Carbon Tracker Initiative

The Real Emissions of Peterhead-CCS

Key Findings

This report estimates the real emissions of the proposed Peterhead gas power plant with carbon capture by SSE & Equinor. The main goal is to assess whether the emissions reported in the Environmental Impact Assessment report provide an accurate estimate of the future emissions of this project.

We found serious omissions and shortcomings in the developer's Environmental Impact Assessment report, resulting in a severe underestimation of the project's climate impact.

The underestimate is driven by three major factors:

- omissions of emissions related to the **supply of natural gas**,
- emissions during periods of **unplanned outage** of the carbon capture plant are not estimated,
- **capture rates** might be lower than claimed by the developers.

In particular, the omission of upstream emissions would be in contrast with the approach adopted in England for a similar project, Net Zero Teesside Power.

We found that the lifetime emissions of Peterhead-CCS could be three to five times higher than reported by the developer.

As a result, the project would have a **Major Adverse impact** on the Scottish carbon budget. In our central scenario, the project would increase annual Scottish emissions by 5% in its first operating year, reaching almost 50% of Scotland's annual emissions in 2044. Worryingly, the project will continue its operations past the Scottish 2045 carbon neutrality target, thus necessitating a substantial increase in costly and unproven carbon removal technologies.

While this report focuses on the Peterhead-CCS case study, it is crucial to highlight that these issues extend well beyond this project. Carbon Tracker has identified this as a **structural problem,** with similar under-reporting errors found across all gas-based CCUS projects currently under development in the UK.

1 Introduction

Carbon Tracker's report "*Kind of Blue*" from July 2024 highlighted how climate emissions from gas-CCS power plants and blue hydrogen are often under-reported by either ignoring or underestimating the intensity of upstream emissions

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Disclaimer

in the natural gas supply chain[1]. Upstream emissions refer mostly to carbon dioxide and methane emissions occurring in the natural gas supply chain through the extraction, processing, transport and distribution of the fossil fuel.

In this report, we apply these findings to the proposed gas-CCS power plant, Peterhead Carbon Capture Power Station. This project would be located in Aberdeenshire, Scotland, adjacent to an existing 1180 MW gas-power plant operated by SSE. Peterhead-CCS aims to construct a 910MW gas power plant coupled with a carbon capture unit to abate CO2 emissions for its operation. The project, developed in collaboration by SSE and Equinor, is currently awaiting a planning decision from the Scottish Government.

Peterhead-CCS is part of a wider group of "low-carbon" dispatchable power plants supported by the UK Government as part of its efforts to decarbonise the power sector. Numerous similar projects are being considered, among which are SSE's Keadby 3, bp's and Equinor's Net Zero Teesside Power, Uniper's planned retrofit of the Grain power plant and three projects planned by RWE. Peterhead-CCS anticipates linking to the proposed Scottish cluster, which aims to collect carbon emissions from several industrial applications in the area and store them in the Acorn storage site in the North Sea[2].

However, as Carbon Tracker pointed out in two recent reports – *"Curb your Enthusiasm"* and "*Kind of Blue*" – there are many issues with gas-CCS projects including high delivery risk, stranded asset risk and high operating costs. Amongst all, the most concerning issue is that the real climate impact of these projects is constantly underestimated by ignoring upstream emissions in the natural gas supply chain. In this report, we'll focus on the potential climate impact of Peterhead-CCS and show how its developers are severely underestimating it. The findings of this analysis are vital for Scottish policymakers who are tasked to make a final decision on this project.

2 Shortcomings in emission reporting

The project's climate change impact assessment, submitted as part of the planning application for the power station, calculates that the lifetime greenhouse gas (GHG) emissions of Peterhead-CCS, under their reference scenario, are 6.3 million tonnes of CO2 ($Mton_{CO2e}$)[3]. SSE reports that almost 90% of the total emissions will be generated from the residual share of CO2 that the carbon capture plant will not be able to sequester from the flue gases. The remaining emissions come from the construction and operations of the project. The developers claim that the carbon capture plant (CCP) will be able to capture between 90-95% of the combustion emissions with the residual flow being released into the atmosphere (note that 100% capture rates are technically unachievable).

Our analysis found important shortcomings in this analysis:

- It ignores upstream emissions related to the consumption of natural gas.
- It ignores the impact of operations in unabated mode during periods of unavailability of the carbon capture plant, due to maintenance or outages.
- It risks overestimating the carbon capture rate.

2.1 Upstream emissions

Critically, we believe that the most important shortcoming regards the upstream emissions related to the supply of natural gas needed for the power plant's operations. Upstream emissions are produced across the natural gas supply chain, most notably during the extraction, processing, transport and distribution of gas.

[1] *Carbon Tracker (2024) Kind of Blue (here)*
[2] *The Scottish Cluster: Ready to Deliver Industrial Decarbonisation 2023 (here)*
[3] *Refer to Environmental Impact Assessment Report – Volume 2 Chapter 18 – submitted by SSE to The Scottish Government in February 2022 (here)*

The Environmental Impact Assessment (EIA) report for Peterhead-CCS explicitly states that emissions related to the "raw material extraction" should be included in the scope of the analysis of the project's climate impact[4]. In principle, this should include emissions related to the extraction and supply of natural gas consumed by Peterhead-CCS; however, the EIA report ignores them. This is a severe shortcoming as upstream emissions are one of the most significant sources of CO2 emissions for gas-CCS projects.

As we showed in "*Kind of Blue*", upstream emissions can vary drastically depending on the origin of natural gas and mode of transport. While gas extracted from the North Sea is generally linked to lower emissions, imported liquefied natural gas (LNG) has a much higher carbon footprint – up to five times greater than that of domestically sourced gas.

Currently, three-quarters of the UK's gas supply is sourced from the North Sea either via domestic production or from imports from Norway, however, the share of LNG imports is increasing rapidly, especially from the USA. Today, imports of LNG from the USA already increase the carbon intensity of the UK's gas supply due to their higher level of upstream emissions, especially for gas from the Permian basin where fracking produces much higher methane emissions[5].

In the next decade, this trend is set to worsen. Production from the North Sea, even including the unlikely development of future reserves, is expected to drop much faster than demand, widening the already growing gap between supply and demand. Our analysis suggests that in the 2030s the UK could rely for more than half of its supply on imported LNG, especially from the USA and Qatar. As a result, the emission intensity of the average gas supply mix could increase by 50% compared to today, see Figure 1 and Table 1.

The planned development of gas-CCS and blue hydrogen projects in the UK could worsen this problem by creating a new significant source of natural gas demand. In "*Kind of Blue*", we estimate that by 2035 the new gas demand from the gas-CCS and blue hydrogen plants planned by the UK's strategy could be more than twice the projected domestic production[6].

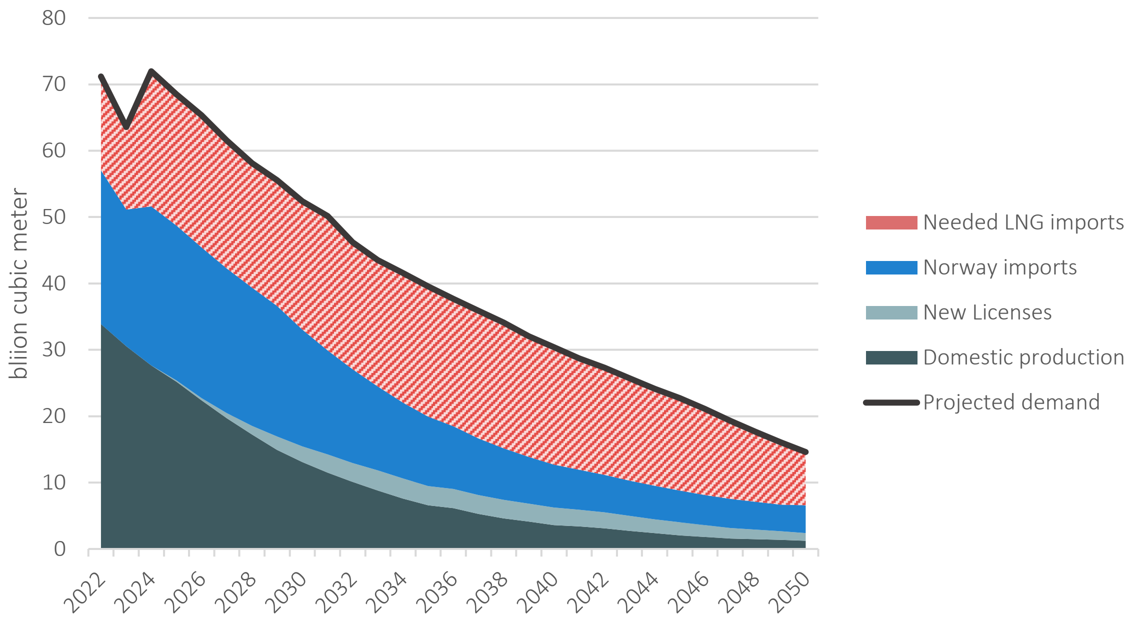
Even considering today's average emission factors of the natural gas supplied to the UK, emissions of the Peterhead-CCS plant would increase substantially once upstream emissions are factored in. Moreover, as the carbon intensity of the gas supply mix is expected to increase, the impact of this omission would be even greater.

Notably, the Department for Energy Security and Net Zero (DESNZ) recognised this problem in a study from 2023 and called for more studies to assess the impact of the increasing reliance on LNG[7].

Furthermore, there is already an important precedent in the UK showing that upstream emissions must not be ignored. The UK Planning Inspectorate requested Net Zero Teesside Power – a similar gas-CCS proposal –to include upstream emissions in its EIA Report to properly reflect its true climate impact[8]. As a result, the projects' lifetime emissions more than doubled from 6MtonCO2 initially reported to 16MtonCO2. Nonetheless, we claim that even this adjustment is under-estimating the real emissions, as the project used historical emission factors rather than accounting for future changes in the supply mix[9].

[4] *Peterhead-CCS EIA Report - Volume 2 - Chapter 18 - Climate Change – Table 18-7 (here)*
[5] *For more details on upstream emissions please consult Carbon Tracker (2024) Kind of Blue (here)*
[6] *Carbon Tracker (2024) Kind of Blue (here)*
[7] *DESNZ 2023 - Role of gas storage and other forms of flexibility in security of supply (link)*
[8] *Net Zero Teesside – See "NZT Power Ltd & NZNS Storage Ltd 9.53 Applicants' Response to CEPP Letter dated 30 May" available here*
[9] *For details see Carbon Tracker (2024) Kind of Blue (here)*

FIG 1: SCHEMATIC REPRESENTATION OF THE UK'S FUTURE NATURAL GAS SUPPLY OUTLOOK



Source: Carbon Tracker (2024)[10]

2.2 Carbon capture plant (CCP) unavailability

SSE's EIA report for Peterhead-CCS states that in the event that the carbon capture plant (CCP) is unavailable (due to maintenance or outages), the plant would operate in the unabated mode, hence, releasing all the CO2 emissions to the atmosphere[11]. However, the report fails to estimate the potential emissions of unabated operations during such periods of CCP unavailability. Even short periods of CCP unavailability could impact total GHG emissions considerably as hourly CO2 emissions in unabated mode are ten times greater than during normal operations[12].

2.3 Carbon Capture rate

Finally, the EIA report assumes that the plant will achieve an average carbon capture rate of 90-95%. This assumption is based on manufacturers' estimates of the technology's performance. However, strong evidence is not available to support that such high capture rates can be achieved consistently under real-life operating conditions.

On the contrary, as Carbon Tracker reports in "Curb your Enthusiasm", the CCUS industry has a history of over-promising and under-delivering. Most of the carbon capture plants operating today struggle to achieve high capture rates above 80%, let alone 90-95%[13].

[10] *Carbon Tracker analysis based on multiple sources including "NSTA: March 2024 Production and expenditure projections" – "DENSZ Energy Trends Gas: June 2024" – "ESO Future Energy Scenarios 2024". This outlook includes the unlikely contribution of the new gas licenses that are currently being considered by the NSTA. These licenses are unlikely to be approved by the current government due to the policy position in the Labour's 2024 manifesto.*
[11] *Peterhead-CCS EIA Report - Volume 2 - Chapter 18 - Climate Change (here)*
[12] *Peterhead-CCS EIA Report - Volume 2 - Chapter 18 - Climate Change (here)*
[13] *IEEFA(2024) – Carbon Capture and Storage (here)*

One of the most telling cases is the Boundary Dam coal-based CCS power station in Canada which throughout its 10-year operating period has achieved an average capture rate estimated at around 65%, far lower than the original promise of 90%.

Reaching high levels of carbon capture for a gas-power plant is even more challenging due to the lower concentration of CO2 in the flue gases (i.e., 4% for gas turbine vs 12% for coal) and the increased demand for flexible operations. Gas power plants are increasingly required to operate flexibly with frequent on-and-off periods to cover the periods of low renewable output. However, there are still uncertainties around the capability of capture units to operate efficiently in these operations.

Furthermore, carbon capture on gas combustion flue gases has not been tested yet on a large scale, increasing the uncertainty of whether such high capture rates could be achieved. Today, there are only a couple of pilot projects applying carbon capture on gas turbines at a scale about 20 times smaller than the proposed Peterhead-CCS[14].

For these reasons, we consider a scenario with a more pessimistic carbon capture rate but that would still allow the plant to comply with the existing regulation. According to the provisional documentation for the Dispatchable Power Agreement gas-CCS plants will need to achieve a minimum capture rate of 70% in order to receive subsidy payments[15].

3 Scenarios

We model five scenarios to evaluate the impact of the key shortcomings in the Peterhead-CCS EIA report:

- **EIA Report** – replicates the same assumptions of the EIA report.
- **Current Supply** – considers the impact of CCP unavailability and upstream emissions related to today's average gas supply mix.
- **Future Supply** – same as above but considers the upstream emissions of the future gas supply (i.e., average 50% from LNG).
- **100% LNG** – same as above, but it assumes that the plant runs on 100% imported LNG.
- **75% Capture** – same as Future Supply but considers a lower capture rate of 75%. Note under this scenario the power plant would still comply with the minimum levels required for the subsidy scheme proposed by the UK's government.

TABLE 1: SUMMARY OF SCENARIOS

Scenario	LNG share (%)	Upstream Emissions (gCO2/MJ_NG)	CCP Availability (%)[16]	Capture Rate (%)
EIA Report	n.a.	0	100	90
Current Supply	25%	9.0	95	90
Future Supply	50%	13.3	95	90
100% LNG	100%	21.6	95	90
75% Capture	50%	13.3	95	75

[14] *Glacier CCS in Alberta Entropy Corporate presentation December 2023 (link) - Tata Chemical in Winnington Integrated annual report 2022/23 (link)*
[15] *DESNZ (2024) - Dispatchable Power Agreement (DPA) Provisional Heads of Terms (here)*
[16] *We estimate a conservative Availability factor of 95% for the CCP unit. For reference, a scientific paper from 2021 shows that the Boundary Dam 3 power plants (i.e. a coal power plant with CCS) that the average availability was below 95% for each year of operation from 2014 to 2020. Janowczyk et al. (2021) Derates and Outages Analysis - A Diagnostic Tool for Performance Monitoring of SaskPower's Boundary Dam Unit 3 Carbon Capture Facility (link)*

For detailed methodology, data inputs and calculations see Annex

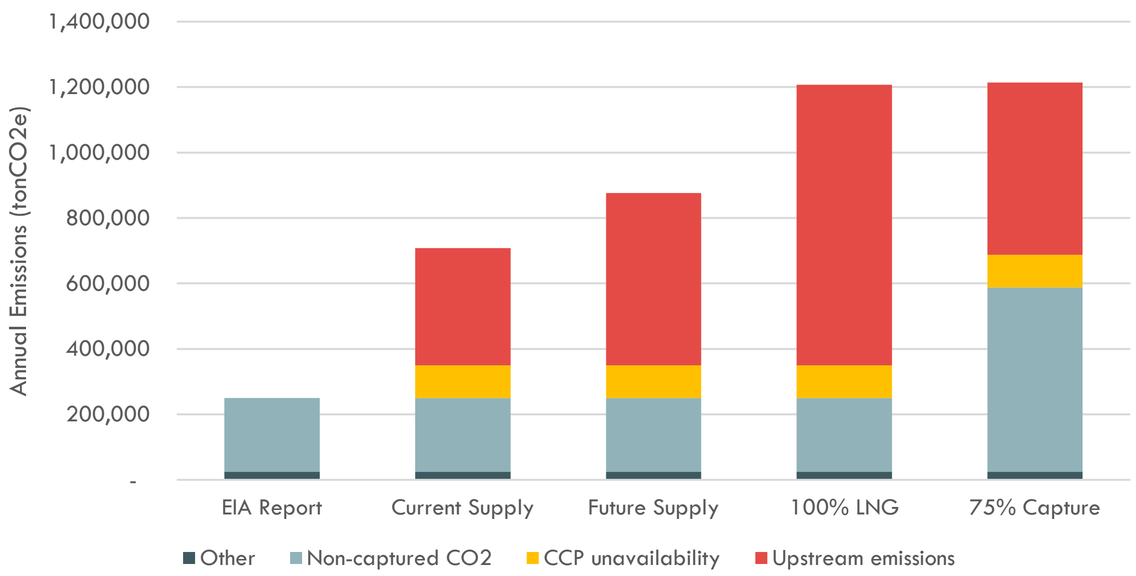
Modelling parameters are based on the "Reference Scenario" provided in the Environmental Impact Assessment report submitted by SSE to the Scottish Government and complemented with Carbon Tracker analysis (See Annex for details). In the Annex we also present the results for two additional scenarios with more pessimistic capture rates.

4 Results

The reference scenario in the EIA report for Peterhead-CCS projects **annual emissions** of 250,000 tonnes of CO2 equivalent (tonCO2e), where 90% would come from the residual CO2 in the flue gases after the carbon capture process.

However, our scenarios show that the omission of upstream emissions, CCP unavailability and partial capture would dramatically increase the project's climate impact, see Figure 2.

FIG 2: ANNUAL EMISSIONS PETERHEAD-CCS, REPORTED VS CARBON TRACKER ESTIMATES



Source: Carbon Tracker (2024). Other is sourced from the EIA report and covers minor sources of emissions including materials and product transport, waste disposal and worker commute.

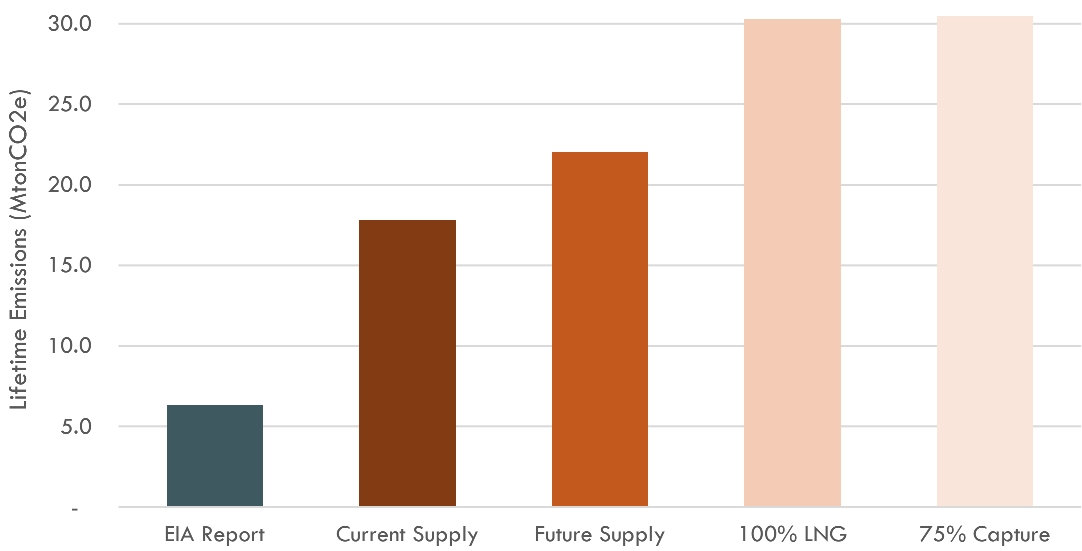
Accounting for periods when the plant would run in unabated configuration due to unavailability of the carbon capture plant would increase annual emissions by 40% compared to the baseline case. We accounted for a conservative estimate of a 95% availability factor for CCP, which translates into roughly 18 days of unplanned outages per year.

Upstream emissions increase the climate impact further. Even using today's supply mix, upstream emissions would increase total emissions by 140%. However, as mentioned above the future gas supply mix is expected to change significantly due to the expected drop in domestic production and consequent increase in LNG imports. In that case, annual emissions could reach 709,000 tonCO2e, 3.5 times higher than the emissions reported in the EIA report. Emissions would grow even further in case the plant would run on 100% imported LNG, reaching 1,207,000 tonCO2e, almost five times higher than reported.

Finally, the scenario with the 75% capture rate would reach 1,214,000tonCO_2e per year, almost five times higher than the values reported in the EIA documentation. Note that under this scenario, the project would still be eligible for UK Government subsidy regardless of the high climate impact[17].

In aggregate, **we found that the scenarios presented in the EIA Report severely underestimate lifetime emissions**. We estimate that the real emissions of the Peterhead-CCS during its planned 25 years of operation could be between 2.8 to 4.8 higher than reported in SSE's EIA Report. We estimate that lifetime emissions could range from 18 to 31 million tonnes of CO_2 equivalent ($Mton_{CO2e}$) compared to only 6.3 $Mton_{CO2e}$ reported by the developer.

FIG 3: LIFETIME EMISSIONS PETERHEAD-CCS REPORTED VS CARBON TRACKER ESTIMATES



Source: Carbon Tracker (2024)

Climate Impact of Peterhead-CCS

Following the criteria set out in the Environmental Impact Assessment report, we consider that the project's emissions have a "high significance" and a "major adverse" impact if they exceed 1% of the relevant annual Scottish or UK Carbon Budgets.

Currently, Scotland does not adopt the carbon budget approach and is in the process of reviewing its climate targets. For assessing the climate impact of Peterhead on the Scottish climate budget we used the same approach adopted by SSE in the EIA report, relying on the projected annual carbon budget from the current annual targets that would lead to achieving the target of net zero emissions by 2045. We recognise that annual targets are currently under revision, thus the exact impact on each year's budget might differ, but using this method allows comparison with the developer's projections.

SSE already determined that the project could determine a high increase in GHG emissions starting from the first year of operation (i.e., 2034) at 1.7% and reaching 16.5% in 2044 one year before carbon neutrality, hereafter the budget effectively falls to zero. Our analysis shows that emissions could be much higher than this. In the Future

[17] *The plant would be complying with the minimum criteria for carbon capture rate detailed in the Dispatchable Power Agreement is 70%. DESNZ (2024) - Dispatchable Power Agreement (DPA) Provisional Heads of Terms (here)*

Supply scenario, emissions would be 4.9% of Scotland's carbon budget in the first year and 47.2% in 2044. In the "75% Capture" scenario, these values would grow to 8.4% and 81.0%.

Worryingly, the project's emissions would extend far beyond the net zero emission target year of 2045 threatening the achievement of this target. To compensate for this project Scotland would need to increase its reliance on costly and yet unproven carbon removal technologies.

Therefore, the GHG emissions of the Peterhead-CCS are considered as having a '**high increase**' (i.e., >1%) magnitude and therefore classified as '**major adverse**' significance.

TABLE 2: RELATIVE IMPACT OF THE PROJECT'S GHG EMISSIONS VS THE SCOTTISH CARBON BUDGET

	Annual Emissions Million Tonnes CO2e				Percentage Contribution to the Scottish Carbon Budget		
	Scottish Carbon Budget	EIA Report	Future Supply	75% Capture	EIA Report	Future Supply	75% Capture
2034	14.4	0.25	0.71	1.21	1.7%	4.9%	8.4%
2035	13.2	0.25	0.71	1.21	1.9%	5.4%	9.2%
2036	12.1	0.25	0.71	1.21	2.1%	5.9%	10.0%
2037	11	0.25	0.71	1.21	2.3%	6.4%	11.0%
2038	9.8	0.25	0.71	1.21	2.6%	7.2%	12.4%
2039	8.7	0.25	0.71	1.21	2.9%	8.1%	14.0%
2040	7.6	0.25	0.71	1.21	3.3%	9.3%	16.0%
2041	6.1	0.25	0.71	1.21	4.1%	11.6%	19.9%
2042	4.5	0.25	0.71	1.21	5.6%	15.7%	27.0%
2043	3	0.25	0.71	1.21	8.3%	23.6%	40.5%
2044	1.5	0.25	0.71	1.21	16.7%	47.2%	81.0%
2045	0	0.25	0.71	1.21			
....							
2058		0.25	0.71	1.21			

Source: Carbon Tracker (2024). The Scotland Carbon Budget has been determined with the same approach used in the EIA report for Peterhead in accordance with The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019

TABLE 3: RELATIVE IMPACT OF THE PROJECT'S GHG EMISSIONS VS THE UK'S CARBON BUDGETS

Project impact	EIA Report	Current Supply	Future Supply	100% LNG	75% Capture
UK 6th Carbon Budget 2033-37	0.1%	0.3%	0.4%	0.5%	0.5%
UK 7th Carbon Budget 2033-37	0.2%	0.5%	0.7%	0.9%	0.9%

Source: Carbon Tracker (2024). Assumes project start year of 2034. The UK's 7th Carbon Budget is estimated at 526 MtonCO2 from "The Sixth Carbon Budget" Climate Change Committee (2020) emission pathway under the Balanced Net Zero Pathway

Annex

TABLE 4: BREAKDOWN OF ASSUMPTIONS FOR MODEL SCENARIOS + TWO ADDITIONAL MORE CONSERVATIVE SCENARIOS

Scenario	LNG share (%)	Upstream Emissions (gCO2/MJ_NG)	CCP Availability (%)	Capture Rate (%)
EIA Report	n.a.	0	100	90
Current Supply	25%	9.0	95	90
Future Supply	50%	13.3	95	90
100% LNG	100%	21.6	95	90
75% Capture	50%	13.3	95	75
75% Capture +100% LNG	100%	21.6	95	75
70% Capture	50%	13.3	95	70

TABLE 5: DETAILED MODELLING RESULTS FOR ANNUAL EMISSIONS

tonnesCO2e	EIA Report	Current Supply	Future Supply	100% LNG	75% Capture	75% Capture + 100% LNG	70% Capture
Non-captured Emissions CCS	225,238	225,238	225,238	225,238	563,094	563,094	675,713
Emissions CCS unavailability	0	99,562	99,562	99,562	99,562	99,562	99,562
Upstream emissions	0	359,038	527,018	857,394	527,018	857,394	527,018
Other	24,733	24,733	24,733	24,733	24,733	24,733	24,733
Total	**249,971**	**708,571**	**876,551**	**1,206,928**	**1,214,407**	**1,544,784**	**1,327,026**

Modelling assumptions from “SSE THERMAL PETERHEAD LOW CARBON CCGT POWER STATION PROJECT Environmental Impact Assessment Report - Volume 2: Chapter 18 – Climate Change and Sustainability” (Available here)

Main values of Reference Case:

- Gross Capacity: 773 MW
- 8000 hours per year at 100% capacity

TABLE 6: DETAILED MODELLING RESULTS FOR LIFETIME EMISSIONS

Million tonnesCO2e	EIA Report	Current Supply	Future Supply	100% LNG	75% Capture	75% Capture + 100% LNG	70% Capture
Total lifetime emissions	**6.3**	**17.8**	**22.0**	**30.3**	**30.5**	**38.7**	**33.3**

Lifetime emissions based on developer estimate of 25 years of operation

TABLE 5: GAS SUPPLY SCENARIOS BY SOURCE AND AVERAGE CARBON INTENSITY

Supply Share (%)	Current Supply (2023)	Future Supply	100% LNG
Domestic	43%	28%	0
Norway Pipeline	32%	22%	0
LNG USA	15%	31%	61%
LNG Qatar	3%	7%	14%
LNG Other	6%	12%	25%
Carbon Intensity (gCO2/MJ_NG) Including grid losses	**9.0**	**13.3**	**21.6**

Supply mix 2023 extracted from DENSZ Energy Trends Gas: June 2024 (here)

For future scenarios, we assume that the relative import share between LNG sources and domestic/Norway remains constant as the overall balance shifts towards LNG.

TABLE 6: CARBON INTENSITY NATURAL GAS BY SOURCE

Carbon Intensity (gCO2/MJ_NG) Share (%)		Sources
Domestic	3.4	UK NSTA 2024
Norway Pipeline	3.5	UK NSTA 2024 and EU DG Energy 2015
LNG USA	22.5	UK NSTA 2024, Zhu et al 2024, IFEU 2023, Thinkstep 2017
LNG Qatar	15.1	UK NSTA 2024 and IFEU 2023
LNG Other	17.2	All the above

Sources:

- UK NSTA 2024 – Emissions Monitoring Report 2023 ()
- EU DG Energy 2015 – Study on actual GHG data for diesel, petrol, kerosene and natural gas (here)
- IFEU 2023 - Analysis of the greenhouse gas intensities of LNG imports to Germany (here)
- Zhu et al 2024 – Geospatial Life Cycle Analysis of Greenhouse Gas Emissions from US Liquefied Natural Gas Supply Chains (here)
- Thinkstep 2017 – GHG Intensity of Natural Gas Transport (here)