale of expansion, number of trees and type of development, whilst protecting existing high carbon soils. Ensure low carbon materials are used for associated infrastructure (seating, lighting, tree protective equipment etc). Consider the use of the green network for providing renewable heating. Ensure that green network is well linked with other active travel routes and public transport modes to further reduce potential emissions from transport.				

Table A.7: Chapelcross Power Station Redevelopment

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Chapelcross Power Station Redevelopment	Business development with a particular focus on energy and energy supply chain with sustainable and active travel connections	**Transport**		Negligible negative effects from transportation of machinery and materials required for the development.	Negligible negative effects from transport relating to the operation of businesses based at the development, including workers commuting to/from the site, partly mitigated by provision of sustainable and active travel opportunities.		Negligible negative effects from decommissioning related transport of resources and waste for processing.	Scale of business and employment generation is uncertain.
		Electricity			Negligible negative effects from electricity requirements for businesses based at the development	Negligible positive effects from indirect support for renewable energy generation		Unsure as to whether businesses will utilise the low carbon energy generated elsewhere within the development.
		Buildings/ Heat	Heat provided by unsustainable sources		Negligible negative effects from heat requirements for businesses based at the development			
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in construction materials used to build the development, and energy requirements of land remediation of potentially contaminated land.	Negligible negative effects from energy requirements of businesses based at the development.		Negligible negative effects from decommissioning of development	
		Waste		Negligible negative effects from waste produced during construction	Negligible negative effects from waste produced by businesses based at the development.		Negligible negative effects from decommissioning of development	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		LULUCF	Carbon stored in soils	Negligible negative because of the potential disturbance to soil and vegetation during construction.	Negligible positive effects from landscaping elements of the development may provide some opportunities for carbon sequestration.	Negligible positive from the use of a brownfield site and avoiding the use of a greenfield site.	Negligible negative effects from disturbance to soil and vegetation during decommissioning.	Unsure of the inclusion and scale of any landscaping
	Energy generation from solar, electricity storage, generation of heat	**Transport**	Existing emissions from vehicles	Negligible negative effects from transport of materials for the development of green energy generating storage and distribution facilities.	Negligible negative effects from commuting of workers to/from site, partly mitigated by provision of sustainable and active travel opportunities. Maintenance required during the operation of solar, storage and heat generation facilities		Negligible negative effects from decommissioning related transport of resources and waste for processing.	
		Electricity	Need for more green energy		Minor positive effects from increased electricity production from renewable energy. This will have lower GHG emissions compared to electricity from fossil fuels.	Minor positive effects from the role of the site supporting or as a catalyst for energy generation, storage and distribution. Battery storage facility provides greater reliability and security of energy supply by utilising intermittent supply of electricity from offshore wind and supporting additional offshore wind energy development.		Scale of solar energy generated is uncertain.
		Buildings/ Heat			Minor positive effects from low carbon heat generation and use.			
		Industrial, manufacture and construction	Carbon stored in materials for construction	Negligible negative effects from carbon embodied in materials for the development and any associated infrastructure.	Negligible negative effects from energy requirements for the successful operation of the battery storage		Negligible negative effects from decommissioning of development	Scale of battery storage unknown.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		processes		Battery storage facility may have high carbon footprint.	facility.		infrastructure.	
		Waste		Negligible negative effects from waste material generated during the construction phases			Negligible negative effects from waste material generated during the decommissioning phases	
		LULUCF	Carbon stored in soils; reuse of land prevents disturbance of soils elsewhere	Negligible negative because of the potential disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	Renewable hydrogen production	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development.	Negligible negative effects from transportation of hydrogen, including leakage.	Minor positive effects from hydrogen which provides a low carbon fuel for transport.	Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	
		Electricity			Negligible positive effects from use of surplus renewable electricity to generate renewable hydrogen.	Minor positive effects from renewable hydrogen as it facilitates renewable energy storage.		It is uncertain how much renewable hydrogen will be produced.
		Buildings/ Heat				Negligible positive effects from production of low carbon heating source		Impact will depend on the scale; how much renewable hydrogen will be produced
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of renewable hydrogen facilities.	Negligible negative effects from potential for hydrogen leakage. Fugitive emissions from transport of hydrogen.	Minor positive effects from hydrogen which provides low carbon fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the activities.
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
							decommissioning	
		LULUCF		Negligible negative because of the potential disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	Low carbon hydrogen production	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development.	Negligible negative effects from energy requirements for transportation of oil and gas, hydrogen and captured carbon.	Minor positive effects from hydrogen which provides low carbon fuel for transport.	Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	
		Electricity			Minor negative effects from electricity required for carbon capture and storage.			It is uncertain how much low carbon hydrogen will be produced.
		Buildings/ Heat				Negligible positive effects from production of lower carbon heating source		Impact will depend on the scale; how much hydrogen will be produced
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen and ammonia production and storage facilities.	Minor negative effects from energy required for hydrogen production; energy required for carbon capture, storage and utilisation. Use of oil and gas only in combination with CCUS. Potential for fugitive emissions from hydrogen, ammonia, oil and gas and CCUS (from production, distribution and storage).	Minor positive effects from hydrogen which provides a low carbon fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the activities. Low carbon hydrogen production dependent on oil and gas production.
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		LULUCF		Negligible negative because of the potential disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	storage of hydrogen and ammonia	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for construction of transport and storage infrastructure.	Negligible negative effects from energy requirements for transportation of hydrogen and ammonia.	Minor positive effects from hydrogen and ammonia storage and distribution infrastructure will enable use of hydrogen as a low carbon fuel for transport.	Negligible negative effects from transportation of staff, materials and equipment after decommissioning	Type and method of hydrogen and ammonia storage
		Electricity			Negligible negative effects from electricity required for hydrogen and ammonia storage.			
		Buildings/ Heat				Negligible positive effects from production of lower carbon heating source		Impact will depend on the scale; how much hydrogen will be produced
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials and equipment used for construction of transport and storage infrastructure. Energy required for construction.	Negligible negative effects from potential for fugitive emissions from hydrogen and ammonia storage.	Minor positive effects from hydrogen storage will enable use of hydrogen as a low carbon fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Level of hydrogen and ammonia storage.
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative because of the potential disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	

Table A.8: Chapelcross Power Station Redevelopment

Chapelcross Power Station Redevelopment					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of machinery and materials required for the development.	Negligible negative effects from transport relating to the operation of businesses based at the development, and transportation of hydrogen and ammonia.	Minor positive effects from hydrogen which provides low or carbon fuel for transport. Hydrogen and ammonia storage and distribution infrastructure will enable use of hydrogen as a low carbon fuel for transport.	Negligible negative effects from decommissioning related transport of resources and waste for processing.	Minor negative GHG balance from transport. Medium confidence as this development is likely to lead to an increase in transport related emissions from the site, only partly mitigated by sustainable and active travel provision.
Electricity		Negligible positive effect from increased production of renewable electricity that will have lower GHG emissions compared to electricity from current fossil fuels, balanced against minor increases in electricity demand.	Minor positive effects from the role of the site supporting or as a catalyst for energy generation, storage and distribution. Energy storage facility provides greater reliability and security of energy supply by utilising the intermittent supply of electricity from offshore wind.		Minor positive GHG balance from electricity. Medium confidence, as although this development will generate renewable electricity it will also use electricity for operational activities.
Buildings (heat)		Neutral effects from heat requirements for businesses based at the development balanced by low carbon heat generation.	Minor positive effects from the production of hydrogen for low carbon heat		Neutral GHG balance from buildings (heat), medium confidence as it is assumed that heat generation is low/zero carbon and meets on site heat demands.
Industrial, manufacture and construction processes	Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen production and storage facilities.	Minor negative effects from the potential for hydrogen leakage. Use of natural gas in combination with CCUS results in net emissions. Potential for fugitive emissions from hydrogen, natural gas and CCUS (from production, distribution and storage).	Minor positive effects from hydrogen as it will enable use of hydrogen as a low or zero carbon fuel (depending on whether renewable hydrogen or low carbon hydrogen is deployed) for industrial purposes.	Negligible negative effects from decommissioning of development.	Minor negative GHG balance from industrial processes. Medium confidence as it is due to embodied carbon in construction materials and potential for hydrogen and ammonia leakage during the operations.
Waste	Negligible negative effects from waste produced during construction.	Negligible negative effects from waste produced by businesses based at the development.		Negligible negative effects from decommissioning of development.	Minor negative GHG balance from waste, medium confidence as it is assumed the development will increase waste generation overall.
LULUCF	Negligible negative because of the potential disturbance to soil and vegetation during construction.	Negligible positive effects from landscaping elements of the development may provide some opportunities for carbon sequestration.	Negligible positive from the use of a brownfield site and avoiding the use of a greenfield site.	Negligible negative effects from disturbance to soil and vegetation during decommissioning.	Minor negative GHG balance from LULUCF, low confidence due to the small scale of landscaping potential.

Chapelcross Power Station Redevelopment					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Low confidence in minor positive effects arising from **electricity** because of the uncertainty around the amount of renewable electricity generated versus the amount of electricity required for site operations. ▪ Medium confidence in minor negative effects arising from **transport** as this development is assumed to generate additional transport. ▪ Medium confidence in minor negative emissions from **industrial processes** due to embodied carbon in materials for its construction and also it will lead to hydrogen and ammonia leakage during its operations. ▪ Low confidence in minor negative effects on **LULUCF** due to the small scale of landscaping potential at this site.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive effect on indirect lifecycle GHG emissions**. The development is likely to support and provide a catalyst for low carbon energy generation, storage and distribution which is likely to help displace emissions from current fossil fuel-based energy, including for **transport, heat** and **industrial processes**. The indirect positive effects could range from minor to moderate positive due to uncertainty over how much the development supports hydrogen for fuel or supports renewable energy development elsewhere. Negligible positive effects are identified in relation to **LULUCF**, as this development is likely to avoid using a greenfield site which could have led to more significant soil carbon and vegetation loss.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the production of renewable and low carbon energy and support for energy related business development. The scale of effects could range from low negative to low positive. A low negative effect would result from a lower level of renewable / low carbon energy produced or stored, and lower levels of enabling support for renewable energy related development which could be insufficient to balance against the embodied energy of construction and on site energy demands and increase in transport emissions, Conversely, if the levels of renewable/low carbon energy production and storage are higher and the enabling effect of the development for renewable energy is greater a low positive effect could be achieved. An overall net positive effect is concluded based on the assumption of a higher level of renewable/low carbon energy production and storage. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects means there is low confidence in this overall conclusion.				
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or at least recycled. Consideration of the type and scale of green energy generation and whether it can be used to provide electricity to the businesses forming the development. Consideration should be given to potential restoration of the development site (or individual components) upon decommissioning. Ensure public transport connections and links to active travel routes.				

Table A.9: Circular Economy Materials Management Facilities

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Sites and facilities to retain the resource value of waste materials		**Transport**		Negligible negative effects from transportation of staff, materials and equipment for construction of the facilities.	Minor negative effects from transportation of materials to and from facilities. Increased travel to and from the site (supply of waste and distribution of reprocessed materials). Transportation of staff.		Negligible negative effects from transportation of staff, materials and equipment for decommissioning of the facilities.	Details on how many such facilities will be delivered.
		Electricity			Minor negative effects from electricity to process materials.			What percentage of the processes are going to be powered with renewable energy.
		Buildings/ Heat			Negligible negative effects from heat for processing of materials.	Minor positive effects where surplus by-products can be utilised, for example surplus heat.		
		Industrial, manufacture and construction processes	Existing waste processing facilities	Negligible negative effects from carbon embodied in the materials used for constructing of the facilities.	Negligible negative effects from potential emissions from processing of materials.	Minor positive effects from potential for new innovative businesses that would reuse new materials and displace carbon emissions from current processes.	Negligible negative effects from energy required for the decommissioning of the facilities.	
		Waste	Limited recycling for certain materials, recycling decreases value of materials, some materials are cheaper new than recycled.	Negligible negative effects from construction waste.	Significant positive effects from potential for reduced waste as materials will be reprocessed and recycled. Increased capacity for waste reprocessing, increased reuse of materials. Reduced amount of virgin materials used for manufacturing and production. Increased potential for plastics reprocessing, reduced amount of virgin plastic used in the supply chain.	Minor negative effects from greater potential for other innovative circular economy businesses to reuse new materials.		
		LULUCF		Negligible negative effects from loss of soil and vegetation/ through development			Negligible negative effects from disturbance to soil and vegetation.	Depending on the site chosen.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				at a brownfield site				

Table A.10: Circular Economy Materials Management Facilities

Circular Economy Materials Management Facilities					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of staff, materials and equipment for construction of the facilities.	Minor negative effects from transportation of materials to and from facilities (supply of waste and distribution of reprocessed materials) and staff commute.		Negligible negative effects from transportation of staff, materials and equipment for decommissioning of the facilities.	Minor negative GHG balance from transport. Medium confidence as this development is likely to significantly increase emissions from transport considering the timescale of the development, however in the longer-term it is uncertain how these vehicles will be fuelled.
Electricity		Minor negative effects from electricity to process materials.			Minor negative GHG balance from electricity, with medium confidence as this development will require a significant amount of electricity, however it is uncertain what percentage of this will be renewable electricity.
Buildings (heat)		Negligible negative effects from heat for processing of materials.	Minor positive effects where surplus by-products can be utilised, for example surplus heat.		Minor negative GHG balance from buildings (heat), medium confidence as it is not anticipated that this development will significantly increase the demand for heat.
Industrial, manufacture and construction processes	Negligible negative effects from carbon embodied in the materials used for constructing of the facilities.	Negligible negative effects from the potential emissions from processing of materials.	Minor positive effects from the potential for new innovative businesses that would reuse new materials and displace carbon emissions from current processes.	Negligible negative effects from energy requirements for decommissioning.	Minor negative GHG balance from industrial processes with medium confidence as this development will lead to limited additional emissions compared to existing processing facilities.
Waste	Negligible negative effects from construction waste.	Significant positive effects from the potential for reduced waste as materials will be reprocessed and recycled. Increased capacity for waste reprocessing, increased reuse of materials. Reduced amount of virgin materials used for manufacturing and production. Increased	Minor positive effects from greater potential for other innovative circular economy businesses to reuse new materials.		Major positive GHG balance for waste, high confidence as this development has the potential to reduce waste from a range of materials by repurposing and reusing them.

Circular Economy Materials Management Facilities					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
		potential for plastics reprocessing, reduced amount of virgin plastic used in the supply chain.			
LULUCF	Negligible negative effects from the loss of soil and vegetation.			Negligible negative effects from disturbance to soil and vegetation.	Neutral GHG balance from LULUCF, low confidence as it is assumed that such facilities will be delivered on brownfield sites and having very little impact on soil and vegetation.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects arising from **transport** as it is assumed that more complex supply chains may be developed which may increase the transport, but it is uncertain how such vehicles will be fuelled in the future. ▪ Medium confidence in minor negative effects from **electricity** and **heat** as materials processing will require additional electricity and heat, but there is uncertainty over the source of electricity or heat . ▪ Medium confidence in minor negative effects from industrial, manufacture and construction processes as it is assumed this development will lead to limited additional emissions compared to existing processing facilities. ▪ High confidence in significant positive effects in relation to **waste** as this development has the potential to reduce waste from a range of waste streams by keeping them in the loop, repurposing and reusing them.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. This development may potentially encourage more innovation and may enable some businesses to use new materials that will reduce the demand for virgin materials, with positive effects for industrial, manufacture and construction processes. Potential for positive effects where surplus by-products can be utilised, for example surplus heat. The indirect positive effects could range from minor to moderate due to uncertainty over the role of the development in reducing emissions from production and processing of raw materials.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to increased efficiency in waste management and use of raw materials The scale of the positive effects could range from low to high positive depending on the volume of waste reprocessed. If the amount of waste reprocessed is relatively minor, vehicle movements are higher, energy demands of reprocessing are higher from reprocessing the overall positive effects will be minor. However, if this development enables reprocessing at a significant scale, uses low carbon transport, from reprocessing , it will lead to high positive effects. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects mean that there is medium confidence in this conclusion.				
Additional mitigation and enhancement	Ensure that where possible transport is decarbonised to reduce the overall emissions from this development and also from transport sector. Ensure use of waste heat where possible. Support on site low carbon energy generation. Support local processing and reuse where possible. Ensure development on brownfield land where possible.				

Table A.11: Clyde Mission

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Clyde Mission	Redevelopment of vacant and derelict land, upgrading buildings and facilities for residential, commercial, business and industrial uses; tackling contamination and climate adaptation	**Transport**		Negligible negative effects from transportation of staff, materials, and equipment for construction phase of the development.	Negligible negative effects from transport linked with resident's commute to work and education, or staff travel; maintenance of the development.		Negligible negative effects from transport of staff, materials, and equipment after decommissioning.	Uncertainty over scale of the development; number of housing units and employment units. Number of journeys generated. Extent of provision of other transport modes connections (bus, rail, active travel routes).
		Electricity			Negligible negative effects from electricity demand of residents and businesses from the development.			Impact depends on the scale and the energy sources
		Buildings/ Heat			Negligible negative effects from heat requirements for residents and businesses within the development.			Impacts depend on the type of heating provided for this development
		Industrial, manufacture and construction processes		Minor negative effects from embodied carbon in the materials used for construction. Energy required for construction and remediation of potentially contaminated land.	Negligible negative effects from potential emissions from business operations.		Negligible negative effects from energy required to decommission and recycle materials that can be reused.	Depends on the nature of businesses located within the development
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from operational waste from households and businesses.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	Depends on the scale of the development, number of households and the nature of the businesses; depends on the timeframes of this development

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		LULUCF	Vacant and derelict land	Negligible negative effects from disturbance to soil and vegetation during the construction.	Negligible positive effects from potential for carbon sequestration through green and blue infrastructure as part of the development	Negligible positive effects from development on vacant and derelict land takes pressure off from greenfield land.	Negligible negative effects from disturbance to soil and vegetation during the decommissioning.	
	Upgrade of existing port and harbour assets for servicing marine functions including freight and cruise uses and associated landside commercial and/or industrial land for supporting services	**Transport**		Negligible negative effects from transportation of staff, materials, and equipment for construction phase of the development.	Negligible negative effects from additional land and water based transport.		Negligible negative effects from transport of staff, materials, and equipment when decommissioning.	Scale of the additional transport movements uncertain.
		Electricity			Negligible negative effects from electricity demand of port operations.			Impact depends on the scale and the energy sources
		Buildings/ Heat			Negligible negative effects from heat requirements for port buildings			Impacts depend on the type of heating provided for this development
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in the materials used for construction. Energy required for construction and remediation of potentially contaminated land.	Negligible negative effects from potential emissions from port and harbour operations.		Negligible negative effects from energy required to decommission and recycle materials that can be reused.	Depends on the nature of businesses located within the development
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from operational waste from households and businesses.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	Depends on the scale of waste generation from port and harbour operations

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		LULUCF	Vacant and derelict land	Negligible negative effects from disturbance to soil and vegetation during the construction.		Negligible positive effects from development on vacant and derelict land takes pressure off from greenfield land.	Negligible negative effects from disturbance to soil and vegetation during the decommissioning.	

Table A.12: Clyde Mission

Clyde Mission					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transport activity for the construction of the development	Minor negative effects from transport for residents, business, employment, and marine transport.		Negligible negative effects from decommissioning transport.	Minor negative GHG balance from transport. Medium confidence based on the nature of development which will generate travel, and uncertainty over the extent of sustainable travel which will be used.
Electricity		Negligible negative effects from electricity demand for residents and businesses from the development			Minor negative GHG balance from increased energy demand. Medium confidence based on the fact that the development will provide residential and business units with unknown electricity demands, uncertainty over energy efficiency measures or renewable energy generation as part of the development.
Buildings (heat)		Negligible negative effects from heat requirements for residents and businesses within the development			Minor negative GHG balance for heat demand. Low confidence based on unknown energy demands of households or businesses and on an assumption that this development will exist for at least 25 years and will use sustainable heating sources.
Industrial, manufacture and construction processes	Minor negative effects from carbon embodied in the materials and energy required for construction.	Negligible negative effects from business operations			Minor negative GHG balance from carbon embodied in the materials. Medium confidence based on requirement for carbon heavy materials required for development, but uncertainty over use of low carbon construction materials.
Waste	Negligible negative effect of waste produced during the construction of the	Negligible negative effects from waste produced by residents and businesses		Negligible negative effect of waste materials after decommissioning.	Minor negative GHG carbon balance from additional waste produced. Medium confidence based on unknown levels of waste associated with businesses and number of residential units.

Clyde Mission					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	development.				
LULUCF	Negligible negative effects from disturbance to soil and vegetation during construction.	Negligible positive effect from potential for carbon sequestration from green and blue infrastructure	Negligible positive effects as development on vacant and derelict land takes pressure off from greenfield land.	Negligible negative effects from disturbance to soil and vegetation during construction.	Minor positive GHG balance from the potential for carbon sequestration through green and blue infrastructure over lifetime of development. Low confidence depending on the final details of the development.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects related to **industrial, manufacture and construction processes** based on an assumption that this development will require a significant amount of carbon heavy materials, although there is uncertainty over the use of low carbon construction materials. ▪ Medium confidence in minor negative effects related to **transport**, **electricity** and **waste**, based on assumptions that the development will encourage an increase in travel, electricity demand and waste production. ▪ Low confidence in relation to minor negative effects for **buildings (heat)** based uncertainty over the use of sustainable heating sources. ▪ Low confidence in minor positive effects from **LULUCF** based on an assumption that the impact of development and implementation of green and blue infrastructure are unknown.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is taking place on previously developed land, and it is assumed that the development reduces pressure on greenfield land and reduces potential transport emission generated from equivalent development on greenfield land with fewer sustainable transport connections and LULUCF associated emissions. The scale of this effect is likely to be minor, due to the regional effect of this development.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net negative** effect on lifecycle GHG emissions due to increased emissions from transport, electricity, heat, industrial, manufacture and construction processes and waste. This development is likely to be delivered on vacant or derelict land which is assumed to protect greenfield sites from being developed. The scale of this effect is likely to be low depending on the uptake of sustainable transport modes and low carbon/energy efficiency solutions, and LULUCF benefits. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net negative** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects mean that there is medium confidence in this conclusion.				
Additional mitigation and enhancement	Ensure that electricity and heat demand and supplied from renewable or low carbon sources to reduce potential emissions. Exploit the potential for green and blue infrastructure to ensure climate resilience and adaptation, and also potential for active travel. Ensure requirement for high energy efficiency of new and retrofitted buildings. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or at least recycled.				

Table A.13: Digital Fibre Network

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Digital Fibre Network		**Transport**	Currently limited access to internet in more remote locations	Negligible negative effects from transport of new network towers, fibre cables, equipment for installation, some of the transportation will happen on the mainland, some at the sea (additional emissions from transport).	Negligible negative effects from maintenance related transport (may be more frequent accounting for climate change, towers and overground cables may be damaged by extreme weather conditions)	Negligible positive effects from potential for reductions in travel, especially work-related commuting. May also increase travel due to facilitation of decentralised economic development due to greater connectivity.	Decommissioning related transport of resources and waste for processing.	The exact areas where the work is going to be carried out is still to be defined
		Electricity			Negligible negative effects from energy requirements of towers and cables. Increased number of devices (however they have the potential to be more energy efficient), nevertheless they may lead to overall increased energy demand. This will also increase indirect energy demand from data centres, although for a relatively small number of users overall.		Negligible negative effects from energy requirements for processing waste materials after decommissioning of the infrastructure	It is uncertain how better connectivity across more remote locations will impact on energy use, it is likely that it will decrease the need to travel, however it may encourage usage of more devices, working from second homes may become more frequent.
		Buildings/ Heat				Negligible negative effects from increased heat demands from increased working from home.		
		Industrial, manufacture and construction processes		Negligible negative effects from embedded emissions from network equipment (may include cables, towers, routers and other devices)	Negligible negative effects from maintenance activities		Negligible negative effects from processing of waste materials	Lack of information on how many new towers this development will require, and what impact this may have on land take. .
		Waste					Negligible negative effects from potential for fibre cable and	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
							tower waste after decommissioning	
		LULUCF		Negligible negative effects from disturbance to soil and vegetation installation of cables, towers and green data centres during construction.	Neutral effects from maintenance of cables in the ground may lead to the loss of carbon if biomass needs to be removed over time to dig the cables for maintenance purposes, potential for carbon sequestration once cables are installed.		Neutral effects from decommissioning may include excavation to remove the cables or replacing them with new ones via conduits. Excavation will impact on the soil and land use emissions.	Lack of information on how many new towers this development will require, and what impact this may have on land take, where the cables are going to be laid, impact on high carbon soils and extent of new network and process of decommissioning?

Table A.14: Digital Fibre Network

Digital Fibre Network					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from construction transport.	Negligible negative effects from maintenance travel which may be more frequent considering climate change.	Minor positive effects from potential travel savings due to better digital connectivity		Minor negative GHG balance. Medium confidence based on assumed low levels of maintenance required.
Electricity		Negligible negative effects from the potentially increased number of devices used for internet.			Minor negative GHG balance from increase in electricity use. Medium confidence based on assumed increase in devices and internet use.
Buildings (heat)			Negligible negative effects from increased home working		
Industrial, manufacture and construction processes	Negligible negative effects from embodied emissions in construction materials	Negligible negative effects from maintenance activities		Negligible negative effects from processing of waste materials	Minor negative GHG balance, medium confidence due to uncertainty on scale of embodied carbon in new infrastructure.
Waste				Negligible negative effects from the cable and tower waste after decommissioning	Minor negative GHG balance, medium confidence reflecting uncertain energy requirements for processing waste or loss of embodied carbon in waste materials.

Digital Fibre Network					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
LULUCF	Negligible negative effects from disturbance of soil and vegetation during construction.			Negligible negative effects from decommissioning of the infrastructure (cables, cement, digging up soil)	Minor negative GHG balance, medium confidence due to uncertainty over extent of loss of sequestered carbon in soils and vegetation.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects arising from **transport** related to the assumed more frequent maintenance travel. ▪ Medium confidence in minor negative effects from **electricity** due to an assumed increase in the number of devices and internet use. ▪ Medium confidence in minor negative effects related to **industrial, manufacture and construction processes** from the embodied carbon in the materials. ▪ Medium confidence in minor negative effects for **waste** reflecting uncertain energy requirements for processing waste or loss of embodied carbon in waste materials. ▪ Medium of confidence in minor negative GHG balance for **LULUCF**, due to uncertainty over extent of loss of sequestered carbon in soils and vegetation.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is likely to support digital connectivity in less well-connected areas of the Highlands and Islands. There is low confidence over the scale of impact of indirect positive effects on transport. The indirect positive effects may only be minor due to uncertainty over reductions in travel for work, as increased connectivity may also encourage an increase in travel in the medium to long term. Increased home working may result in minor indirect negative effects on heat demand, however this is likely to be limited in scale.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **negligible** effect on lifecycle GHG emissions as the potential increases in maintenance travel and electricity use, and industrial, manufacture and construction processes could be counterbalanced by reduced journeys from improved connectivity. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **negligible** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty over the balance between reductions in travel and increases in travel means there is low confidence in this conclusion.				
Additional mitigation and enhancement	Avoid development of in areas with high carbon soil. Development of best practice guidance/regulation to ensure that fibre cables and tower construction do not impact on high carbon soils. Ensure cable laying utilises conduits or existing infrastructure for lower carbon future cable replacement.				

Table A.15: Dundee Waterfront

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Dundee Waterfront	Mixed use development with new and or upgraded green and blue infrastructure and new and/or upgraded active and sustainable travel routes	**Transport**	Site centrally located with good links to public transport and with proximity to essential services. Areas of undeveloped brownfield land.	Negligible negative effects from transportation of staff, materials and equipment for the construction phase of the development.	Negligible negative effects from increased travel resulting from the development, balanced by increased transport using sustainable and active travel modes.		Negligible negative effects from transportation of staff, materials and equipment for decommissioning.	Number of additional journeys generated.
		Electricity			Negligible negative effects from increased electricity demand from the operations of the development (household and business demand), lighting along the paths and at bus stops and public transport stations.	Minor positive effects due to supporting off-shore renewables production.		
		Buildings/ Heat			Negligible negative effects from increased demand for heat from residential and business premises			
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials and equipment used for construction, and energy required for construction.	Negligible negative effects from potential for emissions from business operations.		Negligible negative effects from energy required for decommissioning	Energy demands of business
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from construction waste and increased waste production from households, and business operations.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects from disturbance to soil and vegetation during	Negligible positive effects from potential for carbon sequestration through green and blue		Negligible negative effects from disturbance to soil and vegetation during decommissioning.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				construction.	infrastructure.			
	New and/or upgraded port facilities for vessel berthing and related landside activities including for lay-down, freight handling and marine sector services	**Transport**	Existing vessel emissions Most marine vessels and vehicles are fuelled by diesel	Negligible negative effects from transportation of machinery and materials required for the construction of manufacturing and support services and renewable energy development.	Mixed effects from the development. It will enable larger vessels to visit Dundee. These larger vessels may therefore travel more often to the harbour, however they will be more efficient. New or upgraded port facilities for vessel berthing and related activities may reduce journey length for vessels. It may also increase the number of vessels accessing the port. In addition, GHG emissions will arise from port workers commuting to/from work and maintenance activities.		Negligible negative effects from decommissioning related transport of resources and waste for processing.	Unsure of the number of marine vessel journeys which will be made to/from the harbour.
		Electricity			Negligible negative effects from electricity requirements for the operational phase of the development.	Minor positive effects from renewable energy generation enabled by the port enhancements.		It is uncertain how much renewable electricity will be generated at this site or supported by it.
		Buildings/ Heat	Heating is dependent on fossil fuels		Negligible negative effects from heating for buildings.			
		Industrial, manufacture and construction processes	Existing facilities/buildings at the harbour. Carbon embodied within existing infrastructure	Minor negative effects from embodied carbon in new infrastructure and materials to be used in the development. Energy required for	Negligible negative effects from energy requirements for the operation of marine sector.		Negligible negative effects from decommissioning of development infrastructure. Energy required for decommissioning.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				construction.				
		Waste		Negligible negative effects from waste material generated during the construction phases.	Negligible negative effects from operational waste.		Negligible negative effects from waste material generated during the decommissioning phases.	
		LULUCF	Previously developed land	Negligible negative effects from disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	

Table A.16: Dundee Waterfront

Dundee Waterfront					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of staff, materials and equipment for the construction phase of the development.	Minor negative effects from increased travel overall resulting from the development, including port related travel, partly balanced by high levels of use of sustainable and active travel modes.		Negligible negative effects from transportation of staff, materials and equipment for decommissioning.	Minor negative GHG balance from transport. Medium confidence as even though this development is likely to increase transport it is also assumed that sustainable and active provisions will be delivered and that over time it will become the most convenient transport mode.
Electricity		Negligible negative effects from increased electricity demand from the operations of the development (household and business demand).	Minor positive effect from supporting off-shore renewable energy production.		Minor negative effects from electricity, medium confidence as it is uncertain to what extent renewable energy will be incorporated on site.
Buildings (heat)		Negligible negative effects from increased demand for heat from residential and business premises			Minor negative effects from buildings (heat), due to increased heat demand, medium confidence as it is uncertain to what extent low carbon heat will be incorporated on site.
Industrial, manufacture and construction processes	Minor negative effects from carbon embodied in the materials and equipment used for construction, and energy required for construction.	Negligible negative effects from the potential for emissions from business operations.		Negligible negative effects from the energy required for decommissioning	Minor negative GHG balance from industrial processes. Medium confidence as it is assumed that this development will require carbon heavy construction materials.

Dundee Waterfront					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Waste	Negligible negative effects from construction waste.	Negligible negative effects from an increased waste production from households, and business operations.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	Minor negative GHG balance from waste, high confidence as it is assumed that the development will increase overall levels of waste generated.
LULUCF	Negligible negative effects from the disturbance to soil and vegetation during the construction.	Negligible positive effects from the potential for carbon sequestration through green and blue infrastructure.		Negligible negative effects from the potential loss of soil and vegetation.	Neutral GHG balance from LULUCF, medium confidence as it is assumed that the development uses previously developed land and will incorporate green and blue infrastructure.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects in relation to **transport** based on an assumption that this development will increase overall journeys but will also enable sustainable and active transport. ▪ Medium confidence in minor negative effects arising from **electricity** and **heat** due to increased demand and uncertainty over extent of renewable or low carbon electricity or heat incorporated into the development. ▪ Medium confidence in minor negative effects arising from **industrial processes** as it is assumed that carbon heavy materials will be required for the construction phase of the development. ▪ High confidence in minor negative effects from **waste**, as the development will increase overall levels of waste generated. ▪ Medium confidence in negligible GHG balance from **LULUCF** due to assumed use of previously developed land and incorporation of green and blue infrastructure.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is likely to support the decommissioning of the oil and gas industry and increase capacity of off-shore renewables. The scale of indirect effects is likely to be minor, however there is low confidence over the scale of indirect positive effects on electricity due to uncertainty over the quantity of renewables that will be supported by this development.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the transport emissions being partly balanced by indirect support for renewable energy development. The scale of this effect is likely to be low positive to negligible, depending on the level of renewable energy supported by the development and the level of travel generated by the development. If a relatively small amount of renewable energy generation supported by this development negligible effects are expected, whereas if this development supports a significant amount of renewable energy generation then minor positive effects are expected. However, it is assumed that a significant amount of renewable energy capacity will be supported considering the location of the harbour in relation to off-shore renewables and the relatively large-scale expansion of the harbour. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty over the scale of effects means there is low confidence in this conclusion.				
Additional mitigation and enhancement	Ensure that public transport connections are frequent and convenient to offer an effective alternative to private vehicles. Ensure that the site is connected with active travel network. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled. Implement district heating. Ensure renewable energy generation is incorporated into the development.				

Dundee Waterfront					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	Ensure requirements for high energy efficiency buildings.				

Table A.17: Edinburgh Waterfront

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Edinburgh Waterfront	Mixed use development with new or upgraded green and blue infrastructure and upgraded active and sustainable travel routes	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for construction.	Minor negative effects from increased transportation to and from the development once operational (housing and employment sites).		Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	
		Electricity			Mixed effects from increased electricity demand from the development.			
		Buildings/ Heat			Minor negative effects from increased demand for heat from residential and business premises.			Whether any renewable or low carbon heating will be installed.
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials and equipment used for construction. Energy required for development.	Negligible negative effects from energy requirements of operational elements of the development.		Negligible negative effects from energy required for decommissioning.	
		Waste		Negligible negative effects from construction waste.	Minor negative effects from household and business waste.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects from loss of soil and vegetation during construction.	Negligible positive effects from potential for carbon sequestration if green infrastructure is part of the development.		Negligible negative effects from disturbance to soil and vegetation during decommissioning.	Split of development on brownfield or greenfield land.
	New and/or upgraded port facilities for vessel berthing and related landside	**Transport**	Existing vessel emissions Most marine vessels and vehicles are	Negligible negative effects from transportation of machinery and materials required for the construction of	Minor negative effects from the development. It will enable larger vessels to visit Edinburgh. These larger vessels may therefore travel more often to the harbour,		Negligible negative effects from decommissioning related transport of resources and waste for processing.	Unsure of the number of marine vessel journeys which will be made to/from the

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
	activities including for lay-down, and marine sector services.		fuelled by diesel	manufacturing and support services and renewable energy development.	however they will be more efficient. In addition, GHG emissions will arise from port workers commuting to/from work and maintenance activities.			harbour.
		Electricity			Negligible negative effects from electricity requirements for the operational phase of the development.	Minor positive effects from renewable energy generation enabled by the port enhancements.		It is uncertain how much renewable electricity will be generated at this site or supported by it.
		Buildings/ Heat	Heating is dependent on fossil fuels		Negligible negative effects from heating for buildings.			
		Industrial, manufacture and construction processes	Existing facilities/buildings at the harbour. Carbon embodied within existing infrastructure	Minor negative effects from embodied carbon in new infrastructure and materials to be used in the development. Energy required for construction.	Negligible negative effects from energy requirements for the operation of marine sector.		Negligible negative effects from decommissioning of development infrastructure. Energy required for decommissioning.	
		Waste		Negligible negative effects from waste material generated during the construction phases.	Negligible negative effects from operational waste.		Negligible negative effects from waste material generated during the decommissioning phases.	
		LULUCF	Previously developed land	Negligible negative effects from the disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation.	

Table A.18: Edinburgh Waterfront

Edinburgh Waterfront					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of staff, materials and equipment for the construction.	Minor negative effects from increased travel to and from the development once operational (harbour and port, housing and employment site).		Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	Minor negative GHG balance from transport, as it is expected that this development will lead to an increase in overall transport emissions from a high number of residents and marine transport. Medium confidence due to anticipated travel patterns with a high reliance on sustainable and low carbon transport.
Electricity	Negligible negative effects from electricity required for development.	Minor negative effects from an increased electricity demand from the development, partly balanced by support for offshore energy, which is assumed to be renewable.	Minor positive effects from renewable energy generation enabled by the port enhancements.	Negligible negative effects from electricity required for decommissioning.	Minor negative GHG balance from electricity, as it is expected that this development will lead to an increase in the overall electricity demand from a significant number of housing units. Medium confidence , as unknown if development may stipulate certain levels of renewable /low carbon energy generation or heating or the energy demands of the commercial and industrial uses.
Buildings (heat)		Minor negative effects from an increased demand for heat from residential and business premises.			Minor negative GHG balance from buildings (heat) as it is expected that this development will result in an increase in the overall heat demand. Medium confidence , as unknown if development may stipulate certain levels of renewable heat generation.
Industrial, manufacture and construction processes	Minor negative effects from carbon embodied in the materials and equipment used for construction.	Negligible negative effects of energy requirements of employment elements of the development.		Negligible negative effects from energy required for decommissioning.	Minor negative GHG balance from industrial processes. Low confidence due to unknown nature of operational energy demands.
Waste	Negligible negative effects from construction waste.	Minor negative effects from household and business waste.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	Minor negative GHG balance from waste as this development is likely to increase the overall waste production. High confidence due to the assumed number of households.
LULUCF	Negligible negative effects from the loss of soil and vegetation.	Negligible positive effects from the potential for carbon sequestration if green infrastructure is part of the development.		Negligible negative effects from the disturbance to soil and vegetation.	Negligible GHG balance from LULUCF, as this development is likely to result in the loss of soil and vegetation however it has the potential to increase sequestration over the lifetime of the development. Low confidence due to lack of information on existing soil and vegetation carbon stores and extent of new green infrastructure.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects related to the assumed increased **transport**, due to uncertainty over the potential for the greater uptake of sustainable travel. ▪ Medium confidence related to the assumed increase in the overall **electricity** and **heat** demand.				

Edinburgh Waterfront					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	▪ Medium confidence in minor negative emissions from **industrial processes** as it is assumed that this development will require carbon heavy construction materials. ▪ High confidence in minor negative effects related to the assumed increased amount of **waste** produced.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is likely to support the increasing capacity of off-shore renewables. The scale of indirect effects is likely to be minor, however there is low confidence over the scale of indirect positive effects on electricity due to uncertainty over the quantity of renewable energy that will be supported by this development.				
Overall summary of effect	It is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the indirect positive effect from the support for the renewables industry which is judged to outweigh the negative direct effects of the development from the provision of housing, employment and industry leading to increased GHG emissions from transport, electricity and heat demand. The scale of this effect could range from low positive to negligible positive depending on the uptake of sustainable travel, energy efficiency measures, potential blue and green infrastructure, the nature of industries based within the development and their potential emissions, and the scale of support for the renewable sector. There is considerable uncertainty over the scale of renewable energy enabled by this development. If the scale is significant then this development could have low positive effects, whereas if the amount of renewable energy enables is relatively minor it would lead to negligible positive effects. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty over the scale of these effects means there is low confidence in this conclusion.				
Additional mitigation and enhancement	Ensure that active travel routes are provided to the site and across the site. Ensure that good public transport connections are secured and delivered pre-completion of the development. Ensure that high levels of renewable energy and heat are installed. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or at least recycled. Ensure that green infrastructure opportunities are implemented across the development. Ensure that low carbon heating is installed for residential heating and ensure requirement for high energy efficiency buildings.				

Table A.19: High Speed Rail

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
High Speed Rail	high speed rail services to improve rail capacity and connectivity on the main cross-border routes, the east and west coast mainlines including upgrades to track and electrification, new stations and new depot facilities.	**Transport**	Currently, trains within the UK and Scotland do not offer connections that are time or cost competitive to flying.	Negligible negative effects from transportation of staff, materials and equipment for the construction phase of the development.	Significant positive effects from significant potential to reduce emissions from transportation if more people use trains for travel between Scottish cities, other UK areas and to Europe, supporting a modal shift from air to rail.	Minor positive effects from reduction in domestic air travel from Scotland to the UK and Europe.	Negligible negative effects from transportation of staff, materials and equipment for the decommissioning stage of the development.	Number of stations in total that will need to be constructed in Scotland
		Electricity			Negligible negative effects from increased electricity demand to power trains and provide electricity to new stations.			
		Buildings/ Heat			Negligible negative effects from increased demand for heat for new train stations.			
		Industrial, manufacture and construction processes		Minor negative effects from carbon embodied in the materials and equipment used for construction of multi-modal stations, depot facilities and infrastructure , and energy for construction			Negligible negative effects from energy required for decommissioning.	
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from waste from operations.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	
		LULUCF		Minor negative effects from loss of soil and vegetation through a construction of new stations, railway and depot facilities.	Negligible negative effects from maintenance of vegetation along the railway during the operational phase to provide clearance for tracks and power lines.		Negligible negative effects from disturbance to soil and vegetation.	Where will the railway be built?

Table A.20: High Speed Rail

High Speed Rail					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of staff, materials and equipment for the construction phase of the development.	Significant positive effects from the potential to reduce emissions from transportation if more people will use trains for travel between Scottish cities, other UK areas and to Europe.	Minor positive effect from reduction in domestic air travel from Scotland to the UK and Europe.	Negligible negative effects from transportation of staff, materials and equipment for the decommissioning stage of the development.	Major positive GHG balance from transport, medium confidence as this development can divert emissions from private cars and aircraft to trains which can significantly reduce the overall transport emissions, although there is uncertainty over the level of modal shift.
Electricity		Negligible negative effects from an increased electricity demand to power trains and provide electricity to new stations.			Negligible GHG balance from electricity, medium confidence as even though this development will increase the demand for electricity it is assumed that renewable energy will be used.
Buildings (heat)		Negligible negative effects from an increased demand for heat for new train stations.			Minor negative GHG balance from buildings, medium confidence as it should lead to a small increase in heat demand.
Industrial, manufacture and construction processes	Minor negative effects from carbon embodied in the materials and equipment used for construction (steel, concrete, glass, etc.) and energy for construction.			Negligible negative effects from energy required for decommissioning.	Minor negative GHG balance from industrial processes, high confidence as due to the nature of this development significant requirement for carbon heavy materials.
Waste	Negligible negative effects from construction waste.	Negligible negative effects from waste from operations.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	Minor negative GHG balance from waste, medium confidence as overall it should not lead to any significant increase in waste production. Majority of the materials use for rail infrastructure can be fully recycled.
LULUCF	Minor negative effects from the loss of soil and vegetation through a construction of new stations and railway.	Negligible negative effects from the maintenance of vegetation along the railway during the operational phase to provide clearance for tracks and power lines.		Negligible negative effects from the disturbance to soil and vegetation.	Minor negative GHG balance from LULUCF, medium confidence as this development will require land take for infrastructure, although impacts on high carbon soils are unknown.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence for major positive effects in relation to **transport** as this development could divert emissions from private cars and aircraft to trains reducing the overall emissions, although there is uncertainty over the level of this modal shift, it is likely to occur over a long timeframe. ▪ High confidence in minor negative effects in relation to **industrial, manufacture and construction** processes as due to the nature of this development a lot of carbon heavy materials will be required. ▪ Medium confidence in minor negative effects from **buildings** and **waste** as electricity is assumed to be from renewable sources and limited waste will be generated. ▪ Medium confidence in minor negative effects in relation to **LULUCF** as this development will require land take and vegetation maintenance.				
Summary of lifecycle GHG balance	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions.				

High Speed Rail					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
(indirect effects)	This development will provide high speed rail which has the potential to reduce domestic air travel to the UK and Europe and the associated transport GHG emissions. The indirect positive effects are likely influence travel across the UK and occur over the long term. There is low confidence in indirect positive effects as there is uncertainty to how much air travel will be reduced.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to displacement of emissions from private cars and air travel over a long time period The scale of this effect could range from negligible to high positive depending on the level of uptake of train travel. If this development enables a significant amount of modal shift from private car and aeroplane to train, then a high positive effect is expected. Whereas, if this development enables to only a relatively small modal shift, negligible effects are expected. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects means there is low confidence in this conclusion.				
Additional mitigation and enhancement	Ensure that renewable energy is provided for running of the train services. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or at least recycled. Ensure that the development avoids high carbon soils or areas important for carbon sequestration. Ensure limitations on comparable air routes and competitive pricing to support use of rail.				

Table A.21: Hunterston Strategic Asset

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Hunterston Strategic Asset	Electricity generation (of or exceeding 50 megawatts) and related transmission infrastructure of 132kv and above	**Transport**	Emissions from vehicles	Negligible negative effects from transport of materials for the construction phase of the development.	Negligible negative effects from transport emissions relating to the occasional maintenance required during the operation electricity generation and transmission facilities.		Negligible negative effects from decommissioning related transport of resources and waste for processing.	
		Electricity	Need for more green energy		Minor positive effects from increased electricity production, including from renewable energy. This will have lower GHG emissions compared to electricity from current fossil fuels.	Negligible positive effects from infrastructure to support renewable electricity provision will reduce the overall emissions from electricity generation and use		Uncertainty surrounding the scale of renewable energy generation and transmission infrastructure. Uncertainty whether the port supports the renewable energy industry more widely through construction and maintenance.
		Buildings/ Heat						
		Industrial, manufacture and construction processes	Carbon stored in materials for construction	Negligible negative effects from carbon embodied in materials for the construction phase of the development and any associated infrastructure. Energy required for construction.	Negligible negative effects from carbon embodied in the materials used for maintenance.	Negligible negative effects as supports increased renewable energy development and electricity transmission infrastructure which uses carbon intensive materials.	Negligible negative effects from decommissioning of development infrastructure. Energy required for decommissioning.	Uncertainty surrounding the scale and type of renewable energy generation.
		Waste		Negligible negative effects from waste material generated during the construction phases	Negligible negative effects from waste material generated during the operational phases		Negligible negative effects from waste material generated during the decommissioning	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		LULUCF	Carbon stored in soils; reuse of land prevents disturbance of soils elsewhere	Negligible negative effects from the disturbance to soil and vegetation during construction.			Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	
	Low carbon hydrogen production and infrastructure and hydrogen related chemical production (ammonia)	**Transport**		Negligible negative effects from transportation of materials for required infrastructure	Minor negative effects from staff commuting to work and maintenance. Increased transport movement linked to the supply of natural gas and hydrogen.	Minor positive effects as hydrogen provides low carbon fuel for transport. Greater deployment of hydrogen in shipping and heavy transport (HGVs/buses) will reduce or displace GHG emissions from current fossil fuels.	Negligible negative effects from transport of waste materials to disposal or recycling location	Emissions from transport at the operations stage may have a greater impact depending on the scale of the development. If a significant amount of hydrogen is produced, there will be a larger amount of natural gas required (more emissions from production and transport)
		Electricity	Currently, insufficient low carbon electricity to meet the demand (and achieve net-zero)		Minor negative effects from electricity required for carbon capture and storage.			Amount of low carbon hydrogen produced is unknown. Uncertain whether desalinisation is required.
		Buildings/ Heat	Emissions from existing fossil fuel-based power plants and difficult to decarbonise industries.			Negligible positive effects from production of a lower carbon heating source for commercial and industrial uses.		Impact will depend on the scale; how much hydrogen will be produced
		Industrial, manufacture and construction processes	carbon locked in natural gas	Negligible negative effects from carbon embodied in the construction materials. Energy requirements	Minor negative effects from increased use of natural gas in combination with CCUS. Potential for fugitive emissions	Minor positive effects as hydrogen provides low carbon fuel for industrial purposes and will displace GHG emissions	Negligible negative effects from energy requirements of decommissioning.	Uncertain how much hydrogen will be produced.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				during construction of hydrogen production facilities, and CCUS/ SMR facilities.	from hydrogen, ammonia, natural gas and CCUS. Leakage of hydrogen, ammonia, or fossil fuels during transportation.	from fossil fuels without carbon capture. Provision of lower carbon fuel for carbon intensive industries.		
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from disposal waste materials from production plant that cannot be reused or recycled	
		LULUCF		Negligible negative effects from the disturbance to soil and vegetation from construction.		Negligible positive effects from reusing brownfield land and avoiding development on greenfield land.	Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	
	Renewable hydrogen generation and infrastructure	**Transport**		Negligible negative effects from transportation of materials and equipment for the delivery of the development.	Negligible negative effects from transportation of hydrogen, and staff commuting to work and for maintenance purposes.	Minor positive effects from hydrogen as it provides low carbon fuel for transport.	Negligible negative effects from transportation waste materials and equipment after decommissioning.	
		Electricity				Minor positive effects from renewable hydrogen as it facilitates use of surplus renewable electricity to generate renewable hydrogen.		It is uncertain how much renewable hydrogen will be produced.
		Buildings/ Heat				Negligible positive effects from production of low carbon heating source		Impact will depend on the scale; how much renewable hydrogen will be produced

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen production facilities.	Negligible negative effects from potential for hydrogen leakage. Fugitive emissions from transport of hydrogen.	Minor positive effects as hydrogen provides low carbon fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the activities.
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF	Carbon stored in soils; reuse of land prevents disturbance of soils elsewhere	Negligible negative effects from loss of and disturbance of soil and vegetation.		Negligible positive effects from reusing brownfield land and avoiding development on greenfield land.	Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	Infrastructure to support a multi-modal deep water harbour including buildings for industrial, commercial, research and training, facilities for marine energy generation fabrication, decommissioning, and servicing.	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the construction phase of the development.	Minor negative effects from increased transportation due to an improved harbour infrastructure		Negligible negative effects from transportation of staff, materials and equipment for decommissioning.	
		Electricity			Negligible negative effects from electricity demand for the port's operations			
		Buildings/ Heat			Negligible negative effects from heat required for the operations of the development.			

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Industrial, manufacture and construction processes		Minor negative effects from carbon embodied in the materials used for construction of harbour upgrades and infrastructure.	Negligible negative effects from potential emissions from port operations.		Negligible negative effects from energy required for decommissioning.	Depending on the nature and scale of operations carried out at the port.
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from operational waste.		Negligible negative effects from waste from materials which cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects from loss of soil and vegetation on brownfield site.			Negligible negative effects from the disturbance to soil and vegetation during the decommissioning.	
	transport network, including active travel links	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the construction phase of the development.	Mixed effects from increased transportation due to a new road network and active travel paths.		Negligible negative effects from transportation of staff, materials and equipment for decommissioning.	Depending on the scale of uptake of active travel transport mode.
		Electricity			Negligible negative effects from electricity demand for lighting for the roads and active travel paths and other infrastructure electricity demand.			
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials used for construction of			Negligible negative effects from energy required for decommissioning.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				this infrastructure. Energy required for construction.				
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials which cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects from disturbance to soil and vegetation.	Negligible positive effects from potential for regeneration of soil and vegetation along the roads.		Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	broader range of commercial activity	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the construction phase of the development.	Negligible negative effects from increased transport movement to and from facilities as employment sites		Negligible negative effects from transportation of staff, materials and equipment for decommissioning.	
		Electricity			Negligible negative effects from electricity demand for the commercial operations.			Uncertainty about the source of electricity for this development.
		Buildings/ Heat			Negligible negative effects from heat demand for operations.			
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials used for construction of this infrastructure. Energy required for construction.	Negligible negative effects from potential emissions from industrial operations including potentially contaminated land remediation works.		Negligible negative effects from energy required for decommissioning.	Uncertainty of the nature of businesses and their scale.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from operational waste.		Negligible negative effects from waste from materials which cannot be recycled after decommissioning.	Uncertainty of the scale of waste produced by the commercial activity.
		LULUCF		Negligible negative effects from loss of soil and vegetation on brownfield site.			Negligible negative effects from the disturbance to soil and vegetation.	
	Sustainable flood risk management solutions	**Transport**		Negligible negative effects from transport emissions from construction activities related to the development of flood management solutions	Negligible negative effects from transport activities relating to ongoing maintenance of flood management solutions		Negligible negative effects from transport of materials and waste after decommissioning	
		Electricity						
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon within construction materials, and energy use required during construction of hard and soft flood defences.		Negligible positive effects from flood risk management avoids the GHG emissions associated with clean up and replacement property from flood events.	Negligible negative effects from energy requirements of decommissioning of flood defences.	
		Waste		Negligible negative effects from waste material generated during the construction phases			Negligible negative effects from waste material generated during the construction phases	
		LULUCF		Mixed negligible effects from loss	Minor positive effects from enhanced			Scale is uncertain.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				of carbon in soils on land from construction of flood defences Creation and/or enhancement of existing green space to be used as natural flood defences (e.g., maximising flood plains, enhancing riverbanks, SuDS and landscaping)	carbon sequestration through sustainable flood management with biodiversity enhancement.			

Table A.22: Hunterston Strategic Asset

Hunterston Strategic Asset					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transport of materials for the construction of the elements of the development.	Minor negative effects from staff commuting to work and maintenance. Increased transport movement linked to the supply of natural gas and hydrogen, and upgrades to infrastructure of multi-modal deep water harbour that will enable more activity. Leakage of hydrogen or fossil fuels during transportation.	Minor positive effects from renewable and low carbon hydrogen as it provides low carbon fuel for transport. Greater deployment of hydrogen in shipping and heavy transport (HGVs/buses) will displace GHG emissions from current fossil fuels.	Negligible negative effects from decommissioning related transport of resources and waste for processing.	Minor negative GHG balance from transport as this development is likely to increase the overall transport emissions from the site due to increased journeys and the transport of natural gas and hydrogen will result in GHG emissions. Medium confidence as the level of additional journeys is uncertain, and the extent of low carbon and renewable hydrogen production is unknown.

Hunterston Strategic Asset					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Electricity		Minor positive effects from an increased electricity production from renewable energy. This will have lower GHG emissions compared to electricity from fossil fuels, partly balanced by increased energy demand from some processes.	Minor positive effects from increased use of surplus renewable energy which will displace emissions from current fossil fuels and increase efficiency of renewable energy produced.		Minor positive GHG balance from electricity, as the development supports increased electricity production from renewable sources. Low confidence as it is uncertain how much renewable electricity will be produced. It is uncertain whether there will be demand for desalinisation for hydrogen production and whether this will be powered by electricity, and if so, whether the electricity would be renewable.
Buildings (heat)		Negligible negative effect from heat demand for commercial operations.	Minor positive effects from the production of hydrogen as a lower carbon heating source.		Minor negative GHG balance from buildings (heat). High confidence as it is assumed limited heat requirement from the development.
Industrial, manufacture and construction processes	Negligible negative effects from carbon embodied in materials for the construction of renewable energy schemes and any associated infrastructure, hydrogen production facilities and upgrades to oil and gas infrastructure to facilitate low carbon hydrogen production and CCS. Energy required for construction and land remediation.	Minor negative effects from the use of natural gas in combination with CCUS for hydrogen production. Potential for fugitive emissions of hydrogen, ammonia, natural gas and carbon dioxide from CCUS. Increased demand for natural gas for the operations process.	Minor positive effects from hydrogen as it provides low carbon fuel for industrial purposes and will displace GHG emissions from current fossil fuels. Provision of lower carbon fuel for carbon intensive industries.	Negligible negative effects from decommissioning of development infrastructure. Energy required for decommissioning.	Minor negative GHG balance from industrial processes as this development will continue reliance on fossil fuels such as natural gas. Low confidence as it is uncertain how much low carbon and renewable hydrogen will be produced.
Waste	Negligible negative effects from waste material generated during the construction phases of renewable energy schemes	Negligible negative effects from the operational waste.		Negligible negative effects from waste material generated during the decommissioning phases of renewable energy schemes	Minor negative GHG balance from waste, medium confidence as it is assumed the development will increase overall waste production but at a limited scale.
LULUCF	Negligible negative effects from disturbance to soil and vegetation during the construction.	Minor positive effects from enhanced carbon sequestration through sustainable flood management.		Negligible negative effects from the disturbance to soil and vegetation during decommissioning. .	Minor positive GHG balance from LULUCF as this development will enable greater carbon sequestration also sustainable flood management. Low confidence as the scale of this element of the development is uncertain.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects arising from **transport** as it is assumed that there will be an increase in transport movements and vehicles will be				

Hunterston Strategic Asset					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	fossil fuel powered. ▪ High confidence in minor positive effects in relation to **electricity** as it is assumed that more electricity will be produced than consumed by other processes at the site, although there is uncertainty over the scale of production of renewable energy in excess of 50 megawatts. ▪ High confidence in minor negative effects from **heat** due to assumed increase in heat demand. ▪ Low confidence in minor negative effects in relation to **industrial processes** as it is uncertain how much low carbon and renewable hydrogen respectively will be produced and uncertainty generally regarding the deployment of new and emerging technologies. ▪ Low confidence in minor positive effects from **LULUCF** as the development will enable carbon sequestration through sustainable flood management as it is assumed it will include green infrastructure, although the scale is uncertain.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development is likely to support renewable energy and renewable and low carbon hydrogen production which is likely to enable displacement of GHG emissions from fossil fuel-based energy sources with and without carbon capture for electricity, transport and heat. There is low confidence in the scale of indirect positive effect as the scale of effect depends on the scale of renewable energy and hydrogen production.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to support for renewable and low carbon hydrogen production, and electricity generation I from renewable energy, increasing the renewable energy supply and security of supply over a long time period. The scale of these effects could range from low to high positive depending on the scale of electricity generation and storage, and the scale of use of fossil fuels. This development can deliver high positive effects if it will generate and store a significant amount of renewable and lower carbon energy displacing emissions from current fossil fuels. However, if this development delivers only a small amount of renewable or lower carbon energy then low positive effects are expected. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the scale of these effects means there is medium confidence in this conclusion.				
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled. Ensure that heat is renewable or low carbon.				

Table A.23: Industrial Green Transition Zone

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Hydrogen production	Low carbon hydrogen production	**Transport**		Negligible negative effects from transportation of materials for required infrastructure	Negligible negative effects from staff commuting to work and maintenance. Increased transport movement linked to the supply of natural gas and hydrogen.	Minor positive effects from hydrogen provides low carbon fuel for transport. Greater deployment of hydrogen in shipping and heavy transport (HGVs/buses) will displace GHG emissions from current fossil fuels.	Negligible negative effects from transport of waste materials to disposal or recycling location	
		Electricity	Currently, insufficient low carbon electricity to meet the demand (and achieve net-zero)		Minor negative effects from electricity required for carbon capture and storage.			
		Buildings/ Heat	Emissions from existing fossil fuel-based power plants and difficult to decarbonise industries.			Minor positive effects from production of lower carbon heating source.		Impact will depend on the scale; how much hydrogen will be produced
		Industrial, manufacture and construction processes	Carbon locked in natural gas	Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen production facilities, and CCUS/ SMR facilities.	Minor negative effects from use of natural gas in combination with CCUS. Potential for fugitive emissions from hydrogen, and natural gas . Increased demand for natural gas for the hydrogen production process.	Minor positive effects from hydrogen provides low carbon fuel for industrial purposes and will displace GHG emissions from current fossil fuels. Provision of lower carbon fuel for carbon intensive industries.	Negligible negative effects from transport of waste materials to disposal or recycling location	Amount of low carbon hydrogen produced is unknown. Uncertain whether desalinisation is required if insufficient freshwater availability. Uncertain if desalinisation is powered by electricity or fossil

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
								fuel. If a significant amount of hydrogen is produced there will be a larger amount of natural gas required (greater fugitive emissions)
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from disposal waste materials from production plant that cannot be reused or recycled	
		LULUCF		Negligible negative effects from loss of soil and vegetation on brownfield and greenfield sites.			Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	
	Renewable hydrogen production	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development.	Negligible negative effects from energy requirements for transportation of hydrogen and staff commuting to and from work or for maintenance purposes.	Minor positive effects as hydrogen provides a low carbon fuel for transport.	Negligible negative effects from transportation of staff, waste materials and equipment during decommissioning.	
		Electricity			Negligible positive effects from use of surplus renewable electricity to generate renewable hydrogen.	Minor positive effects as renewable hydrogen will facilitate greater efficiency of renewable electricity via renewable energy storage		It is uncertain how much renewable hydrogen will be produced.
		Buildings/ Heat				Negligible positive effects from production of lower carbon heating source		Impact will depend on the scale; how much renewable hydrogen will be produced

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen production and storage facilities.	Negligible negative effects from potential for hydrogen leakage. Potential for fugitive emissions from transport of hydrogen.	Minor positive effects from use of renewable hydrogen fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the activities.
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative effects from loss of and disturbance of soil and vegetation on brownfield and greenfield site			Negligible negative effects from disturbance to soils and vegetation during decommissioning.	
Hydrogen processing for storage	Pumping and compression equipment, and storage areas	**Transport**		Negligible negative effects from transport of staff, materials and equipment for construction.	Negligible negative effects from maintenance travel.		Negligible negative effects from transport of staff, materials and equipment for decommissioning.	
		Electricity			Negligible negative effects from electricity required for the compressor to operate.			
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in pumping and compression equipment. Energy requirements for the construction of storage facilities.	Negligible negative effects from potential for leakage of hydrogen and ammonia during the storage phase.			
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from disposal of waste materials that cannot be reused or recycled	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		LULUCF		Negligible negative effects from loss of soil and vegetation on brownfield and greenfield sites.			Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	
Carbon Capture Utilisation and Storage (CCUS)	CCUS (including upgrades to/ new pipelines for transport of carbon; structures for carbon capture, storage plant and facilities)	**Transport**		Negligible negative effects from transportation of staff, materials and machinery required for construction	Negligible negative effects from energy requirements for transportation of oil and gas and captured carbon. Maintenance travel and travel associated with workers commuting to/from the development.	Minor positive effects from development of CCUS infrastructure supports the production of low carbon hydrogen which can be used as a lower carbon fuel for transport, displacing fossil fuels without carbon capture.	Negligible negative effects from transportation of staff, materials and machinery after decommissioning	
		Electricity			Minor negative effects from electricity required for CCUS operations, such as pumping and compression			
		Buildings/Heat				Negligible positive effects from development of CCUS infrastructure supports the production of low carbon hydrogen which can be used as a lower carbon heating source, displacing fossil fuels without carbon capture.		

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Industrial, manufacture and construction processes		Negligible negative effects from energy required for the construction of infrastructure to enable CCUS.	Minor negative effects from use of oil and gas only in combination with CCUS. Potential for fugitive emissions from oil and gas, and CCUS (from production, distribution and storage).	Minor positive effects from development of CCUS infrastructure supports the production of low carbon hydrogen which can be used as a low carbon fuel for industrial purposes.	Negligible negative effects from energy required for the decommissioning of the development.	Will depend on the scale of the activities. Low carbon hydrogen production dependent on oil and gas production. Timescales of CCUS untested.
		Waste		Mixed negligible effects from waste from construction and reuse of existing oil and gas infrastructure (such as pipelines)			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative effects from loss of soil and vegetation on brownfield and greenfield sites.			Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	Uncertain if site is brownfield or greenfield.
	Bioenergy	**Transport**		Negligible negative effects from transport of staff, materials and equipment for construction.	Minor negative effects from transportation of materials for production of bioenergy.		Negligible negative effects from transport of staff, materials and equipment for decommissioning.	Uncertain if the bioenergy is used for electricity or heat or only carbon capture.
		Electricity			Minor positive effects from the lower carbon energy produced.			
		Buildings/Heat			Minor positive effects from lower carbon heat produced.			
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon bioenergy facility.	Negligible negative effects from the potential of carbon leakage during the bioenergy			

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
					production process.			
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from disposal of waste materials that cannot be reused or recycled	
		LULUCF		Negligible negative effects from the construction of biofuel facility.	Negligible negative effects from harvesting biofuels.		Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	Net negative emissions technologies with CCUS	**Transport**		Negligible negative effects from transport related to construction activities.	Minor negative effects related with transportation of biomass for burning over the lifetime of the development.		Negligible negative effects from decommissioning.	
		Electricity			Minor positive effects from the lower carbon energy produced and carbon captured.			
		Buildings/Heat			Minor positive effects from lower carbon heat produced.			
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon bioenergy facility and/or facilities for direct air carbon capture.	Negligible negative effects from the potential of carbon leakage during the bioenergy production process.			
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from disposal of waste materials that cannot be reused or recycled	
		LULUCF		Negligible negative effects from the disturbance to soil and vegetation during construction.	Minor negative effects from land use disturbance from harvesting biofuels.		Negligible negative effects from the disturbance to soil and vegetation decommissioning.	
		Negative Emissions Technologies			Minor positive effects from net carbon removal			

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
	CCS on existing or replacement thermal power plant	**Transport**		Negligible negative effects from transportation of materials for required infrastructure	Negligible negative effects from staff commuting to work and maintenance. Increased transport movement linked to the supply of natural gas.		Negligible negative effects from transport of waste materials to disposal or recycling location	Emissions from transport at the operations stage may have a greater impact depending on the scale of the development.
		Electricity	Currently, insufficient low carbon electricity to meet the demand (and achieve net-zero)		Minor positive effects from producing a lower carbon energy source.			
		Buildings/ Heat	Emissions from existing fossil fuel-based power plants and difficult to decarbonise industries.			Negligible positive effects from production of a lower carbon heating source for commercial and industrial uses.		
		Industrial, manufacture and construction processes	Carbon locked in natural gas	Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen production facilities, and CCUS/ SMR facilities.	Minor negative effects from increased use of natural gas in combination with CCUS. Potential for fugitive emissions from natural gas and CCUS. Leakage of fossil fuels during transportation.	Minor positive effects from provision of lower carbon fuel for carbon intensive industries.	Negligible negative effects from energy requirements of decommissioning.	
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from disposal waste materials from production plant that cannot be reused or recycled	
		LULUCF		Negligible negative			Negligible negative effects from the	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				effects from disturbance to soil and vegetation.			disturbance to soil and vegetation during decommissioning.	
Grangemouth	Delivery of flood protection scheme to support continued and enhanced port operations and new or upgraded blue and green infrastructure	**Transport**		Negligible negative effects from transport emissions from construction activities related to the development of flood defences	Negligible negative effects from transport activities relating to ongoing maintenance	Negligible positive effects from the additional provision of green infrastructure and active travel.	Negligible negative effects from transport of materials and waste after decommissioning	Uncertain scale/connectivity of footpath network and to what extent this could facilitate active travel.
		Electricity						
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Minor negative effects from embodied carbon within construction materials, and energy use required during construction of hard and soft flood defences.		Minor positive effects from flood risk management avoids the GHG emissions associated with clean up and replacement property from flood events.	Negligible negative effects from energy requirements of decommissioning of flood defences.	
		Waste		Negligible negative effects from waste material generated during the construction phases		Minor positive effects from avoidance of waste generated during flood events	Negligible negative effects from waste material generated during the construction phases	
		LULUCF		Mixed negligible effects from loss of carbon in soils on land from construction of flood defences Creation and/or enhancement of existing green space to be used as natural flood defences (e.g., maximising flood plains, enhancing	Negligible positive effects from ongoing enhancements to natural flood defences such as SuDS and landscaping techniques will increase rates of carbon sequestration.			

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				riverbanks, SuDS and landscaping)				
	Town centre regeneration,	**Transport**		Negligible negative effects from transport emissions from construction activities related to the regeneration of Grangemouth	Negligible negative effects from increased journeys to and from Grangemouth	Mixed negligible effects from transport via private vehicle and sustainable modes linked with residents' commute to work and education, or staff travel. Transport related to the running of businesses within the town centre (deliveries etc.)	Negligible negative effects from transport of materials after decommissioning	Uncertain as to type and extent of regeneration and how many additional journeys this may generate.
		Electricity			Negligible negative effects from electricity requirements for residents and businesses within the town.			
		Buildings/ Heat			Negligible negative effects from heat requirements for residents and businesses within Grangemouth			Uncertain as to scale of district heating networks in Grangemouth
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in building materials. Energy requirements of construction.	Negligible negative effects from emissions from businesses operating within the town centre.		Negligible negative effects from decommissioning of buildings in the town centre.	Uncertain on the scale/type of restoration proposed and the energy use associated with it
		Waste		Negligible negative effects from waste produced during the development of new buildings/ redevelopment of existing buildings	Negligible negative effects from waste produced by residents and commercial/retail industries within the town centre		Negligible negative effects from waste materials after decommissioning	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		LULUCF		Negligible negative effects from reuse of vacant and derelict land/ buildings - potential for a minor carbon loss on land areas where there is green open space.	Negligible positive effects from developing and enhancing green space - greater rates of carbon sequestration		Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	
	Industrial and port development including new or upgraded utilities and or local energy network, new and or upgraded facilities at the port for inter-modal freight handling facilities at Grangemouth.	**Transport**		Negligible negative effects from transport emissions from construction activities related to the regeneration of Grangemouth port	Negligible negative effects from increased journeys to and from Grangemouth port	Mixed negligible effects from transport via private vehicle and sustainable modes linked with commute to work	Negligible negative effects from transport of materials after decommissioning	Uncertain number of additional journeys this development may generate.
		Electricity			Negligible negative effects from electricity requirements from port operations			
		Buildings/ Heat			Mixed effects from negligible negative effects from heat requirements of port operations, and negligible positive effects from local energy networks.			Uncertain as to scale of district heating networks in Grangemouth
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in building materials. Energy requirements of construction.	Negligible negative effects from emissions from port development.		Negligible negative effects from decommissioning of buildings	
		Waste		Negligible negative effects from waste produced during the development of new buildings/	Negligible negative effects from waste produced by port activities		Negligible negative effects from waste materials after decommissioning	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				redevelopment of existing buildings				
		LULUCF		Negligible negative effects from reuse of vacant and derelict land/ buildings - potential for a minor carbon loss on land areas where there is green open space.	Negligible positive effects from landscaping and green infrastructure that will enable carbon sequestration.		Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	
	New and/or upgraded buildings for industrial, manufacturing, business, and educational or research uses related to the industrial transition and renewable energy innovation	**Transport**		Negligible negative effects from transportation of machinery and materials required for the development.	Negligible negative effects from transport relating to the operation of businesses based at the development, including workers commuting to/from the site, partly mitigated by provision of sustainable and active travel opportunities.			
		Electricity			Negligible negative effects from electricity requirements for businesses based at the development	Negligible positive effects from indirect support for renewable energy innovation		
		Buildings/ Heat			Negligible negative effects from heat requirements for businesses based at the development			
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in construction materials used to build the development	Negligible negative effects from energy requirements of businesses based at the development.		Negligible negative effects from decommissioning of development	
		Waste		Negligible negative	Negligible negative		Negligible negative effects from	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				effects from waste produced during construction	effects from waste produced by businesses based at the development.		decommissioning of development	
		LULUCF		Negligible negative because of the potential disturbance to soil and vegetation during construction.	Negligible positive effects from landscaping elements of the development may provide some opportunities for carbon sequestration.		Negligible negative effects from disturbance to soil and vegetation during decommissioning.	

Table A.24: Industrial Green Transition Zone

Industrial Green Transition Zone					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of materials for required infrastructure	Minor negative effects from staff commuting to work and maintenance, increased transport movement linked business operations and to the supply of natural gas and hydrogen, transportation of hydrogen and biomass throughout the lifetime of the development.	Minor positive effects from hydrogen as it provides low carbon fuel for transport. Greater deployment of hydrogen in shipping and heavy transport (HGVs/buses) will displace GHG emissions from current fossil fuels. Development of CCUS infrastructure supports the production of low carbon hydrogen which can be used as a low carbon fuel for transport.	Negligible negative effects from transport of waste materials to disposal or recycling location	Moderate negative GHG balance from transport as this development is likely to lead to significant increase in port traffic, transportation of staff, hydrogen and captured carbon, which increase energy use and potential for leakage during transport. Low confidence as it is unclear what scale of low carbon hydrogen production is anticipated, which affects the scale of overall losses during transport and increase in GHG emissions overall.

Industrial Green Transition Zone					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Electricity	Negligible negative effects from electricity required for the construction of this development	Negligible positive effects from low carbon and renewable electricity generation balanced by increased energy requirements for some processes such as hydrogen compression and carbon storage.	Minor positive effects from indirect support for renewable energy innovation and facilitation of renewable energy storage from hydrogen production.	Negligible negative effects from electricity required for decommissioning	Minor positive GHG balance from electricity, as this development supports low carbon energy generation, but may increase electricity demand for hydrogen storage and carbon capture. Low confidence due to the efficiency of carbon capture, scale of hydrogen production, quantity of carbon captured and source of power for these processes.
Buildings (heat)		Minor positive effects from lower carbon heat produced from biomass, heat networks and hydrogen.	Minor positive effects from the displaced emissions from current fossil fuels used for heat generation partly balanced by heat demand from businesses.		Minor positive balance from buildings (heat). Medium confidence as the scale of heat networks in Grangemouth or use of hydrogen for heat is uncertain.
Industrial, manufacture and construction processes	Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen production facilities, bioenergy and CCUS facilities, flood protection scheme, town centre regeneration and port development.	Minor negative effects from the use of natural gas for low carbon hydrogen production, and the potential for fugitive emissions from hydrogen, natural gas, ammonia, and CCUS, including from production, storage and distribution. Emissions from business and port operations. Partly balanced by renewable hydrogen production.	Minor positive effects as hydrogen provides renewable or low carbon fuel for industrial purposes and will displace GHG emissions from current fossil fuels. Provision of lower carbon fuel for carbon intensive industries. Development of CCUS infrastructure supports the production of low carbon hydrogen which can be used as a low carbon fuel for industrial purposes. Some leakage of hydrogen may occur during the hydrogen production process. Flood risk management avoids the GHG emissions associated with the clean up and replacement of property from flood events. Partly balanced by increased energy requirements of businesses.	Negligible negative effects from energy required for decommissioning	Minor negative GHG balance from industrial processes due to high levels of embodied carbon in construction projects and ongoing fugitive emissions from hydrogen, natural gas, and carbon capture. Low confidence as the scale of fugitive emissions is uncertain, long-term reliability of carbon capture is untested, and scale of development is uncertain.
Waste	Negligible negative effects from construction waste balanced by the potential for reuse some of existing oil	Negligible negative effects from waste produced by businesses based at the development.		Negligible negative effects from the disposal waste materials from production plant that cannot be	Minor negative GHG balance from waste, high confidence due to assumed low levels of waste generated.

Industrial Green Transition Zone					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	and gas infrastructure (such as pipelines).			reused or recycled.	
LULUCF	Negligible negative effects from the loss of soil and vegetation on brownfield and greenfield sites.	Minor negative effects from land use disturbance from biomass harvesting throughout the lifetime of the development.		Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	Minor negative GHG balance from the LULUCF, high confidence due to the reliance on biomass for biofuels production.
Negative Emissions Technologies		Minor positive effects from net carbon removal			Minor positive GHG balance from Negative Emissions Technologies. Low confidence as scale of NETs is uncertain and use of bioenergy with carbon capture or direct air capture is unknown.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Low confidence in moderate negative effects from **transport** due to the uncertainty on how majority of hydrogen and captured carbon will be transported for storage and distribution domestically and for export and the potential for leakage. ▪ Low confidence in minor positive effects for **electricity**, as this development supports low carbon energy generation but may increase electricity demand for some processes. ▪ Medium confidence in minor positive effects for **heat**, as this development supports heat networks but the scale is unknown, and also supports hydrogen production which can be used for heat. ▪ Low confidence in minor negative effects from **industrial processes**, due to high levels of embodied carbon and as the long-term reliability of carbon capture is untested. ▪ High confidence in minor negative GHG balance from **waste** due to assumed low levels of waste generated. ▪ High confidence in minor negative GHG balance from **LULUCF**, from land use disturbance from biomass harvesting releasing soil carbon. ▪ Low confidence in minor positive GHG balance from **NETs** due to uncertain scale of development.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. This development is likely to enable renewable and low carbon hydrogen production as a lower carbon fuel for transport, heating and industry compared to use of fossil fuels without carbon capture and storage. Moreover, it is likely to displace the emissions from current energy sources and it is likely to enable carbon capture. The development also indirectly supports renewable energy innovation, enabling further improvements in carbon reductions. The development is likely to result in a minor negative GHG balance from LULUCF, from land use disturbance from biomass harvesting releasing soil carbon . There is a low confidence in the scale of indirect positive effects due to uncertainty over the scale of bioenergy production, renewable and low carbon hydrogen production and extent to which the hydrogen will displace higher carbon energy sources in transport, industry and heating.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to support for the transition to hydrogen from direct fossil fuel dependency using low carbon hydrogen production with carbon capture, utilisation and storage, and from renewable hydrogen production. The scale of positive effect could range from low to very high. A low scale of effect would result from higher levels of increased transport emissions, lower levels of low carbon electricity generation, higher levels of fugitive emissions, smaller scale heat networks, and smaller scale NETs development. Conversely, if a greater amount of low carbon energy and hydrogen is produced, there are lower levels of fugitive emissions, more widespread heat networks and larger scale NETs development and wider deployment and use of hydrogen, this could result in a very high positive effect. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets.				

Industrial Green Transition Zone					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	Uncertainty over the scale of these effects means there is low confidence in this conclusion.				
Additional mitigation and enhancement	Prioritise use of existing infrastructure on and offshore which can be refurbished, ensure that technologies for minimising leakage are in place. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled.				

Table A.25: Energy Innovation Development on the Islands

Development	**Sub-category**	**Source of emissions**	**Baseline**	**Stage of development**				**Uncertainty**
				Construction	**Operations (direct)**	**Operations (indirect)**	**Decommissioning**	
Energy Innovation Development on the Islands	Infrastructure to support renewable energy generation, including landside operations to support marine energy, and electricity transmission cables and converter stations.	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development.	Negligible negative effects from maintenance transportation and staff commute.		Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	
		Electricity			Minor positive effects from renewable electricity generation will reduce the overall emissions from electricity generation and use.	Significant positive effects from infrastructure to support renewable electricity provision will reduce the overall emissions from electricity generation and use.		Uncertain scale of the renewable energy projects
		Buildings/ Heat				Minor positive effects as supports increased use of renewable energy for heating and cooking		

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials required for the construction phase. Energy required for construction.	Negligible negative effects from carbon embodied in the materials required for maintenance.	Minor negative effects as supports increased renewable energy development and electricity transmission infrastructure which uses carbon intensive materials.	Negligible negative effects from energy required for decommissioning	
		Waste		Construction waste.	Operational waste.		Waste from materials that cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects from loss of soil and vegetation during construction of renewable energy schemes and electricity transmission infrastructure; impact on seabed from towers' foundations, loss of marine carbon.		Negligible positive effects from potential for ecosystems regeneration and carbon sequestration on and offshore once renewable energy generation is operating	Negligible negative effects from disturbance to marine sediments and soil during decommissioning.	
	Renewable hydrogen production, storage and transportation	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development.	Negligible negative effects from energy requirements for transportation of hydrogen and staff commuting to and from work or for maintenance purposes.	Minor positive effects as hydrogen provides a low carbon fuel for transport.	Negligible negative effects from transportation of staff, waste materials and equipment during decommissioning.	Low carbon fuel may include fossil fuel based or renewable energy-based production methods.
		Electricity			Negligible positive effects from use of surplus renewable electricity to generate renewable hydrogen.	Minor positive effects as low carbon hydrogen will facilitate greater efficiency of renewable electricity via renewable energy storage		It is uncertain how much renewable hydrogen will be produced.
		Buildings/ Heat				Negligible positive effects from production of lower carbon heating source		Impact will depend on the scale; how much renewable hydrogen will be produced
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements	Negligible negative effects from potential for hydrogen leakage. Potential for fugitive emissions from transport	Minor positive effects from use of renewable hydrogen fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the activities.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				during construction of hydrogen production and storage facilities.	of hydrogen.			
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative effects from loss of and disturbance of soil and vegetation on brownfield and greenfield site			Negligible negative effects from disturbance to soils and vegetation during decommissioning.	
	Infrastructure to support shipping including freight at various locations	**Transport**	Existing emissions from marine vessels primarily from diesel	Negligible negative effects from transportation of staff, materials and equipment for construction of shipping and freight handling infrastructure.	Negligible negative effects from emissions arising from vessels travelling to the area		Negligible negative effects from decommissioning related transport of resources and waste for processing/ recycling.	Uncertain as to the breakdown of refuelling by fuel type. Uncertain scale of impact on marine vessel emissions overall.
		Electricity						
		Buildings/ Heat						
		Industrial, manufacture and construction processes	Carbon embodied within construction materials.	Minor negative effects from carbon embodied in materials for the development and infrastructure.	Negligible negative effects from energy requirements of shipping and freight handling activities and leakage/fugitive emissions. Carbon embodied in fuel and carbon losses during production process.		Negligible negative effects from decommissioning of development infrastructure	Uncertain as to the breakdown of refuelling by fuel type. Uncertain levels of leakage/fugitive emissions during refuelling
		Waste		Negligible negative effects from waste from construction of refuelling infrastructure	Negligible negative effects from waste material generated during shipping and freight handling operations		Negligible negative effects from waste material generated during the decommissioning phases	Uncertain how much waste will be produced.
		LULUCF	Land has previously been	Negligible negative effects from parts of the development will			Negligible negative effects from disturbance to soils and	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
			developed.	include reuse of land that has been previously developed and it will also include development of greenfield land.			vegetation during decommissioning.	
	Associated opportunities in the supply chain for fabrication, research and development	**Transport**		Negligible negative effects from transportation of machinery and materials required for the construction of the fabrication, research and development premises.	Negligible negative effects from transport related to the distribution (supply chain), work commuting.	Negligible positive effects from ensuring that the supply chain is sourced locally, and therefore will reduce emissions relating to the transportation of materials.	Negligible negative effects from decommissioning related transport of resources and waste for processing/ recycling.	
		Electricity			Negligible negative effects from electricity required for the operations.	Minor positive effects from supporting renewable energy development. More R&D within the field may lead to significant improvements and innovation in renewable energy generation.		
		Buildings/ Heat			Negligible negative effects from heat required for the buildings.			
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials required for the construction phase. Energy required for construction.	Negligible negative effects from energy requirements during fabrication/assembly and the operation of warehouse activities.		Negligible negative effects from decommissioning of development infrastructure.	
		Waste		Negligible negative effects from waste from construction of development.	Negligible negative effects from waste materials generated from the supply chain.		Negligible negative effects from waste materials generated during the decommissioning phase.	
		LULUCF		Negligible negative effects from loss of soil and vegetation to development.			Negligible negative effects from disturbance to soils and vegetation during	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
							decommissioning.	
	Oil terminal modifications to support move towards net zero, and improved oil storage infrastructure for Stornoway with appropriate emissions abatement	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for construction and upgrades to oil storage infrastructure.	Negligible negative effects from maintenance transportation and staff commute.	Mixed negative and positive effects as development will continue to provide fossil fuel for use in transport, however in the shift to net zero, low carbon fuels such as hydrogen provides a low carbon fuel for transport.	Negligible negative effects from decommissioning related transport of resources and waste for processing/ recycling.	
		Electricity						
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials required for constructing and upgrading existing infrastructure. Energy required for construction/upgrade works.	Negligible positive effects as improvements to oil storage infrastructure will prevent the leakage of oil and fugitive emissions. Upgrades to the oil terminal infrastructure will can be used to store lower carbon fuels. Emissions reduction facility will reduce greenhouse gas emissions.	Negligible positive effects as upgrades to the oil terminal infrastructure, to facilitate a move towards net zero, will promote the storage and use of low carbon fuels such as hydrogen.	Negligible negative effects from energy required for decommissioning	Uncertainty surrounding how the upgrades will facilitate a shift towards net zero.
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative effects from the disturbance to soil and vegetation.		Negligible positive from the reuse of a brownfield site and avoiding using greenfield site which development could lead to more significant emissions.	Negligible negative effects from disturbance to soils and vegetation during decommissioning.	
	Low carbon hydrogen	**Transport**		Negligible negative effects from	Negligible negative effects from energy	Minor positive effects from hydrogen which provides	Negligible negative effects from	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
	production			transportation of staff, materials and equipment for the delivery of the development.	requirements for transportation of oil and gas, hydrogen and captured carbon.	low carbon fuel for transport.	transportation of staff, materials and equipment after decommissioning.	
		Electricity			Minor negative effects from electricity required for carbon capture and storage.			It is uncertain how much low carbon hydrogen will be produced.
		Buildings/ Heat				Negligible positive effects from production of lower carbon heating source		Impact will depend on the scale; how much hydrogen will be produced
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of hydrogen and ammonia production and storage facilities.	Minor negative effects from energy required for hydrogen production; energy required for carbon capture, storage and utilisation. Use of oil and gas only in combination with CCUS. Potential for fugitive emissions from hydrogen, ammonia, oil and gas and CCUS (from production, distribution and storage).	Minor positive effects from hydrogen which provides a low carbon fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the activities. Low carbon hydrogen production dependent on oil and gas production.
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative because of the potential disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	Carbon capture and storage	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development.	Negligible negative effects from energy requirements for transportation of captured carbon to the storage location.	Minor positive effects as carbon capture enables production of low carbon fuels for transport.	Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Electricity			Minor negative effects from electricity required for carbon capture and storage.			It is uncertain how much carbon will be captured and stored. The energy requirements of carbon capture are uncertain.
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the construction materials. Energy requirements during construction of carbon capture and storage facilities.	Minor positive effects from carbon capture and storage. Potential for fugitive emissions from CCS (from production, distribution and storage).	Minor positive effects from carbon storage enabling low carbon fuel for industrial purposes.	Negligible negative effects from energy required for decommissioning	Will depend on the scale of the carbon capture and storage activities.
		Waste		Negligible negative effects from construction waste.			Negligible negative effects from waste from materials that cannot be recycled after decommissioning	
		LULUCF		Negligible negative because of the potential disturbance to soil and vegetation during construction.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	

Table A.26: Energy Innovation Development on the Islands

Energy Innovation Development on the Islands					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**

Energy Innovation Development on the Islands					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of staff, materials and equipment for the delivery of the development.	Minor negative effects from the increased transportation due to new supporting infrastructure for renewable energy and hydrogen; carbon capture and storage, workers commuting to/from work; ongoing transport for maintenance; any transport related to the distribution of goods produced in the warehousing or fabrication/assembly areas; transport of fuels for marine vessels, and emissions arising from vessels travelling to the area to refuel with lower carbon fuel, and transport related to the supply chain; transport of natural gas for energy generation and transport of captured carbon.	Minor positive effects from hydrogen as it will provide low carbon fuel for transport because of the potential brought by hydrogen storage and distribution infrastructure, and enabling effect of carbon capture and storage. Ensuring that supply chain and fabrication are as local as possible will reduce potential emissions from transportation of materials and parts.	Negligible negative effects from transportation of staff, materials and equipment during decommissioning.	Moderate negative GHG balance from transport. Increased transport related to distribution and shipping activities will lead to an increase in overall emissions. Medium confidence as the level of hydrogen fuel produced and quantity of captured carbon transported is uncertain. The provision of low carbon fuel will support decarbonisation of transport, however the level of lower carbon fuel provided is uncertain.
Electricity		Minor positive effects from renewable energy production partly balanced by negative effects from increased demand for electricity during the operational phase of the development and electricity requirements of carbon capture.	Minor positive effects as more research and development related to these technologies may lead to significant improvements and innovation in renewable energy generation. This development will provide support for the roll out of renewable energy, and through the production of renewable hydrogen will facilitate renewable energy storage.		Minor positive GHG balance from electricity, as although this development will increase electricity demand, it will use surplus renewable electricity to generate hydrogen and support the roll out of renewable energy schemes. Medium confidence as it is unclear how much electricity will be required and what proportion of it will come from renewable energy sources.
Buildings (heat)		Negligible negative effects from heat required for buildings.	Minor positive effects from increased use of renewable energy and hydrogen for heating and cooking.		Minor negative GHG balance from buildings (heat), high confidence due to limited heat requirements.
Industrial, manufacture and construction processes	Minor negative effects from carbon embodied in the materials required for the construction phase of renewable and low carbon hydrogen production and storage facilities.	Minor positive effects from carbon capture and storage and renewable hydrogen production partly balanced by negative effects from the production of low carbon hydrogen, the potential for fugitive emissions during from production, distribution and storage of	Minor positive effects as use of hydrogen fuels will help reduce emissions from industrial processes and carbon capture will store carbon.	Negligible negative effects from energy required for decommissioning.	Minor positive GHG balance from industrial processes, as this development will facilitate carbon capture and storage although it will require a significant amount of carbon heavy materials for the construction phase of the development. The development also supports renewable hydrogen

Energy Innovation Development on the Islands					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	Carbon embodied in materials for the development and infrastructure.	hydrogen, oil and gas, and captured carbon. However, upgrades to oil infrastructure will prevent leakage and fugitive emissions released from oil, and will provide future storage for lower carbon fuels.			production. Low confidence, as the quantity of captured carbon, and levels of leakage from hydrogen storage, oil and gas and captured carbon are unknown.
Waste	Negligible negative effects from construction waste.	Minor negative effects from operational waste.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	Minor negative GHG balance from waste. Medium confidence as it is assumed that recyclable materials will be recycled.
LULUCF	Minor negative effects from the loss of soil and vegetation; impact on seabed from towers' foundations, loss of marine carbon.		Negligible positive effects from the reuse of brownfield land and avoiding development on greenfield land.	Negligible negative effects from disturbance to soil, vegetation and marine sediments during decommissioning.	Minor negative GHG balance from LULUCF. Medium confidence as it is assumed that the development will have a negative impact on soil, vegetation and marine life during construction and decommissioning which will outweigh positive effects from recovery during operation, but the scale of the development is uncertain.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net negative** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in moderate negative effects arising from **transport** related emissions, due to an overall increase in emissions but uncertainty over the amount of hydrogen produced for transport, or levels of use of low carbon fuel. ▪ Low confidence in minor positive effects in relation to **electricity** as it is uncertain how much electricity demand there will be from the development, and what proportions of the development's electricity needs will be met by renewable and non-renewable sources and how much renewable electricity will be generated. ▪ High confidence in minor negative effects from **heat** due to limited heat requirements. ▪ Low confidence in minor positive effects from **industrial processes**, due to facilitation of carbon capture and storage, and renewable hydrogen production, but taking into account the amount of carbon heavy materials required for this development, use of fossil fuels and potential for fugitive emissions. ▪ Medium confidence in minor negative effects from **waste** due to assumed low levels of waste and high levels of recycling. ▪ Medium confidence in minor negative effects in relation to **LULUCF** as such scale of development will lead to disturbance of soil, vegetation and marine areas, although there is uncertainty over the scale of this effect.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development includes renewable and low carbon hydrogen production. Hydrogen can provide low carbon fuel for transport, heating and industry compared to the use of fossil fuels. Low confidence in indirect positive effects due to uncertainty over the scale of renewable hydrogen production. The development is likely to support R&D activities which have the potential to enhance innovation and efficiency for net zero developments at a national scale, both enabling further development and supporting new developments over the long term.				

Energy Innovation Development on the Islands					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	Delivering developments on already developed land is likely to lead to reduced emissions from LULUCF as it is likely to avoid disturbance of soil and vegetation.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to uncertainty of the scale and type of renewable energy production, hydrogen production, distribution and storage, supporting infrastructure, supply chain for fabrication and R&D, the scale of carbon capture and storage and the use of lower emission fuels for shipping. It is assumed that these developments will be large scale and long-term and would outweigh the negative effects from the embodied carbon in the infrastructure. Indirect positive effects from the support for the renewables industry and production of renewable hydrogen on balance is likely to outweigh the negative direct effects identified due to relatively minor nature of these direct effects, which during the construction and decommissioning phases would be short term in nature. The positive indirect effects identified would be experienced throughout the operational phase of the development. The scale of this effect could range from low to high positive, depending on the scale of renewable energy and low carbon fuels produced over time. For example, smaller scale renewable energy and hydrogen production will likely have low positive effects. However, if this is deployed at a large scale, and is utilised across sectors, it could have high positive effects. Depending on the nature of the projects taken forward and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is medium confidence in this overall conclusion.				
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled. Provide low carbon transport options to the sites to reduce car dependency.				

Table A.27: National Walking, Cycling and Wheeling Network

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
National Active Travel Network	New/and or upgraded routes suitable for a range of users for walking, cycling and wheeling that help create a national network that facilitates short and longer distance journeys and linkages to multi-modal hubs.	**Transport**	Currently a small % of people commuting using active travel routes	Negligible negative effects from transportation of staff, materials and equipment for construction	Significant positive effects from potential for a significantly higher uptake of active travel reducing the overall emissions from transport. Furthermore, improved linkages and connections will enable more convenient travel using active travel paths and public transport as a result reducing the emissions from transport.			
		Electricity			Negligible negative effects from electricity required for lighting of the network.			
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials used for construction and as street furniture.	Negligible negative effects from carbon in maintenance materials			
		Waste		Negligible negative effects from construction waste.				
		LULUCF		Negligible negative effects from minor loss of soil and vegetation during construction.	Minor positive effects from carbon sequestration through green and blue infrastructure			

Table A.28: National Walking, Cycling and Wheeling Network

National Walking, Cycling and Wheeling Network					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of staff, materials and equipment for construction phase of the developments.	Significant positive effects from increased uptake of active travel and public transport modes displacing emissions from private vehicles.		Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	Super positive GHG balance from transportation as this infrastructure can encourage a significant amount of people across all areas of Scotland to travel actively and use public transport. Medium confidence due to current low levels of active travel take up.
Electricity		Negligible negative effects from electricity required for lighting of the network and in the multi-modal hubs.			Minor negative GHG balance from electricity, with medium confidence based on an assumption that majority of the electricity will come from renewable sources.
Buildings (heat)					Neutral GHG balance from buildings (heat). High confidence as assumed the development has no heat requirement.
Industrial, manufacture and construction processes	Negligible negative effects from carbon embodied in the materials used.				Minor negative GHG balance from industrial processes, with medium confidence based on an assumption that this development will not require significant amounts of materials for the delivery.
Waste	Negligible negative effects from construction waste.			Negligible negative effects from waste materials that cannot be recycled after decommissioning.	Minor negative GHG balance from waste, with medium confidence as it assumed minimal waste will be generated.
LULUCF	Negligible negative effects from loss of soil and vegetation during construction of the links balanced against reuse of brownfield land.	Minor positive effects from the potential for carbon sequestration through green and blue infrastructure.			Minor positive GHG balance from LULUCF through expansion of green and blue infrastructure, with low confidence based on an assumption that this development can lead to a significant increase in carbon sequestration capacity, but that construction of the links will have some adverse effects on soil carbon and vegetation.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in super positive effects for **transport** related to the assumed greater uptake of active and sustainable modes of travel facilitated by the construction and enhancement of the walking and cycling network across Scotland, in addition to better linkages with public transport and multi-modal hubs. However, there is uncertainty over levels of uptake of active and sustainable travel, and the extent and scale of the active travel network. Super positive effects would only arise with a high level of journeys made by active or sustainable modes of travel. ▪ Medium confidence in minor negative effects for **electricity, industrial processes and waste**, due to assumed low levels of demand for electricity and heat, low generate of waste and quantity of materials required. ▪ Medium confidence in positive effects for **LULUCF** from increased carbon sequestration, assuming there is increased vegetation planted along active travel routes, partly balanced by some negative effects during construction and decommissioning phases.				
Summary of lifecycle GHG balance (indirect effects)	No indirect effects identified.				

National Walking, Cycling and Wheeling Network					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Overall summary of effect	It is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the support for low carbon and active travel. The scale of this effect could range from high to very high positive assuming a high level of uptake and a long timeframe for the benefits. If this development facilitates a shift in travel behaviour, with a significant amount of people travelling through the network via active modes, very high positive effects are expected. These very high positive effects is likely to be further enhanced by opportunities for carbon sequestration linked to the provision of green and blue infrastructure. However if uptake of active travel is less, and there are fewer opportunities for carbon sequestration this may reduce to high positive. Depending on the nature of the projects taken forward and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is low confidence in this overall conclusion.				
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled. Ensure that waste is minimised during the construction phase.				

Table A.29: Pumped Hydro Storage

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Pumped Hydro Storage	Enhanced capacity of the water holding reservoir and dam and provide new and/or upgraded electricity generating equipment, pumps and pipework,	**Transport**		Negligible negative effects from transportation of materials for construction phase of the development	Negligible negative effects from maintenance transportation		Negligible negative effects from transportation of waste after decommissioning	
		Electricity	Existing fossil fuel power stations provide power to supply surges in demand		Significant positive effects as use of excess renewable energy to pump water to upper reservoir allows more generation of energy from the hydro power plants.	Minor positive effect as enables additional renewable energy storage capacity.		Uncertainty over whether this involves construction of a new reservoir and dams or increasing the capacity of the existing infrastructure.
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Minor negative effect due to significant amount of concrete and steel is required to enlarge power stations or build new power stations elsewhere, and associated infrastructure. Energy requirements of construction processes.	Negligible negative effects from release of CO_2 and CH_4 during the operations of the dams.		Negligible negative effects from energy requirements of decommissioning	
		Waste		Negligible negative effects from waste from construction processes	Negligible negative effects from waste from maintenance activities.		Negligible negative effects from waste from decommissioning	
		LULUCF		Minor negative effect due to loss of soil carbon and vegetation cover during construction	Negligible negative effects from production of methane from sediments in standing water.		Negligible negative effects from impact on land after decommissioning; Accumulation of sediments at the bottom of the reservoir consist of large quantities of carbon	Creation of a new reservoir would result in loss of greater land area than expansion of existing reservoir. Area of land to be inundated uncertain.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
							which is released after decommissioning.	
	New and/or upgraded substations, transformers and transmission cables required for the pumped hydro scheme.	**Transport**		Negligible negative effects from transportation of materials for construction phase of the development	Negligible negative effects from maintenance transportation		Negligible negative effects from transportation of waste after decommissioning	
		Electricity	Insufficient existing electricity infrastructure for upgrades to the hydro-power scheme.			Minor positive effect as enables additional renewable energy through providing additional energy storage capacity.		
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Minor negative effect due to high embodied carbon of materials required to construct supporting grid infrastructure including substations, transformer and transmission cables. Energy requirements of construction processes.	Negligible negative effects from release of CO2 and CH4 during the operations of the dam		Negligible negative effects from energy requirements of decommissioning	Uncertain how many supporting facilities would need to be upgraded or constructed.
		Waste		Negligible negative effects from waste from construction processes	Negligible negative effects from waste from maintenance activities.		Negligible negative effects from waste from decommissioning	
		LULUCF		Minor negative effect due to loss of soil carbon and vegetation cover during construction			Negligible negative effects from impact on land after decommissioning; Accumulation of sediments at the bottom of the reservoir consist of large quantities of carbon	Uncertain extent of new or upgraded infrastructure and impact on soils.

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
							which is released after decommissioning.	

Table A.30: Pumped Hydro Storage

Pumped Hydro storage					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of materials for construction phase of the development	Negligible negative effects from maintenance transportation		Negligible negative effects from transportation after decommissioning	Minor negative GHG balance from transportation. Medium confidence as the additional hydro power plants and supporting electricity infrastructure will require transportation of a significant quantity of materials for the construction and decommissioning phase of the development, in addition to maintenance and operational staff movement.
Electricity		Significant positive effect from significant increase in hydroelectric power generation from low carbon energy, over a lifetime of 50-100 years	Minor positive effect as enables additional renewable energy development through providing additional energy storage capacity.		Super positive GHG balance from electricity. Medium confidence based on the assumption that the pumped storage energy will be provided by renewables and if hydro power plant capacity is not extended there will be a requirement for continued fossil fuel power generation which may lead to continued significant negative effects. There is uncertainty over the frequency of operation of the hydro plants, the scale of additional capacity constructed, and the scale of any additional upgrades/provision of electricity infrastructure. However due to trends of continued reliance on renewable energy it is assumed that there will be more frequent use of this power source.
Buildings (heat)					
Industrial, manufacture and construction processes	Minor negative effect due to large quantity of materials required to enlarge existing power stations and construct new hydro power stations, and any associated electricity infrastructure required. Energy requirements of construction.	Negligible negative effects from release of CO_2 and CH_4 during the operations of the dam		Negligible negative effects from energy requirements of decommissioning	Minor negative GHG balance from industrial processes. Medium confidence based on the embodied carbon of the construction materials and assumption that operations of a hydro power plant lead to CO_2 and CH_4 emissions, but lack of certainty on the scale of construction of new or extended hydro power stations and their ancillary infrastructure.
Waste	Negligible negative effects from waste from construction	Negligible negative effects from maintenance waste generation.		Minor negative effect due to large amount of waste after decommissioning	Minor negative GHG balance for waste as the development will lead to a significant amount of waste materials after decommissioning. Low confidence as extent to which project material would be removed from site or left in situ is unknown.

Pumped Hydro storage					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
LULUCF	Minor negative effect on soil and land from dam construction/upgrades, and any associated upgrades or construction of electricity infrastructure. This will result in loss of vegetation and soil carbon.	Negligible negative effects from sediment production of methane and carbon dioxide.		Negligible negative effects from release of GHG from sediment after decommissioning.	Minor negative GHG balance from LULUCF. Enlargement of the existing hydro dams or construction of new hydro power plants will lead to loss of carbon from flooding of soil and inundation of vegetation. Operations lead to disturbance of sediments, releasing carbon dioxide and methane. Decommissioning will lead to additional carbon and methane emissions from the sediments that have been accumulating at the bottom of the reservoir. Medium confidence as this depends on the location and extent of the new reservoir and amount of vegetation inundated.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects in relation **transport**, due assumed transport impacts during construction and high volumes of construction material. ▪ Medium confidence in super positive effects in relation to **electricity** assuming that the energy required for pumping water will be renewable, and the development will operate over a long time period. ▪ Medium confidence in minor negative effects from **industrial processes** as this development is likely to require a significant amount of carbon heavy materials, but the scale of new hydroelectric development and potential releases of carbon dioxide and methane from operation is uncertain. The scale of effects will be dependent on whether the development relates to upgrades to existing facilities or construction of new infrastructure. ▪ Low confidence in minor negative effects from **waste** as it is unknown whether materials would be left in place after decommissioning or removed. ▪ Medium confidence in minor negative effects from **LULUCF** as the locations of a new reservoirs are unknown and may lead to a significant loss of vegetation and soil.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The development indirectly enables further renewable energy development across Scotland in the medium to long term by increasing storage capacity, and displacing fossil fuel emissions. There is low confidence in the scale of indirect positive effects due to uncertainty over the scale of other storage capacity for renewable energy, and the scale of increased pumped hydro-electric storage capacity.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to the facilitation and enabling of renewable energy development across Scotland from the provision of energy storage and rapid capacity during demand peaks. The scale of this effect could range from medium to very high depending on the project details, the location and frequency of use. If the development enables significantly more renewable electricity to be generated, whilst minimising energy associated with construction and decommissioning, and effects on soil carbon, a very high positive effect will be expected. However, if renewable electricity generation provided by the development is lower, and there are more significant amounts of energy and carbon intensive materials used during construction, this positive effect might reduce to medium. Furthermore, significant disturbance to soils and release of soil carbon is likely to reduce the effect to medium. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is low confidence in this overall conclusion.				
Additional mitigation and enhancement	Ensure that the design of the extension of the hydro power plant and extensions of other existing facilities will have minimal impacts on LULUCF. Ensure that sediment creation and build up is managed to reduce emissions. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled.				

Table A.31: Stranraer Gateway

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Stranraer Gateway	Redevelopment of Stranraer harbour east pier and development of sustainable road, rail and freight infrastructure for access to Stranraer and or Cairnryan.	**Transport**	Existing vessel emissions	Negligible negative effects from transportation of staff, materials and equipment for construction.	Mixed effects from maintenance transport, transport related to the use of the renovated harbour east pier and new infrastructure including sustainable road, rail, and freight.		Negligible negative effects from transportation of staff, materials and equipment after decommissioning	Unclear about scale of change to freight handling and impact on change to carbon emissions
		Electricity			Negligible negative effects from electricity required for operations of the harbour and sustainable transport.			
		Buildings/ Heat			Negligible negative effects from heat required for the buildings and offices of the harbour			
		Industrial, manufacture and construction processes	Embodied carbon in existing infrastructure	Negligible negative effects from carbon embodied in the materials and equipment. Energy required for construction.	Negligible negative effects from maintenance of the pier and sustainable transport.		Negligible negative effects from energy required for decommissioning.	
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from operational waste.		Negligible negative effects from waste of materials that cannot be recycled after decommissioning.	Waste from operations will depend on the nature of operations and the timeframes of the project (whether the port is for freight or passengers or both)
		LULUCF	Carbon in marine environment	Negligible negative effects from disturbance to seafloor.	Negligible negative effects from carbon release during maintenance dredging			Carbon values of the marine environment uncertain.
	High quality place-based regeneration,	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for	Negligible negative effects from increased transport movements resulting from		Negligible negative effects from transportation of staff,	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
	including marina expansion and reuse of vacant and derelict buildings and brownfield land including regeneration of Blackparks industrial estate			the construction	regeneration, including business and residential movements.		materials and equipment after decommissioning	
		Electricity			Negligible negative effects from electricity requirements during the operations of businesses located at the industrial estate			
		Buildings/ Heat			Negligible negative effects from heat requirements during the operations of businesses located at the industrial estate			
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials from construction. Energy required for construction.	Negligible negative effects from business operations' emissions		Negligible negative effects from energy required for decommissioning.	Business operations' emissions will depend on the nature of the business
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from operational waste.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects form disturbance to soil and vegetation.				
	New and/or upgraded infrastructure for the transportation and use of low carbon fuels	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for the construction	Negligible positive effects from transportation and use of low carbon fuels	Minor positive effects from transportation of low carbon fuels enabling emissions reduction in other locations.	Negligible negative effects from transportation of staff, materials and equipment after decommissioning	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Electricity						
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from production and processing of low carbon fuels	Negligible positive effects from use of low carbon fuels in industrial, manufacture and construction processes.		Negligible negative effects from energy required for decommissioning.	
		Waste						
		LULUCF		Negligible negative effects from the disturbance to soil and vegetation during construction.			Negligible negative effects from the disturbance to soil and vegetation during decommissioning.	

Table A.32: Stranraer Gateway

Stranraer Gateway					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects for transportation of staff, materials and equipment for the construction phase of the project	Negligible positive effects overall as increased transport to and from ports/pier, stations, industrial estate and residential developments is balanced by the provision of sustainable transport and the use of low carbon fuels.	Negligible positive effects from supporting the distribution of low carbon fuels.	Negligible negative effects for transportation of waste materials and machinery after decommissioning	Minor positive GHG balance from transport. Although increased transport from port, rail stations and staff travel will lead to carbon emissions, this is balanced by provision of sustainable transport and use of low carbon fuels. Low confidence as will depend on the scope of the development (residential and employment sites), the balance between increased efficiency of travel from sustainable connectivity and increased number of journeys, and the scale of low carbon fuel use.
Electricity		Negligible negative effects from increased demand for electricity from transport and regeneration, assumed partially sourced from renewables.			Minor negative GHG balance from electricity. Increased electricity use during operational phase of the development will lead to emissions despite measures taken to ensure energy efficiency. Medium confidence due to uncertainty over the extent to which electricity is provided by renewable sources, and scale of increased energy use.
Buildings (heat)		Negligible negative effects from an increased demand for heat from			Minor negative GHG balance from buildings (heat) as it is expected that this development will result in an increase in the overall heat demand. Medium confidence , as uncertain as to

Stranraer Gateway					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
		residential and business premises.			what extent low carbon heat will be incorporated.
Industrial, manufacture and construction processes	Negligible negative effect from the carbon embodied in the materials used for infrastructure	Negligible negative effects for emissions from business operations	Negligible positive effects from use of low carbon fuels in industrial, manufacture and construction processes.	Negligible negative effects from energy required for decommissioning.	Minor negative GHG balance for industrial processes. Low confidence as the quantity of materials required for the delivery of the developments is uncertain due to lack of detail on the scale of the development, there is also uncertainty over the use of low carbon fuels in industrial, manufacture and construction processes.
Waste	Negligible negative effects from construction related waste, reuse of existing materials and infrastructure will be minimal.	Negligible negative effects from waste produced by business operations		Negligible negative effects from materials that cannot be recycled after decommissioning	Minor negative GHG balance from waste. Medium confidence based on assumptions over levels of increased waste from construction, operation phase waste from businesses and residential units will lead to negative overall emissions and assumed low level of waste generated.
LULUCF	Negligible negative effects from use of a brownfield site and land take and soil carbon loss from construction of road and rail.	Negligible negative effects from carbon release during maintenance dredging.		Negligible negative effects from disturbance to soil and vegetation during decommissioning.	Minor negative GHG balance from LULUCF. Medium confidence as it is assumed that some development will be on brownfield sites, but there will be overall soil carbon loss from development of road and rail links, with some carbon sequestration during operational phase.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net negligible** effect on direct lifecycle GHG emissions. This is based on: ▪ Low confidence in minor positive effects from **transport** due to uncertainty over the scale of the development and impact on journeys generated, balanced by some assumed increase in rail transport and scale of use of low carbon fuels. ▪ Medium confidence in increased **electricity** and **heat** demand due to assumed low levels of increased demand and uncertainty over the extent of renewable energy or heat generation. ▪ Low confidence in effect from **industrial, manufacture and construction processes** due to uncertainty over the scale of development. ▪ Medium confidence in emissions from waste due to assumed net increase in **waste** but uncertainty over quantity of waste generated. ▪ Medium confidence in minor negative effects from **LULUCF** due to assumed net loss of soil carbon from development, despite some assumed development on brownfield land.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **negligible positive** effect on indirect lifecycle GHG emissions. The development is likely to support low carbon fuels distribution. The scale of indirect effects is likely to be negligible, however there is low confidence as it is uncertain how much low carbon fuel will be distributed via this development.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that the development will have a **net positive** effect on lifecycle GHG emissions due positive effects from use and distribution of low carbon fuels, increased transport efficiency from new rail facilities and transportation which is judged to outweigh the negative effects from increased transport emissions. The scale of this effect is likely to be low. Depending on the nature of the projects taken forward and considering both the direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and scale of these effects means that there is low confidence in this overall conclusion.				

Stranraer Gateway					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled. Ensure that energy efficiency solutions are in place within the developments. Support low carbon fuel for marine vessels. Minimise disturbance to marine sediments.				

Table A.33: Strategic Renewable Electricity Generation and Transmission Infrastructure

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Strategic Renewable Energy Generation and Transmission Infrastructure	On and offshore electricity generation, including electricity storage, from renewables of or exceeding 50 Megawatts capacity	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for construction in a wide number of locations.	Negligible negative effects from staff commuting to work and for maintenance.	Minor positive effects as additional renewable energy provides low carbon fuel/energy for transport/industry.	Negligible negative effects from transportation of staff, materials and equipment for decommissioning.	Number and extent of developments.
		Electricity			Minor positive effects from large scale production of renewable energy in multiple locations on and offshore.	Minor positive effects as large scale renewable energy production supports battery storage and hydrogen production		Uncertain whether hydrogen will also be produced using renewable energy.
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Minor negative effects as embodied carbon in the carbon heavy materials needed for this development. Energy required for construction.		Minor positive effects as renewable energy availability will have indirect benefits on reducing emissions associated with industrial processes.	Minor negative effects from potential for energy demand for recycling materials after decommissioning; decommissioning of the development; recycling of copper has a higher carbon footprint that production of the cable.	
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from waste from maintenance activities.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects from land take and loss of vegetation and carbon stored in soils/marine sediments and vegetation due to construction activities.			Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	On and offshore electricity transmission grid reinforcement	**Transport**		Negligible negative effects from transport of staff, materials (cables) and equipment for construction	Negligible negative effects from transport for maintenance purposes.		Negligible negative effects from transport of staff, materials (redundant cables) and equipment after decommissioning.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Electricity				Significant positive effects from the facilitation of transmission of renewable energy and increases use of surplus of energy from wider transmission and through connectivity to energy storage facilities.		
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Minor negative effects from carbon embodied in the carbon heavy materials used for this development (transmission cables). Energy requirements of construction processes.	Negligible negative effects from energy losses through transmission infrastructure. Maintenance requirements of transmission infrastructure.	Negligible positive effects as improved energy transmission infrastructure will enable wider use of renewable energy.	Minor negative effects from potential for energy demand for recycling materials after decommissioning; decommissioning of the development; recycling of copper has a higher carbon footprint that production of the cable	
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from waste from maintenance activities.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects from loss of soil and marine carbon from pylons and when underground cables installed, land take for substation and switching stations. Impacts from construction tracks to pylon locations and temporary construction compounds.	Negligible positive effects due to potential for regeneration of soil and vegetation after construction works are completed.		Negligible negative effects from disturbance to soil and vegetation during decommissioning.	
	New infrastructure to support on and off-shore electrification in order that electricity generated can be	**Transport**		Negligible negative effects from transportation of staff, materials and equipment for construction.	Negligible negative effects from increased transport due to improved infrastructure. .		Negligible negative effects from transport of staff, materials and equipment after decommissioning.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
	transmitted to consumers in Scotland the rest of the UK and beyond							
		Electricity			Negligible negative effects from electricity required for operation of infrastructure	Significant positive effects from the facilitation of transmission of renewable energy and increases use of surplus of energy from wider transmission and through connectivity to energy storage facilities.		
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Minor negative effects from carbon embodied in the carbon heavy materials used for construction, including concrete and metals such as aluminium or copper. Energy requirements of construction processes.			Minor negative effects from potential for energy demand for recycling materials after decommissioning; decommissioning of the development; recycling of copper has a higher carbon footprint than production of the cable. Where cables are left in situ, this represents a carbon loss.	
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from operation waste.		Negligible negative effects from waste from materials that cannot be recycled after decommissioning.	
		LULUCF		Negligible negative effects from land take and loss of vegetation and carbon stored in soils/marine sediments and vegetation due to construction activities.	Negligible positive effects from potential for minor carbon sequestration and land regeneration of areas surrounding the supporting infrastructure		Negligible negative effects from disturbance to soil and vegetation after decommissioning.	

Table A.34: Strategic Renewable Electricity Generation and Transmission Infrastructure

Strategic renewable energy generation and transmission infrastructure					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of staff, materials and equipment for construction in a wide number of locations.	Negligible negative effects from staff commuting to work and maintenance.	Minor positive effects from renewable energy and hydrogen provides low carbon fuel for transport.	Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	Minor negative GHG balance from transport as this development will increase the overall emissions linked to transport. Medium confidence as it is uncertain as to the travel generated by the renewable energy delivered, due to the potential variations from the type and location of development, although assumed large scale and in numerous locations both on and offshore.
Electricity		Significant positive effects from large scale production of renewable energy.	Significant positive effects from energy storage to increase reliance on renewable energy, from transmission of renewable energy, potential for using surplus of energy by distributing it across the country, and from more efficient use of renewable energy through Smart grids.		Major positive GHG balance in relation to electricity as this development will deliver large scale renewable energy generation and transmission infrastructure, enabling on and offshore renewable energy development. Medium confidence in the scale of the renewable energy delivered and enabled due to uncertainty as to how many large-scale developments will be delivered.
Buildings (heat)			Negligible positive effects from production of lower carbon heating source		Neutral GHG balance from buildings (heat). High confidence as assumed the development has no heat requirement.
Industrial, manufacture and construction processes	Minor negative effects from carbon embodied in the materials used for this development. Energy requirements of construction processes.	Negligible negative effects from energy losses through transmission infrastructure and from maintenance requirements of transmission infrastructure.	Minor positive effects from availability of renewable energy which will have indirect benefits on providing renewable energy and reducing emissions associated with industrial processes.	Minor negative effects from the potential for energy demand for recycling materials after decommissioning; decommissioning of the development; recycling of copper has a higher carbon footprint that production of the cable	Moderate negative GHG balance from industrial processes. Low confidence as although it is certain that this development will require a significant amount of carbon heavy materials which may also be energy intensive to recycle, there is uncertainty over the quantity required and associated GHG balance.
Waste	Negligible negative effects from construction waste.	Negligible negative effect from waste from maintenance		Negligible negative effects from waste from materials that cannot be recycled	Minor negative GHG balance from LULUCF, medium confidence as it is assumed that no significant or ongoing waste is produced.

Strategic renewable energy generation and transmission infrastructure					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
		activities.		after decommissioning.	
LULUCF	Negligible negative effects from land take and loss of vegetation and carbon stored in soils and marine sediments due to construction activities.	Negligible positive effects from the potential for regeneration of soil and vegetation after construction works are completed.		Negligible negative effects from disturbance to soil and vegetation during decommissioning.	Neutral GHG balance from LULUCF as the development will result in soil and vegetation disturbance both onshore and offshore. Low confidence as it is assumed that some land restoration will occur.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in major positive effects arising from **electricity**, as this development will deliver large scale renewable energy generation displacing emissions from current fossil fuel energy sources, however there is uncertainty how many such developments will be delivered. ▪ Medium confidence in minor negative effects from **transport**, as it is uncertain how many transport journeys will be generated. ▪ Medium confidence in minor negative effects from **waste** due to assumed low levels of waste produced. ▪ Low confidence in moderate negative effects in relation to **industrial processes** due to uncertainty over the extent and GHG emissions of the materials required, although high confidence in the carbon intensity of the materials.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The proposed national development facilitates renewable energy generation which may support hydrogen production and provide low carbon fuel for transport, heating and energy for industrial processes compared to use of fossil fuels. The indirect effect is judged to be of super scale, but with medium confidence due to uncertainty on the actual scale of renewable energy and hydrogen production.				
Overall summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to potential for substantial generation and transmission of renewable electricity. The scale of positive effect is assumed to be between medium and very high positive, depending on the scale of renewable energy generation and the role of the development in facilitating further renewable energy development. A medium scale of effect would result from higher embodied carbon in construction infrastructure, and lower levels of renewable energy generation and use. Conversely, lower embodied carbon in construction infrastructure, and higher levels of renewable energy generation would result in a very high scale of effect. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Greater certainty about the nature and scale of these effects means that there is medium to high confidence in this overall conclusion.				
Additional mitigation and enhancement	Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused again or recycled. Ensure that cabling and supporting infrastructure avoids carbon rich soils and vegetation that store or absorb significant amounts of carbon.				

Table A.35: Urban/Mass Rapid Transit Networks

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Urban Mass/Rapid Transit Networks	Edinburgh – Edinburgh mass transit system. It would complement and integrate with the current bus, tram and heavy rail networks.	**Transport**	Existing tram line from Edinburgh Airport to York Place, with extension to Newhaven (under construction)	Negligible negative effects from transportation of machinery and materials required for the construction of the mass transit system such as tram lines, tracks, and stops.	Minor positive effects as more journeys will be made via the tram network, reducing transport related GHG emissions. Transport (including bus rapid transit (BRT) and trams) will be substituting fossil fuelled buses and private cars. This advantage may decrease over time if EVs are increasingly used, and the bus fleet is converted to low carbon fuels.		Negligible negative effects from decommissioning related transport of resources and waste for processing.	Level of passenger use unknown
		Electricity		Negligible negative effects from electricity required during construction of tram tracks/stops.	Negligible negative effects from increased electricity demand to power the transit modes.		Negligible negative effects from electricity required during decommissioning phase.	
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in new infrastructure and energy required during construction of transport infrastructure (e.g., extensive use of cement for trams)	Negligible negative effects from embodied carbon in energy and material requirements for maintenance.		Negligible negative effects from energy requirements for decommissioning of the infrastructure.	Whether hydrogen fuel is produced by renewable or low carbon hydrogen. Whether hydrogen fuel is used.
		Waste		Negligible negative effects from waste materials generated during construction phase.			Negligible negative effects from waste materials generated during the decommissioning phases.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		LULUCF	Tram lines / BRT primarily run along main roads and would not result in significant loss of greenspace	Negligible negative effects from development may result in loss of undeveloped land at least for some of the required new infrastructure.			Negligible negative effects from disturbance to soil and vegetation during decommissioning,	
	Glasgow – Glasgow Metro mass transit system	**Transport**	Existing metro system operating in Glasgow	Negligible negative effects from transportation of machinery and materials required for the upgrading and reopening of heavy rail lines to accommodate light rail, and construction of new light rail to strategic locations.	Minor positive effects as more journeys will be made via sustainable modes of transport, reducing transport related GHG emissions. New transit modes will be substituting fossil fuelled buses and private cars. This advantage may decrease over time if EVs are increasingly used, and the bus fleet is converted to low carbon fuels		Negligible negative effects from decommissioning related transport of resources and waste for processing.	Future levels of passenger use unknown.
		Electricity		Negligible negative effects from electricity required during construction of new light rail and any required upgrades to the existing heavy rail lines for use by light rail.	Negligible negative effects from increased electricity demand to power the new transit modes.		Negligible negative effects from electricity required during decommissioning phases	
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in new infrastructure and energy required during construction/ upgrade of	Negligible negative effects from energy and material requirements for maintenance.		Negligible negative effects from energy requirements during decommissioning of infrastructure.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
				infrastructure.				
		Waste		Negligible negative effects from waste material generated during construction/ upgrading phases.			Negligible negative effects from waste material generated during the decommissioning phase.	
		LULUCF	Heavy rail line in place	Negligible negative effects from development may result in loss of undeveloped land at least for some of the required new infrastructure.			Negligible negative effects from disturbance to soil and vegetation during decommissioning,	
	Aberdeen - rapid transit system	**Transport**	Existing reliance on private vehicle, buses etc. as no existing light rail/tram networks operating	Negligible negative effects from transportation of machinery and materials required for the construction of the new tram lines/ stops.	Minor positive effects as more journeys will be made via sustainable modes of transport, reducing transport related GHG emissions. New transit modes will be substituting fossil fuelled buses and private cars. This advantage may decrease over time if EVs are increasingly used, and the bus fleet is converted to low carbon fuels		Negligible negative effects from decommissioning related transport of resources and waste for processing.	Unsure as to the extents of the tram network, and how many journeys it would provide each year.
		Electricity		Negligible negative effects from electricity required during construction of the rapid transit system	Negligible negative effects from increased electricity demand to power rapid transit system.		Negligible negative effects from electricity required during decommissioning phases	
		Buildings/ Heat						

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Industrial, manufacture and construction processes		Negligible negative effects from embodied carbon in new infrastructure and energy required during construction of transport and ancillary development infrastructure (e.g., bus stops).	Negligible negative effects from energy and material requirements for maintenance.		Negligible negative effects from energy requirements during decommissioning of infrastructure	
		Waste		Negligible negative effects from waste material generated during construction phase.			Negligible negative effects from waste material generated during the decommissioning phase.	
		LULUCF	Main city centres where tram would be located are already developed.	Negligible negative effects as development may result in loss of undeveloped land at least for some of the required new infrastructure			Negligible negative effects from disturbance to soil and vegetation during decommissioning,	Uncertain as to the exact locations/routes of the rapid transit system

Table A.36: Urban/Mass Rapid Transit Networks

Urban Mass/Rapid Transit Networks					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects arising from the transportation of machinery and materials required for the upgrade to existing rail infrastructure and construction of the new tram/ light rail/ bus tracks and stops.	Significant positive effects in relation to transport GHG emissions due to more journeys being taken via sustainable modes of transport including BRT, light rail and tram, and displacement of fossil fuelled buses and private cars. This advantage may decrease over time if EVs are increasingly used, and the bus fleet is converted to low carbon fuels		Negligible negative effects for transportation of waste materials and machinery during decommissioning	Major positive GHG balance from transport due to extensive increase in sustainable travel facilitated by the expansion and development of light rail in Edinburgh and Glasgow, and the rapid transit system (buses) in Aberdeen. Medium confidence as this will depend on the rate of uptake of these sustainable modes of transport, and the extent of the networks developed.

Urban Mass/Rapid Transit Networks					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Electricity		Neutral effects arising from increased demand for electricity to power light rail and tram networks, which is assumed to be renewable.			Neutral GHG balance relating to electricity, due to the greater demand of low carbon and renewable electricity to power light rail across some of Scotland's biggest cities. Medium confidence as it would depend on electricity being sourced from low carbon/ renewable sources.
Buildings (heat)					Neutral GHG balance from heat, high confidence as it is assumed no is heat required.
Industrial, manufacture and construction processes	Negligible effects relating to embodied carbon and energy requirements during construction.	Negligible negative effects from energy and material requirements for maintenance.		Negligible negative effects for energy used during decommissioning phase.	Minor negative GHG balance from carbon embodied in building materials and energy demand during construction/ decommissioning. Medium confidence due to assumed moderate overall energy requirements of construction.
Waste	Negligible negative effects of waste produced during construction and upgrading activities			Negligible negative effects of waste disposed of after decommissioning	Minor negative GHG balance from waste produced during construction and decommissioning. High confidence due to waste being limited to construction and decommissioning.
LULUCF	Negligible negative effects will arise from loss of soil carbon due to the required development.			Negligible negative effects from disturbance to soil and vegetation during decommissioning,	Minor negative GHG balance from LULUCF during construction and decommissioning as new infrastructure will be required. Medium confidence due to assumed level of construction on previously developed land.
Summary of GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. ▪ Medium confidence in major positive effects from **transport** related to the assumed greater uptake of sustainable travel and journeys facilitated by the construction and enhancement of the light rail network across Scotland's main cities over the long term. However, there is uncertainty over levels of future passenger use, and the full extent of the networks. ▪ Medium confidence in minor negative effects during construction and decommissioning phases in relation to **industrial, manufacture and construction processes**. ▪ High confidence in minor negative effects from **waste** during construction and decommissioning due to assumed low levels of waste produced. ▪ Medium confidence in minor negative from **LULUCF** during construction and decommissioning due to assumed new infrastructure required.				
Summary of lifecycle GHG balance (indirect effects)	No indirect effects identified.				
Overall summary of effect	It is likely that this proposed national development will have a **net positive** effect on lifecycle GHG emissions as the long-term positive effects of three of Scotland's major cities using sustainable transport powered by low carbon electricity will outweigh the short-term negative effects. The scale of this effect could range from medium to very high positive depending on the network extent and level of uptake. If this development facilitates a shift in travel behaviour, with a significant amount of people travelling via the mass/rapid transit networks very high positive effects are expected. However if uptake is less, and positive effects may reduce to medium positive. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Uncertainty about the nature and				

Urban Mass/Rapid Transit Networks					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	scale of these effects means that there is medium confidence in this overall conclusion.				
Additional mitigation and enhancement	Commitment to the use of low carbon/renewable sources of energy to power the trams and light rail developments. Ensure integration of the mass transit networks with active travel networks. Increase the roll out of mass transit networks to other major towns and cities in Scotland.				

Table A.37: Urban Sustainable, Blue and Green Surface Water Management Solutions

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
Urban Sustainable, Blue and Green Surface Water Management Solutions	Water and drainage infrastructure investment	**Transport**		Negligible negative effects from transportation of staff, materials, and equipment for construction of different elements of drainage infrastructure.	Negligible negative effects from staff and maintenance travel for infrastructure development.		Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	
		Electricity						
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials used for construction of drainage solutions. Energy requirements of construction.	Negligible negative effects from carbon embodied in materials required for maintenance.	Negligible positive effects from improved climate resilience will reduce flood damage and the embodied carbon in replacement materials following flood damage.	Negligible negative effects from energy requirements of decommissioning.	

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
		Waste		Negligible negative effects from construction waste.				
		LULUCF		Negligible negative effects as infrastructure will be on previously developed land. Minor impact on soil and vegetation.			Negligible negative effects from disturbance to soil and vegetation during decommissioning,	
	Nature based solutions	**Transport**		Negligible negative effects from transportation of staff, materials and equipment	Negligible negative effects from maintenance travel.		Negligible negative effects from transportation of staff, materials and equipment for decommissioning.	
		Electricity						
		Buildings/ Heat						
		Industrial, manufacture and construction processes		Negligible negative effects from carbon embodied in the materials and equipment used.	Negligible negative effects as carbon embodied in materials required for maintenance.			
		Waste		Negligible negative effects from construction waste.	Negligible negative effects from waste from bins along the green networks.			
		LULUCF		Negligible negative effects from minor impact on soil and vegetation.	Minor positive effects from enhanced soil and vegetation, carbon sequestration.		Negligible negative effects from soil and vegetation disturbance.	

Table A.38: Urban Sustainable, Blue and Green Surface Water Management Solutions

Urban Sustainable, Blue and Green Drainage Solutions					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
Transport	Negligible negative effects from transportation of staff, materials, and equipment for construction.	Negligible negative effects from staff and maintenance travel.		Negligible negative effects from transportation of staff, materials and equipment after decommissioning.	Minor negative GHG balance from transport, as this development will lead to increases in the emissions from transport. Medium confidence as it assumes that this development will deliver water and drainage infrastructure.
Electricity					Neutral GHG balance from electricity, high confidence as minimal electricity should be required to deliver this development.
Buildings (heat)					Neutral GHG balance from buildings, high confidence as no heat should be required to deliver this development.
Industrial, manufacture and construction processes	Negligible negative effects from carbon embodied in the materials used for construction.		Minor positive effects as improved climate resilience will reduce flood damage and the embodied carbon in replacement materials following flood damage.		Minor negative GHG balance from industrial processes, as considering the scale of this development it should not require significant amount of carbon heavy materials for the construction. . Low confidence due to uncertainty over the carbon intensity of the drainage infrastructure, the extent to which this is applied in other regions.
Waste	Negligible negative effects from construction waste.	Negligible negative effects from waste from bins along the green networks.			Minor negative GHG balance from waste, medium confidence as this development is unlikely to produce significant amounts of waste.
LULUCF	Negligible negative effects from infrastructure will be part of already developed land. Minor impact on soil and vegetation.	Minor positive effects from enhanced soil and vegetation, carbon sequestration.		Negligible negative effects from soil and vegetation disturbance.	Minor positive GHG balance from LUULCF, medium confidence as green infrastructure will enhance carbon sequestration, but the scale and extent of this is unknown.
Summary of lifecycle GHG balance (direct effects)	This proposed national development is likely to result in a **net positive** effect on direct lifecycle GHG emissions. This is based on: ▪ Medium confidence in minor negative effects in relation to **transport** due to minor levels of maintenance travel. ▪ Low confidence in minor negative effects from **industrial, manufacture and construction processes** due to uncertainty over the carbon intensity of the materials used. ▪ Medium confidence in minor negative effects from **waste** due to assumed limited waste produced. ▪ Medium confidence in minor positive effects in relation to **LULUCF** as this development is likely to enhance carbon sequestration, although the scale of the effect is uncertain.				
Summary of lifecycle GHG balance (indirect effects)	This proposed national development is likely to result in a **net positive** effect on indirect lifecycle GHG emissions. The proposed national development reduces flood risk, and there is medium confidence in minor positive effects due to reduced flood damage and embodied carbon in replacement materials due to uncertainty on the scale of flood damage avoided.				
Summary of effect	When direct and indirect effects are combined, it is likely that this development will have a **net positive** effect on lifecycle GHG emissions due to reduced flood risk and				

Urban Sustainable, Blue and Green Drainage Solutions					
Summary of significant effects from all project components including cumulative effects	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**	**GHG balance by sector**
	delivery of more green spaces that are likely to enhance carbon sequestration. The scale of effects could range from low to medium positive depending on how much flood damage is avoided and how many green spaces are delivered. A low scale of effect would result from minimal use of nature-based drainage solutions and the greater use of materials which contain higher embodied carbon. Conversely, if the drainage solutions are widespread and deliver green infrastructure, they are likely to reduce greenhouse gas emissions due to limiting flood damage, with a medium positive effect. Depending on the nature of the projects taken forward and considering both direct and indirect effects, the lifecycle greenhouse gas emissions assessment concludes this development will likely have an overall **net positive** impact on achieving national greenhouse gas emissions reduction targets. Greater certainty about the nature and scale of these effects means that there is medium confidence in this overall conclusion.				
Additional mitigation and enhancement	Ensure that green infrastructure is fully exploited to enhance carbon sequestration. Prioritise the reuse of materials in construction, use of low carbon construction materials and ensure upon decommissioning waste materials are reused or recycled.				

Annex B Assessment Methodology

Introduction

This Annex sets out the methodology which was developed to support the lifecycle assessment of greenhouse gas emissions for the NPF4 proposed and alternative National Developments.

Definitions and terminology

Emissions sectors

The assessment is structured around the six emissions sectors of transport, electricity, buildings (heat), industrial, manufacture and construction processes, waste and land use, land use change and forestry (LULUCF). These emissions sectors reflect the sectors included in the Update to the Climate Change Plan 2018-2032, but exclude agriculture as being outside of the scope of the proposed and alternative proposed national developments. Negative Emissions Technologies (NETs) are included for the assessment of the Industrial Green Transition Zones, which is the only proposed national development for which this sector is relevant.

Emissions sources considered include those set out in the Climate Change (Scotland) Act 2009, as amended ('the Climate Change (Scotland) Act'). This created a statutory framework for greenhouse gas (GHG) emissions reduction in Scotland and set targets for reduction in emissions of the seven Kyoto Protocol Greenhouse Gases compared to the 1990/1995 baseline level. This "basket" of seven GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

CO_2 equivalent

CO_2e is the measure used to compare the emissions from various greenhouse gases on the basis of their global warming potential (GWP) by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential.

Embodied carbon is the total greenhouse gas (GHG) emissions (often simplified to "carbon") generated to produce materials and also applies to the materials and processes required for construction of a building or structure. The embodied carbon of re-use or recycling some materials can be less than the embodied carbon of producing new material from new raw materials.

Carbon is also stored in materials such as wood, which can be released by burning or decomposition, leading to the release of carbon dioxide.

Positive and negative effects

Within the assessment framework, the terminology 'positive effect' refers to reduced emissions relative to the baseline. The term 'negative effect' refers to an increase in emissions relative to the baseline. Within the assessment framework it is clear where both positive and negative effects occur in relation to a sector emissions source. For example, a National Development (ND) which both increases traffic levels in one area,

but also implements infrastructure to support low carbon travel in another. The final column of the assessment framework makes a judgement (with an associated confidence level) about the net GHG balance in relation to that sector. The final summary of overall effects draws conclusions on the balance of GHG emissions between the different sectors.

Lifecycle stages

The assessment considers emissions from different stages of the lifecycle of a National Development. Lifecycle stages include 'baseline' which captures any existing sources of emissions or any sequestration and storage that could be affected by the development. For example, for a road improvement ND the baseline is the current road which may be subject to congestion issues, and the associated vehicle emissions. The baseline for a new freight rail route would be the existing road traffic emissions of the freight transport, and also the emissions associated with the current existing land use. Construction related emissions are more significant for developments which utilise carbon intensive materials such as concrete and steel. Operational emissions are likely to occur over the longest timeframe - during the operation of the development. In many cases, the operational life of a ND is unknown, so assumptions have been made as appropriate.

Finally, the assessment has made assumptions around decommissioning. It is acknowledged that there is a high degree of uncertainty over the decommissioning phase of development, and that different assumptions will apply to different development types and locations. This includes the approach to infrastructure removal or the level of site restoration at the end of the development's lifespan. Where appropriate, restoration to the equivalent of green field condition has been assumed to allow comparison across the NDs. It is acknowledged that future use of a site may be lower or higher intensity in the future.

Direct and indirect effects

The assessment table identifies both direct and indirect effects. Direct effects are those that arise as a direct result of the development, such as the generation of additional traffic movements from a new development. Indirect effects are those that arise because of the development, typically through enabling actions. For example, research and development for renewable energy may enable further renewable energy development.

Embodied energy

Detail on the definitions of embodied energy are set out in McAlinden (2015)[2]. This defines 'embodied energy' as "the sum of the energy requirements associated, directly or indirectly, with the delivery of a good or service" (Cleveland & Morris, 2009). The different ways of defining embodied energy commonly include cradle-to-gate, cradle-to-site, and cradle-to-grave. For the purposes of the assessment, we will use a cradle to

[2] McAlinden, B., (2015) Energy Briefing Sheet: Embodied Energy and Carbon. Institution of Civil Engineers. [online] Available at: https://www.ice.org.uk/knowledge-and-resources/briefing-sheet/embodied-energy-and-carbon [Accessed 15/4/2021]

grave approach, as the assessment framework includes the decommissioning phase of development.

The document notes that the definitions are given for energy but are equally valid when considering embodied carbon (dioxide) emissions. Subtleties in correctly measuring embodied carbon include the sequestration of carbon within building materials such as timber, and the emission (or sequestration) of carbon dioxide through chemical reactions during the production of materials such as cement and the lifetime use of materials such as in the carbonation of concrete.

A cradle-to-grave approach includes the following:

- Initial embodied energy: the energy required to initially produce the building/structure. It includes the energy used for the abstraction, the processing and the manufacture of the materials of the building/structure as well as their transportation and assembly on site [construction].

- Recurring embodied energy: the energy needed to refurbish and maintain the building/structure over its lifetime [operation].

- Demolition energy: the energy necessary to demolish and dispose of the building/structure at the end of its life [decommissioning].

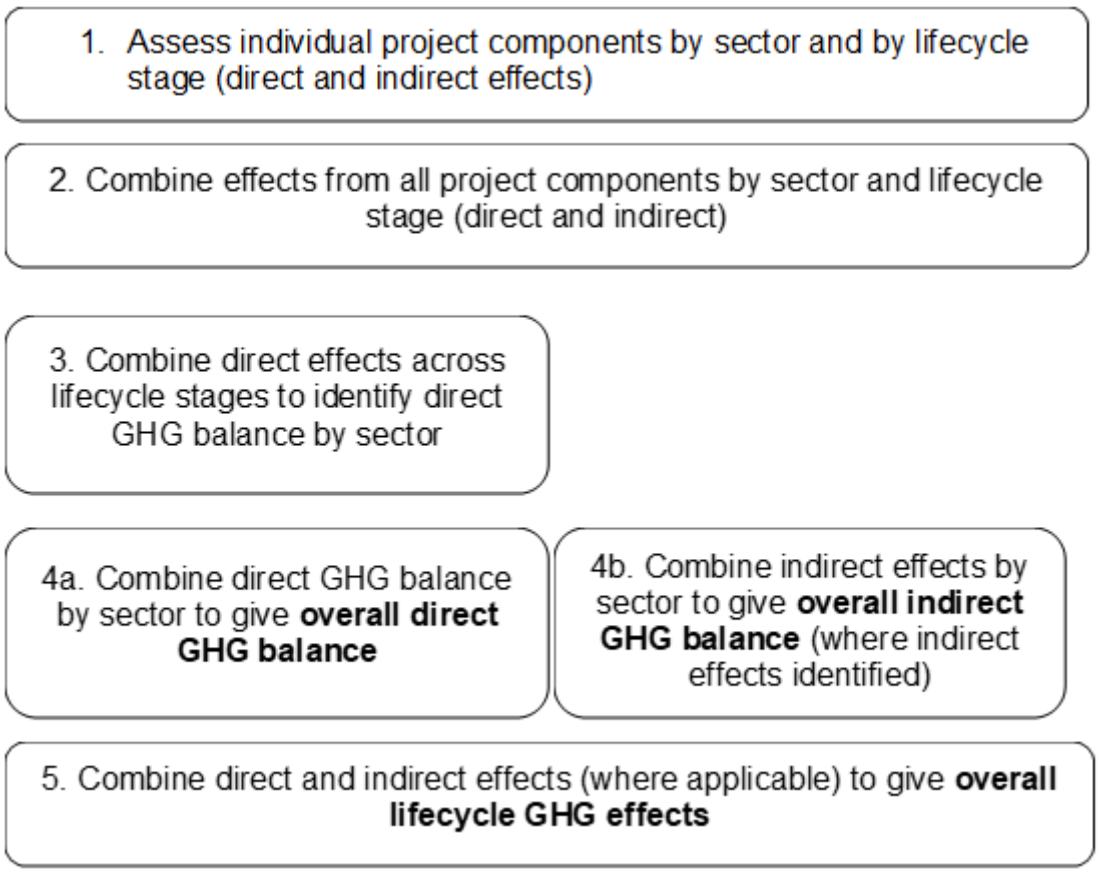
Cradle to grave embodied energy does not include the operational energy or carbon emissions of using the product/building, which is captured in other rows of the assessment framework.

Methodology

Introduction

This section provides an overview of the methodology applied to the assessment process. The stages in this process are summarised in Figure B.1 overleaf, and described in more detail in the following sections. The assessment is based on the proposed national development description and supported by assumptions.

Figure B.1: Assessment stages



Overview of methodology stages

Stage 1

Many of the proposed national developments comprise a number of distinctly different components (e.g. rail infrastructure, industrial development, low carbon energy generation), each of which is likely to have a very different profile of lifecycle GHG emissions. Where this is the case, the assessment is broken down to allow assessment all of the constituent parts. An assessment is undertaken for each of these components, before they are combined to provide an overall picture of the projects GHG effects. Each assessment stage, and the final combined summary are structured as Table B.3.

It should be noted that projects and their components vary considerably in the level of detail available. The assessment has been based on descriptions provided by the Scottish Government. Where project components are high level, the assessment is necessarily broad in nature. The project descriptions should be read alongside the information provided in NPF4. It is acknowledged that more detailed proposals for some NDs have been published elsewhere, but for reasons of certainty and consistency, the assessment has been limited to the components defined by the SG.

The assessment firstly identifies the nature and scale of the effect for each project element, by sector and lifecycle stage. This is scored using the following system, as illustrated in Table B.1:

Table B.1: Project element scoring

Key
Significant negative (increases emissions)
Minor negative (increases emissions)
Negligible negative (increases emissions, several negligible effects could combine in the summary table)
Negligible positive (increases emissions, several negligible effects could combine in the summary table)
Mixed negligible (both increases and reduces emissions at a negligible scale)
Mixed (both increases and reduces emissions at a minor scale)
Minor positive (reduces emissions)
Significant positive (reduces emissions)
No effect

An example of the assessment table which applies this scoring system for each project element is illustrated in Table B.3.

Direct effects on emissions

The assessment framework allows the consistent consideration of direct GHG emissions or savings associated with each proposed national development (ND). This framework distinguishes between different sources of emission (e.g. transport, heating) and different lifecycle stages (e.g. construction, operation).

The framework allows recording of embodied carbon, reflecting the potential for significant amounts of carbon to be embodied in existing structures and materials required for construction, and for the energy use in their production and manufacture. This also allows the 'flow' of carbon to be distinguished in the assessment framework, so that the balance between an initial investment in infrastructure which achieves a long term flow of low carbon activity can be identified. Most infrastructure projects will result in initial carbon emissions from construction, followed by much lower carbon emissions from operation. For renewable energy projects the assessment will include GHG emissions savings over the lifetime of the project as they displace energy generated by fossil fuels.

Indirect effects on emissions

It is recognised that some of the ND include developments which are demonstrator projects will support future roll out of a new technology, or they are projects that enable other low carbon activities, such as enhancements to the transmission network to carry renewable energy. Indirect emissions effects are also identified in the assessment table in relation to the operational phase of development. These are quantified where appropriate in terms of:

- extent (local, regional, national);
- duration (short, medium, long term),
- if the development enables other low carbon activity (such as improvements to grid infrastructure supporting renewable energy development); or
- if the development has a multiplier effect, for example through research and development or demonstration.

Direct emissions and indirect emissions are each reported in a separate section of the conclusions before being drawn together to identify the overall effect.

Predicting GHG effects

Assessment of the likely type and scale of emissions or emission savings draws on published information about GHG emissions associated with different types of development. The level of available information varies considerably between types of emission and also stage of development, which is reflected in the assessment. Equally, where information on the ND is imprecise, it may be necessary to consider a range of emission scenarios. Where no information is available, judgements are based on professional judgement and clearly indicated as such.

Assessing significance

Having identified, calculated or estimated the likely GHG emission effects of each ND component, across each emission type and lifecycle stage, the next stage is to assess their significance.

To assist in this process, we have defined a series of emissions benchmarks based on the sectoral carbon reduction pathways to 2032 set out in the 2020 Climate Change Plan update (CCPu), and updated in 2021. It is recognised that the emissions are projected to decrease over time, and therefore in the future a smaller decrease in emissions contributes a larger proportion of the reduction. The benchmark of 2021 is therefore used to provide a static figure against which all reductions can be assessed, to remove the uncertainty around future targets which may be subject to change. So, for example, the emission reductions resulting from a proposed waste development would be considered in terms of its contribution to the reductions in emissions required from the waste sector up to 2032.

Recognising that these scales of change are somewhat abstract and that predictions may be challenging for some development types and emission sources, we developed a series of benchmarking examples to guide assessors' decisions.

All emissions, either positive or negative have been given equal weighting within the assessment framework in order to allow judgements to be made on the overall balance of GHG emissions.

For example, in terms of buildings, the CCPu has set a requirement for the sector to reduce emissions from 7.6 $MtCO_2e$ in 2021 to 2.6$mtCO_2e$ by 2032, a reduction of 5.0 $MtCO_2e$. The corresponding scales of effect, and benchmarking examples, would be as shown in Table B.2:

Table B.2: Benchmarking

Scale of effect	**Change in emissions**	**Tonnes CO_2e**	**Benchmark #1**	**Benchmark #2**
Minor	<1%	<50,000 tonnes	eq to emissions to up to 2,500 homes	replacement of up to 8,800 conventional boilers
Moderate	1-5%	up to 250,000 tonnes	up to 12,500 homes	up to 44,500 boilers
Major	5-10%	up to 500,000 tonnes	up to 25,000 homes	up to 88,000 boilers
Super	10%	>500,000 tonnes	>25,000 homes	>88,000 boilers

A fuller set of benchmark examples is provided in Table B.8.

Where information is provided on the likely scale of change in GHG emissions for a ND, this was factored into the assessment. However, due to the high level nature of the proposed and alternative proposed national development descriptions, this information is typically very broad.

Table B.3 is repeated for as many elements of the proposed or alternative proposed national development as required. For some projects with a less complex scope only a single assessment table is required before moving to Stage 2.

Table B.3: Example assessment table

Development	Sub-category	Source of emissions	Baseline	Stage of development				Uncertainty
				Construction	Operations (direct)	Operations (indirect)	Decommissioning	
NAME	SUB CATEGORY	**Transport**		*Explanatory text for positive or negative effect and scale of effect*	*Explanatory text*	*Explanatory text*	*Explanatory text*	*Explanatory text*
		Electricity			*Explanatory text*	*Explanatory text*		
		Buildings/Heat						
		Industrial, manufacture and construction processes		*Explanatory text*				
		Waste		*Explanatory text*	*Explanatory text*		*Explanatory text*	
		LULUCF						
		Negative Emissions Technologies (if applicable)						

Stage 2

The Stage 1 assessment is then followed by a summary table which combines all project components to identify the balance of effect by sector, by lifecycle stage. The main body of the summary table is illustrated in Table B.4 below.

Table B.4: Example summary table (excluding final column)

Summary of significant effects from all project components including cumulative effects.	**Baseline**	**Construction/ establishment**	**Operation (direct)**	**Operation (indirect effects not included in GHG balance by sector)**	**Decommissioning**
Transport		*Overall combined transport **construction/establishment** GHG emissions for **all project components***	*Overall combined transport **operation (direct)** GHG emissions for **all project components***	*Overall combined transport **operation (indirect)** GHG emissions for **all project components***	*Overall combined transport **decommissioning** GHG emissions for **all project components***
Electricity					
Buildings (heat)					
Industrial, manufacture and construction processes					
Waste					
LULUCF					
Negative Emissions Technologies ((if applicable)					

Stage 3: Assessment of effects by emissions sector

The next step was to draw conclusions about the overall impact of a pND on GHG emissions. Firstly, where relevant, it was necessary to combine the assessments for individual project components to build a picture of the overall emissions effects of the National Development as currently proposed.

As illustrated in Table B.6: Process for identifying GHG balance by sector (direct effects), the summary table draws conclusions on the combined direct effects across construction/establishment, operation and decommissioning by sector. The overall GHG balance is identified as positive or negative, (see the final column of Table B.6), and the scale of that effect is related to the benchmarking for that sector using the colour coding shown in Table B.5 below. The benchmarking relates to the quantity of 2021 emissions reductions by 2032, and is explained in more detail in the section on 'Assessing significance'.

The next step was to draw conclusions about the overall impact of a pND on GHG emissions. There are two stages to this. Firstly, where relevant, it was necessary to combine the assessments for individual project components to build a picture of the overall emissions effects of the National Development as currently proposed. Secondly, taking account of the scale and significance of effects on emissions at different lifecycle stages, and the duration of lifecycle stages, professional judgement was used to draw conclusions about the overall impact of the development in question. Due to variations in the level of information underpinning the assessment a qualitative approach was used.

Assessment of emissions against the 'Negative Emissions Technologies' sector is only included where this is relevant to the proposed national development.

Table B.5: Benchmarking score colour codes

Overall effect colour codes (positive)	**Overall effect colour codes (negative)**
Minor	Minor
Moderate	Moderate
Major	Major
Super	Super
Neutral	Neutral

Table B.6: Process for identifying GHG balance by sector (direct effects)

Summary of significant effects from all project components including cumulative effects.	Baseline	Construction/ establishment	Operation (direct)	Operation (indirect effects not included in GHG balance by sector)	Decommissioning	GHG balance by sector (direct)
Transport						Overall judgement on direct GHG balance by sector related to benchmarking
Electricity						
Buildings (heat)						
Industrial, manufacture and construction processes						
Waste						
LULUCF						

Stages 4a, 4b and 5: Judgements about overall effect

The next step was to draw conclusions about the overall effect of a pND on GHG emissions. There are two stages to this. Firstly, where relevant, it was necessary to combine the assessments for individual project components to build a picture of the overall emissions impacts of the National Development as currently proposed. Secondly, taking account of the scale and significance of effects on emissions at different lifecycle stages, and the duration of lifecycle stages, professional judgement was used to draw conclusions about the overall impact of the development in question. Due to variations in the level of information underpinning the assessment a qualitative approach was used.

Following the sector by sector combination of effects, summary text is provided for direct effects, indirect effects and the overall summary of effects.

The summary of effect identifies whether effects are net positive (decrease emissions) or net negative (increase emissions). The overall summary draws together effects across different emissions sectors and takes both direct and indirect effects into account. This conclusion is based on the detail provided at the time of the assessment, and the conclusion may be subject to change depending on the nature and detail of the projects taken forward. The overall summary of effect for each proposed national development may include a range of potential impacts on greenhouse gas emissions. This reflects the uncertainties associated with the detail of the proposed national developments, the scale of potential effects, and uncertainties around the implementation of new technologies. The assessment detail identifies the approximate scale of increase or decrease in emissions in qualitative terms, which may range from low to very high.

This information on overall effects is presented beneath the summary table, as illustrated in Table B.7:

Table B.7: Process for identifying summary GHG balance for direct, indirect and overall effects

Summary of direct lifecycle GHG effects	Describes the overall direct lifecycle GHG effects, noting the confidence level related to effects for each sector. The overall effect is identified as net positive or negative.
Summary of indirect lifecycle GHG effects	Describes the overall indirect lifecycle GHG effects. The overall effect is identified as net positive or negative.
Summary of overall lifecycle GHG effects	Describes the overall effect, combining direct and indirect effects. Identifies the scale of the effect, which may be a range depending on uncertainties associated with the proposed national development. The range used is from low, medium, high to very high. The summary attributes a confidence level to the scale and / or nature of the effect.
Additional mitigation and enhancement	Describes suggested mitigation and enhancement.

Mitigation and enhancement

The final step was to consider, for each pND, whether any of the identified sources of GHG emissions could be mitigated or whether there is scope to enhance carbon reductions. The use of the detailed assessment framework allowed this part of the process to focus in on those aspects of developments where additional measures could result in the greatest GHG savings.

Where a pND identifies any project related mitigation, this was reflected in the assessment, but was identified as mitigation identified by the developer, and a level of uncertainty is attributed to this proposed mitigation. LUC also identified mitigation and enhancement and this was identified as 'additional mitigation and enhancement'.

Cumulative effects across all pND

Finally, cumulative effects across all pND were assessed, bringing together the environmental effects from all of the summary tables by emissions sector. The assessment framework allows judgements to be made across the sectors in terms of sources of emissions. The narrative text reflects on the balance of emissions and reductions between the sectors, drawing out where there are shifts in emissions sources between the below sectors:

- Transport
- Electricity
- Buildings (heat)
- Industrial, manufacture and construction processes
- Waste
- LULUCF.

Table B.8: Benchmarking and examples (benchmarked against 2021 emissions reductions by 2032[3])

Sector (reduction from 2021 to 2032)	Significance rate	% required emission reduction	tonnes CO2e	benchmark #1	benchmark #2
Agriculture	Minor	<1%	<15,000		

[3] See Appendix C: https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/pages/17/

Sector (reduction from 2021 to 2032)	Significance rate	% required emission reduction	tonnes CO2e	benchmark #1	benchmark #2
(1.5mtCO2e reduction)			tonnes		
	Moderate	1-5%	75,000 tonnes		
	Major	5-10%	150,000 tonnes		
	Super	0.1	>150,000 tonnes		
Electricity (6.3mtCO2e reduction)	Minor	<1%	<63,000 tonnes	carbon savings from up to 28 2MW turbines[4]	
	Moderate	1-5%	315,000 tonnes	carbon savings from 140 2MW turbines	Shell St Fergus 318k tonnes
	Major	5-10%	630,000 tonnes	carbon savings from 278 2MW turbines	Grangemouth CHP 702k tonnes
	Super	0.1	>630,000 tonnes	carbon savings from >278 2MW turbines	Peterhead PS 2m tonnes
Industry (5.8mtCO2e reduction)	Minor	<1%	<58,000 tonnes	Aberdeen papermill 64k tonnes	
	Moderate	1-5%	290,000 tonnes	15 Dundee tyre factories @20k tonnes	
	Major	5-10%	580,000 tonnes	Blue Circle at Dunbar 573k tonnes	
	Super	0.1	>580,000 tonnes	Peterhead PS 2m tonnes	
Waste	Minor	<1%	<8000	up to 18150	

[4] Compared with grid mix generation: https://www.gov.scot/publications/calculating-carbon-savings-wind-farms-scottish-peat-lands-new-approach/pages/13/

Sector (reduction from 2021 to 2032)	Significance rate	% required emission reduction	tonnes CO2e	benchmark #1	benchmark #2
(0.8mtCO2e reduction)			tonnes	fewer tonnes household waste to landfill	
	Moderate	1-5%	40,000 tonnes	90,000 fewer tonnes household waste to landfill	
	Major	5-10%	80,000 tonnes	181,250 fewer tonnes household waste to landfill	
	Super	0.1	>90,000 tonnes	>181,250 fewer tonnes household waste to landfill	
Transport (3.7mtCO2e reduction)	Minor	<1%	<37,000 tonnes	up to 12,250 fewer cars[5]	up to 310 fewer HGVs[6]
	Moderate	1-5%	up to 185,000 tonnes	61,250 fewer cars	1500 fewer HGVs
	Major	5-10%	up to 370,000 tonnes	122,500 fewer cars	3,100 fewer HGVs
	Super	0.1	>370,000	more than 122,500 fewer cars	more than 3,100 fewer HGVs
Buildings (5mtCO2e reduction)	Minor	<1%	<50,000 tonnes	eq to emissions to up to 2,500 homes[7]	replacement of up to 8,800 conventional boilers[8]

[5] Based on data from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020, medium sized car, 10,000 miles pa

[6] Based on data from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020 for HGV travelling 100,000 miles pa

[7] Based on average house emissions of 20 tonnes CO2e pa

Sector (reduction from 2021 to 2032)	Significance rate	% required emission reduction	tonnes CO2e	benchmark #1	benchmark #2
	Moderate	1-5%	up to 250,000 tonnes	up to 12,500 homes	up to 44,500 boilers
	Major	5-10%	up to 500,000 tonnes	up to 25,000 homes	up to 88,000 boilers
	Super	0.1	>500,000 tonnes	>25,000 homes	>88,000 boilers
LULUCF (1.8mtCO2e increase in sequestration)	Minor	<1%	up to 18,000 tonnes	up to 67ha mature broadleaf	up to 107ha mature conifer[9]
	Moderate	1-5%	90,000 tonnes	333ha mature broadleaf	535ha mature conifer
	Major	5-10%	180,000 tonnes	667ha mature broadleaf	1071 ha mature conifer
	Super	0.1	>180,000 tonnes	>667ha mature broadleaf	>1071 ha mature conifer

[8] http://www.heatingandventilating.net/heat-pumps-performance-and-carbon-saving

[9] https://www.forestresearch.gov.uk/documents/983/fcin048.pdf

This publication is available at **www.gov.scot**

Any enquiries regarding this publication should be sent to us at

The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

ISBN: 978-1-80525-209-2 (web only)

Published by The Scottish Government, November 2022

Produced for The Scottish Government by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
PPDAS1184943 (11/22)

w w w . g o v . s c o t