Sero Net Diwydiant Cymru | Net Zero Industry Wales

Economic Case for Shipping CO_2

A Net Zero Industry Wales Report

Net Zero Industry Wales

Net Zero Industry Wales (NZIW) is a not-for-profit umbrella organisation that supports the Welsh Industrial Clusters and its members in their journey to net zero.

Mission

NZIW's mission is to make Wales the country of choice for sustainable goods and services, by supporting a trusted, sustainable, prosperous and resilient Welsh industry.

Why Wales?

Electricity generation and industry (manufacturing) is currently one of the major contributors to Wales's carbon footprint with over half of its emissions coming from these two sectors. Electricity generation and manufacturing, however, are critical to producing the products, such as steel, cement, insulation, nickel and chemicals - required to transition to net zero. Failure to support the decarbonisation of these industries will, not only have adverse economic impacts on Wales and the UK but also increases the risk of carbon leakage by importing these products from countries that may not be as committed to decarbonisation. The economically sensible and globally responsible course of action is to, therefore, invest in local decarbonisation.

Wales also has a large industrial heritage and played a major role in the first industrial revolution, which was powered by Welsh coal. The abundance of a competitively priced, high quality energy source, attracted energy intensive industry to base itself in Wales resulting in large numbers of well-paid, high-quality jobs in Wales. The challenge now is to future-proof these jobs. The transition to a low carbon economy is both a threat and an opportunity for the industrial base. NZIW is working to ensure that it can preserve Wales' rich industrial heritage whilst also placing it at the forefront of the green industrial revolution. By enabling a green transition, NZIW will together create and support an inclusive, skilled and well-paid workforce that will help future generations prosper.

Supported Clusters

NZIW now governs the South Wales Industrial Cluster (SWIC). SWIC is a South Wales partnership between Welsh industry, energy suppliers, infrastructure providers, academia, legal sector, service providers and public sector organisations committed to a greener economy. As part of NZIW, SWIC's main aim is achieving net zero and at the same time reversing the decline of heavy industry in South Wales, creating economic prosperity for Wales. NZIW and SWIC are working to support the development of net zero manufacturing in the UK by developing low carbon electricity, hydrogen and CCUS infrastructure in Wales. Their work will encourage investment in new, low-carbon technologies that will inspire research, innovation and attract inwards investment from both the UK and abroad.

Foreword by NZIW CEO

CO_2 shipping is the switch that initiates emissions reduction & economic growth across the South Wales region

I am delighted to be launching this Net Zero Industry Wales (NZIW) report looking at the Value for Money (VFM) case for shipping CO_2 emissions.

Carbon Capture & Storage (CCS) technology plays an important role in decarbonising heavy industry in South Wales. Investment in infrastructure to ship captured CO_2 to stores in places like Scotland and Humber will give Welsh industry access to CO_2 storage in a timeline consistent with Wales' net zero ambitions and the switch that will initiate decarbonisation and economic growth across the region.

Our analysis indicates that there is a strong case for public investment in the infrastructure required to ship captured emissions. The investment will protect industries and communities in South Wales, and provide a springboard to the wider development of new low-carbon infrastructure while facilitating the development of the green industries of the future. Our quantitative analysis is underpinned by data from member organisations and is carried out in line with HM Treasury Green Book guidance.

In light of these findings, we hope we can count on the UK Government's support to incorporate CO_2 shipping into the Track 2 process, to enable a Just Transition and to kick-start a transformational change of our industrial landscape in Wales, which NZIW & its members are keen to make a reality.

Ben Burggraaf, CEO, Net Zero Industry Wales

Foreword by Lloyds Bank

LLOYDS BANK

Achieving net zero CO_2 emissions by 2050 is critical to heading off the worst impacts of the climate crisis. It will require big changes – including for the UK economy. But it can also drive UK prosperity for decades to come.

As an industrial cluster South Wales is the UK's second largest carbon emitter with nationally strategic producers in sectors such as iron and steel, petrochemicals, oil refining and power. If anticipated carbon taxes were applied to these industries without mitigating measures, many would be forced to close, with devastating economic and social consequences.

The geology of South Wales is unsuitable for carbon storage. However, the creation of an end-to-end CO_2 capture and transportation solution – to facilitate the shipping of CO_2 to UK sequestration sites – would enable the region's industries to continue to thrive. Moreover, it would secure and create high-value jobs, align with the UK's energy and carbon policies, and boost green growth.

The investment required to make this vision a reality is sizeable. But it's not all about money. Partnerships must be built between Government and stakeholders across financial services, industry and local communities so that together we can deliver a sustainable future for South Wales.

Huw Howells, Managing Director & Head of Manufacturing & Industrials, Lloyds Bank

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Executive Summary

This report analyses the economic case for investment in the infrastructure to facilitate the shipping of CO_2 emissions from South Wales to stores in other UK regions.
Using UK Government Green Book[1] appraisal approaches, the analysis in this report shows that the benefits, in the form of safeguarded Gross Value Added (GVA) and jobs in South Wales' high value industrial base, reduced emissions, and employment in the construction and ongoing operation of new low-carbon facilities, outweighs the costs of an end-to-end CO_2 capture and transportation solution. Although public funding will be required to catalyse the investments required, this will be outweighed by the tax receipts which are protected and created. Furthermore, this support can spread over time through a Contract for Difference (CfD) which will provide revenue certainty for developers and industry.

This report has been developed by Net Zero Industry Wales (NZIW) in conjunction with several member organisations involved in the development of Carbon Capture Utilisation & Storage (CCUS) in South Wales (RWE, Dragon LNG, Associated British Ports, 7CO2).

The South Wales Industrial Cluster (SWIC) is one of the UK's largest in terms of emissions and economic value. It includes producers of national strategic importance in sectors such as iron and steel, petrochemicals, refineries and power. For many of these facilities, CCUS represents the most cost-effective route to deep decarbonisation. However, the region does not have suitable facilities (such as depleted oil and gas fields) where CO_2 emissions can be safely stored.

The Government's Cluster Sequencing process[2] is the policy vehicle for funding investments in CO_2 capture technology and transportation and storage (T&S) networks in the UK. The Government process currently makes provision only for pipeline-based T&S solutions. CO_2 pipelines connecting South Wales with regions such as Humber and Scotland with access to offshore stores are likely to be complex, costly and time-consuming to implement.

In 2023, the UK government announced £20 billion for early deployment of CCUS, including £1 billion for a CCUS Infrastructure Fund to support the capital costs of strategic CCUS infrastructure and T&S networks.[3] This funding could play a vital role in supporting a Just Transition across all industrial clusters including SWIC. However, SWIC would not be able to access this funding without shipping since it is the largest industrial cluster that does not have direct access to a pipeline and store.

While long-distance pipelines are a conventional method for CO_2 transport, they are often subject to extended implementation timelines due to intricate regulatory frameworks and complex planning processes, especially in a densely populated country such as the UK. By contrast, shipping CO_2 could offer a more agile solution that avoids these issues allowing for emissions abatement in South Wales in line with the net zero ambitions of the Welsh and UK Governments.

Approach to assessing the economic case

Our approach is based on a cost-benefit analysis, incorporating multiple scenarios to capture the variability in costs and benefits. The costs we have considered are capital and operational expenditures associated with capturing, transporting and storing CO_2. We have identified a range of benefits from investment in CO_2 shipping infrastructure in South Wales. These benefits are:

-Protection of GVA in emissions-intensive sectors: rising CO_2 prices under the UK Emissions Trading Scheme (UK ETS) have the potential to make some industry uncompetitive and therefore at risk of closure. CCUS allows these industries to limit their exposure to CO_2 prices and continue to operate in South Wales;

-Environmental benefits driven by lower emissions as CCUS is implemented;

-Economic benefits from employment in developing and running the new CCUS infrastructure; and

-Economic impacts from the development of new low-carbon facilities e.g., hydrogen production plants that can benefit from the availability of CCUS.

The analysis presented in this report is based on information regarding the costs of an end-to-end CO_2 shipping solution provided by NZIW partners and supplemented where required by data from publicly available third-party sources. Cost data for different parts of the process (capture, transportation, port handling, shipping) is combined into a consolidated Levelised Cost of Abatement (LCOA) for each industrial sector (reflecting variations in the cost of capture between sectors) expressed in £/tCO_2 terms.

Note: 1. Green Book, HM Treasury, Link; 2. UK Government, Cluster sequencing for carbon capture, usage and storage (CCUS): Track-1 - Link, Track 2 – Link; 3. UK Government, CCUS Net Zero Investment Roadmap, Link

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Approach to assessing the economic case (ctd)

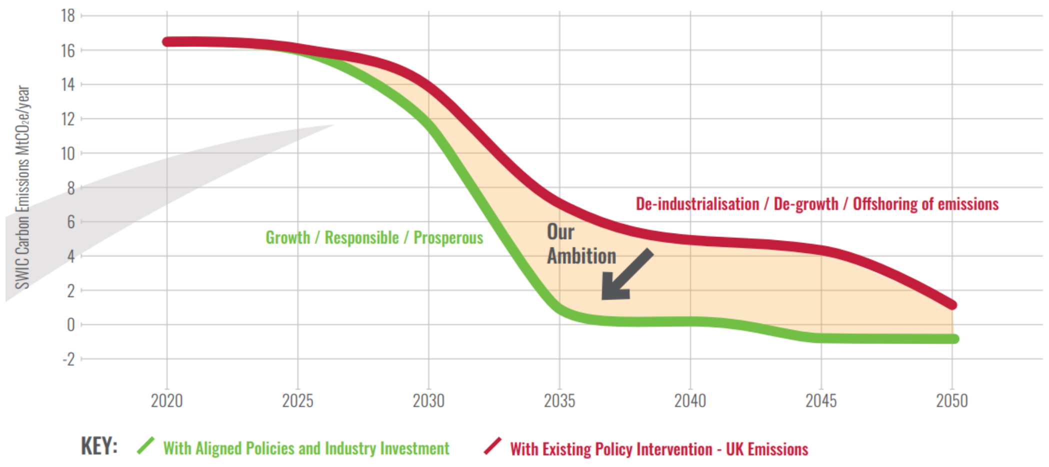
While the report does consider sensitivities surrounding key variables, we have identified a 'balanced case' for costs and benefits which represents a potentially feasible yet conservative scenario. The key assumptions in the balanced case are described below:

- **CCUS Adoption – Gradually till 2040**: Once the T&S network is operational (assumed to be 2029), industrial facilities gradually adopt CCUS over the following decade. This timeframe and adoption rate provides a middle ground that accounts for potential technological advancements and regulatory changes while avoiding the extremes of immediate full-scale deployment or delayed adoption.
- **Shipping Distance (Round Trip) - 1,200km based on Scotland Store**: This distance is based on the scenarios where ships either go to Humber store or go directly from South Wales to Scotland. This does not include the special case where the ships pick up CO_2 from Thames or Southampton on route and then go on to Scotland.
- **LCOA for Port Infrastructure Costs - Higher Estimate, NZIW Partner Information**: we have adopted a conservative approach by using estimates at the upper end of the range of costs provided by NZIW partners.
- **LCOA CCUS – Balanced Estimates**: CO_2 capture costs were originally sourced from the International Energy Agency (IEA). These were then inflated to current year figures based on information provided by NZIW partners.
- **UK ETS Growth Rate (2023-2050) - 4.4% long-term average**: This rate is aligned with historical trends and current policy trajectories, representing a balanced view of expected ETS costs without assuming aggressive policy shifts or market disruptions.

The costs and benefits of a shipping solution are then compared to impacts under a 'Do Nothing' counterfactual. In this scenario, no costs are incurred in terms of infrastructure investments, but industry in South Wales faces negative impacts in terms of loss of competitiveness in the face of rising carbon prices which could force the closure of some facilities in internationally competitive sectors. The comparison with Do Nothing generates a Net Present Value (NPV) which provides an indication of the socio-economic value of the investment.

We have also developed high-level affordability analysis to highlight potential impacts on the public purse. To do this we have estimated the 'funding gap' for CO_2 shipping infrastructure: this is based on overall costs minus what the private sector is likely to be willing to pay at expected UK ETS prices and is an indicator of what the public sector may need to fund (whether through levies or general taxation). This funding gap is then compared to the expected tax receipts for the levels of GVA which are safeguarded by CO_2 shipping to provide a view on the net impact on public finances.

Figure 1: SWIC's carbon emissions projections[2]



Note: 1. Bullish sentiment on global carbon prices continues to persist, 2023, Link; 2. SWIC, A plan for clean growth, Mar 2023, Link - Please note that the numbers presented in this graph might not match with the numbers presented in this report due to different assumptions around CCUS uptake.

Executive Summary

Key results

The principal insights from the analysis are as follows:

- **There is an economic case for CO_2 shipping:** the quantitative outputs of our analysis are set out in the table to the right. In summary, the benefits driven by the investment in CO_2 shipping infrastructure exceed the estimated costs. This positive case is a result of:
  - **Emissions captured and shipped:** 164.1 million tCO_2 during 2029-48 based on sector-specific emissions profiles and the balanced case.
  - **Jobs:** Around 94,000 job years added across construction and operational years. These estimates are based on information shared by NZIW Partners and extrapolated based on the South Wales emissions profile
  - **A solution to ship CO_2 offers a way of reducing industrial emissions in South Wales whilst protecting the industrial base:** Without CCUS, industry in South Wales faces the prospect of becoming less competitive as carbon prices rise. A CO_2 shipping solution is the best alternative for the region which would avoid time-consuming, complex pipeline projects to connect South Wales with the Humber and Scotland.
- **Although public funding will be required to catalyse the necessary investments, these could be recouped through higher tax takes versus the counterfactual:** we estimate that ~£2.4bn of public funding will be required to support the development of CCUS infrastructure in South Wales over the period to 2050. However, we estimate that only ~23% of the increased GVA that would result would need to be recovered in order for public finances to 'break even' from the investment. This is less than the long-term ratio of tax receipts to GVA which stands at around 30%. Furthermore, the adoption of a Contract for Difference (CfD)- a well-established mechanism used to fund (for example) large-scale renewable electricity projects- would spread costs over a defined contract life while providing revenue certainty for investors, and would not involve large amounts of upfront capex support.

Note: Figures in the table have been rounded off and hence might not tally

Table: NPV Components (Hyperlinks to detailed descriptions in body of the report)

Benefit (Value In £ Billion)	Balanced case	Description
NPV of avoided loss of GVA (Benefit 1, Page 22)	6.0	Highlights the project's role in sustaining industrial activity and safeguarding economic resilience in South Wales.
NPV of emissions reduction benefits (Benefit 2, Page 23)	8.5	Refers to the avoided emissions reduction costs that companies no longer pay if they install CCUS.
Total Cost of Do Nothing Counterfactual	**14.6**	**Total cost in terms of facilities getting closed and cost of UK ETS.**
NPV of GVA from new jobs creation (Benefit 3, Page 24)	2.8	The creation of ~64k job years across both CAPEX and OPEX phases.
NPV of GVA from new hydrogen facilities (Benefit 4, Page 25)	1.3	The CCUS enabled upcoming blue hydrogen facilities would generate GVA in the South Wales economy.
NPV of GVA from RWE PNZC (Benefit 5, Page 26)	0.2	Based on independent RWE report.
NPV of Total Gross Benefits	**18.9**	Discounted sum of all the benefits
NPV of Costs	(11.0)	Discounted total of LCOA costs across the value chain and underline the scale required to enable CO_2 shipping solution.
Overall NPV	**7.9**	

We have also developed sensitivities around the balanced case based on using different assumptions around key variables to capture uncertainties. These high and low cases generate an overall NPV range of 4.0 to 18.8. More details on sensitivities can be found in section 5 of this report.

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Next steps

Given the positive impacts of investment in CO_2 shipping for South Wales, and the need to ensure the future viability of the industries and communities which are the cornerstone of the region's economy, a vital next step is to **allow emitters in clusters without adjacent stores to participate in Track 2 of the cluster sequencing process via a shipping solution:** given the strong positive benefits case, we believe that a route to market for non-pipeline emissions should be opened up as part of Track 2. In addition to South Wales, this includes clusters such as 7CO2 and Thames Estuary.

In addition, we recommend **developing a better understanding of additional benefits to UK that the CCUS + shipping solution could create.** Since our analysis primarily concentrates on the potential advantages to South Wales, there is further scope for assessing how shipping can improve the commercial position of all the Track 2 receiving ports. Example, shipping can help improve the economics of receiving ports by addressing variable CO_2 emissions volumes (such as from power sector emitters meeting peak demand), by providing access to increased volumes from elsewhere in the UK. Additionally, the benefits of offering CO_2 management services to European emitters can also be explored which has the potential for distributing CO_2 shipping infrastructure costs across a wider emitter base.

02
Strategic Context

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CCUS' role in meeting net zero

This introductory section sets out the context in which a CO_2 shipping solution for South Wales is being considered. It describes how CCUS is vital for achieving deep emissions reductions in the UK and in the South Wales region and why a CO_2 shipping solution is required to deliver these. It provides an overview of the design of a shipping solution and the current policy and regulatory position regarding CO_2 shipping.

Why CCUS?

CCUS will play a pivotal role in helping the UK reach net zero by 2050. CCUS involves the capture of CO_2 from large CO_2 emitting sources such as power stations and industrial facilities and transportation of captured CO_2 to long-term storage facilities. It has the benefit of being able to be retrofitted to existing plant. It can, therefore, help decarbonise existing operations rather than requiring the construction of new plant.

Reaching **net zero requires the deployment of both established and emerging low carbon technologies including CCUS**. Meeting legally binding commitments will require the use of range of low carbon levers including CCUS, energy efficiency and fuel switches.

CCUS is key to reducing emissions from heavy industry. Industrial sectors, in particular steel, cement production and power generation, are significant contributors to the UK's total greenhouse gas (GHG) emissions producing 79.8 million tCO_2 per year in 2021.[1] These sectors have relatively few options available to help them decarbonise with CCUS being a leading solution.

An additional benefit is that **new low carbon fuel sources are unlocked by CCUS**. Blue hydrogen is expected to be one of the main low carbon fuels that help the UK reach net zero. By attaching CCUS equipment to hydrogen production facilities, the UK can create a new supply of low carbon fuel to power industry and heat our homes.

Note: 1. Statista, 'Carbon dioxide emissions from the manufacturing industry in the United Kingdom (UK) from 1990 to 2021', 9 August 2023, Link

CCUS in South Wales

CCUS is critical to the future survival of industry in South Wales. Manufacturing is the largest contributor in terms of Gross Value Added (GVA) to the Welsh economy and the sector plays a key role in supporting jobs and communities. Proportionately, the manufacturing sector is more significant to Wales than it is for any other UK nation.

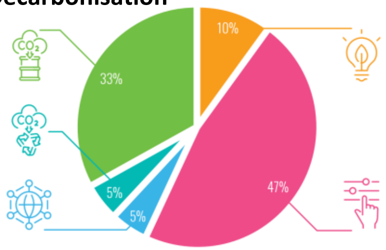
South Wales specifically is home to a significant industrial base across a diverse range of sectors including: UK's largest integrated steelworks, one of seven UK oil refineries, one of four European nickel refineries and industries including steel recycling, cement, paper, glass and chemicals. Industry based in Wales, therefore, underpins economic activities across the UK.

The challenge facing Wales is that many sectors based in the country are hard to abate. There are three main pathways to decarbonisation available (see Figure 2): energy efficiency measures, low-carbon fuel switches and CCUS. Of these options, CCUS is the most promising given the uncertainty surrounding future volumes of low carbon fuel production (such as hydrogen) and the greater levels of emission reductions than those achieved through energy efficiency. Indeed, CCUS will help facilitate fuel switching by enabling blue hydrogen production (produced through Steam Methane Reform processes) to be done in a much less carbon-intensive way.

Without CCUS, carbon price increases have the potential to make emissions intensive industries in Wales financially unviable. Plant will face the choice of closure or relocation abroad, which will adversely impact the national and local economy due to the loss of high-value, high-skilled jobs.

With CCUS there is the opportunity to not only preserve local economies but also grow them. Analysis done by SWIC has assessed the potential benefits decarbonisation can bring to Wales. The headline findings from this work are outlined below[2].

Figure 2: The Five Cogs of Decarbonisation[1]



10%: Energy and Resource Efficiency
47%: Fuel Switching (driven by CCUS)
5%: Clean Growth Hubs
5%: Carbon Capture Utilisation (CCU)
33%: Carbon Capture Storage (CCS)

Reduce Industry Emissions

Transitioning to low carbon industries by 2040 will equate to a 40% reduction of total current Welsh CO_2 emissions.

Protect and Create Jobs

Decarbonising South Wales will result in the preservation of 113,000 jobs as well as a net increase in overall jobs.

Unlock Investment

The shift to net zero will unlock £30 billion in investment opportunities in the region.

Grow the Economy

Supporting CCUS in the region will grow the £6 billion Gross Value Added from South Wales Industry.

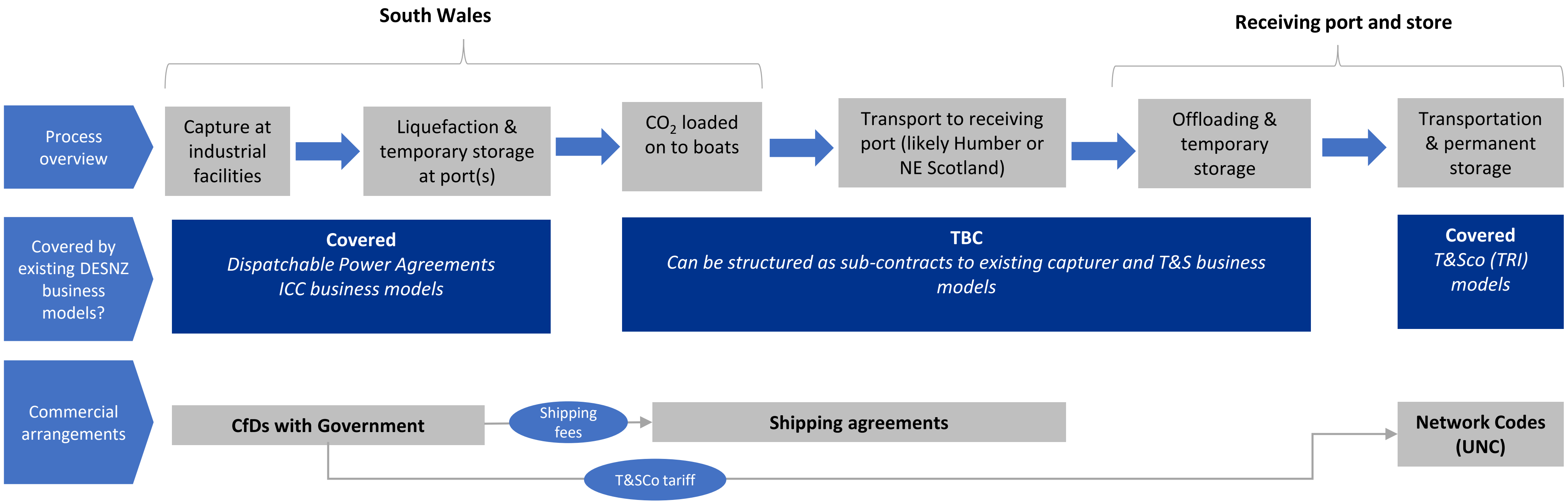
SWIC SOUTH WALES INDUSTRIAL CLUSTER

Note: 1.SWIC, A plan for clean growth, Mar 2023, Link ; 2. SWIC ibid

CO_2 shipping approach

CO_2 shipping is an end-to-end solution linking emitters in one region to a receiving port and storage facilities in another via a specialised fleet of vessels which transport captured CO_2. The technical and economic characteristics of a shipping solution differ from the conventional CO_2 pipeline model, meaning different commercial and regulatory structures may be required to facilitate its development. The schematic below provides an overview of the process, coverage under existing DESNZ funding/business models for the different legs of the process and the potential form of commercial/technical ship and hub agreements.

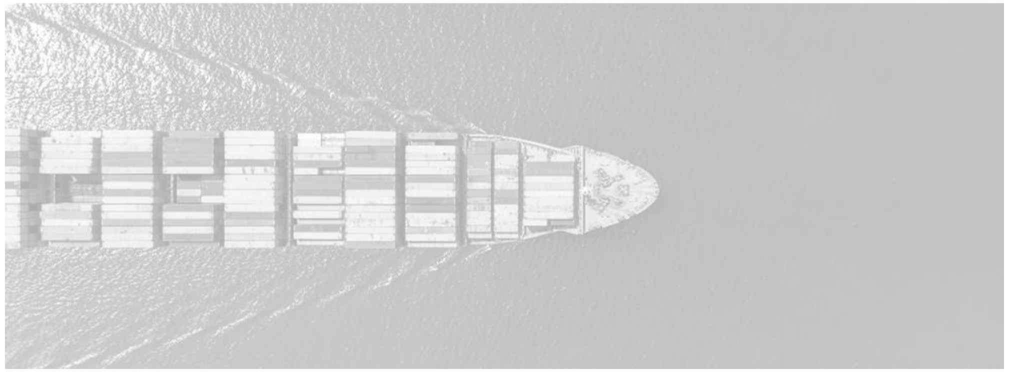
It shows that whereas the front and back ends of the value chain are reflected in business models DESNZ have developed, business models for the shipping phase of the chain are still to be developed, but can be built from existing arrangements for the rest of the value chain.



Shipping vs Pipeline Transportation

Benefits of shipping captured CO_2

- Can leverage existing CO_2 stores
- Capacity scalable with emissions volumes
- Reduced geographical constraints
- Unlocks CCUS in South Wales as well as other clusters e.g. Thames Estuary
- Timeliness: avoids planning and development delays associated with pipelines.



Funding to date has been targeted at clusters able to transport captured CO_2 offshore via pipeline.

Cluster Sequencing process eligibility criteria favours clusters using pipelines to transport captured CO_2 offshore. CO_2 shipping solutions ('non pipeline transportation') has only been mentioned as an avenue to increase future abatement beyond 2030 and confirmation is required that both hubs and shipping can be funded through existing business models as sub-contracts to either emitters or a T&Sco.

However, CO_2 shipping can have benefits in terms of project economics. It allows emissions can be stored in existing offshore storage sites instead of having to fund new offshore stores near to the source of emissions. Shipping provides greater optionality over the choice of store and/or emitters.

CO_2 shipping offers a timely solution for industrial clusters without an adjacent store. CO_2 pipelines connecting clusters such as Thames Estuary and South Wales with stores in Humber and Scotland would be large, complex projects with considerable regulatory hurdles to clear given that they would be transporting a hazardous substance through heavily populated areas. Given this, it is unlikely that pipeline solutions could be developed in time to allow CCUS to play a role in decarbonising South Wales industry before industrial facilities were forced to close by high carbon prices.

Given this, we have not developed detailed quantitative analysis for CO_2 pipelines from South Wales as a counterfactual to a shipped CO_2 solution.

03
Economic Assessment

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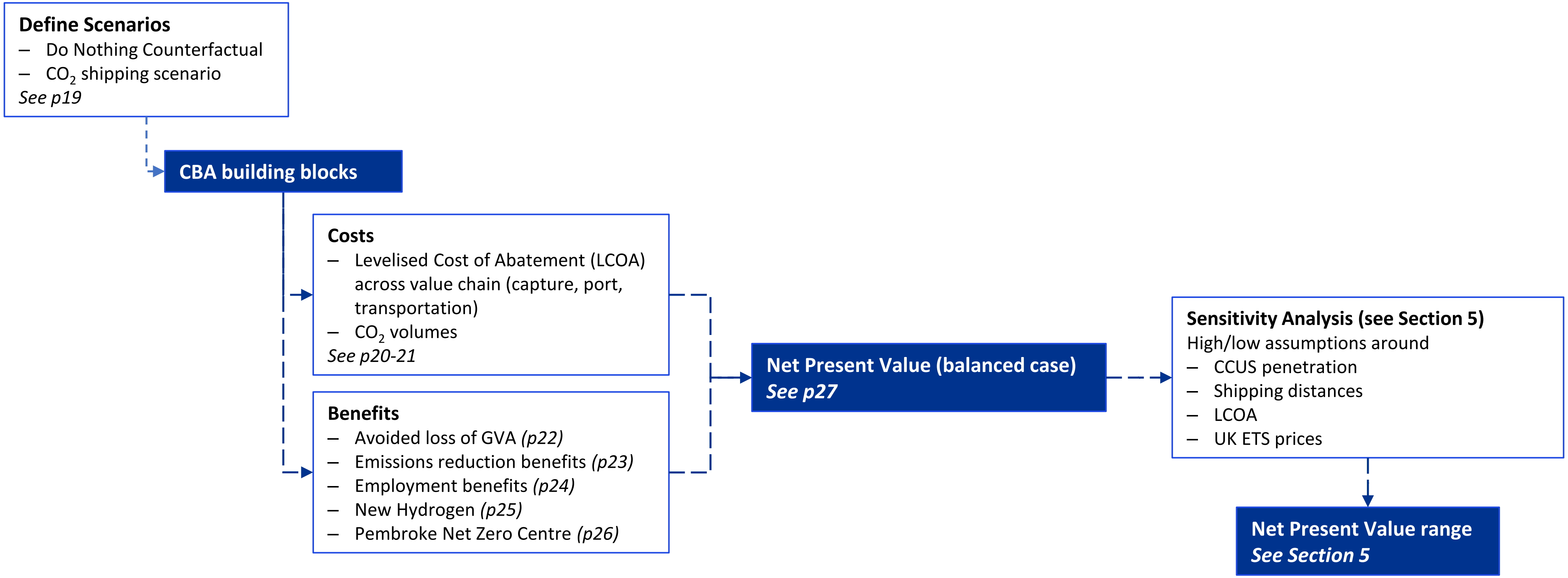
Overview of approach

We have developed a VFM assessment based on HM Treasury Green Book methodologies, focusing on SWIC as the largest industrial cluster without an adjacent CO_2 store.

We identify the costs and benefits of developing the infrastructure for CO_2 shipping and estimate these out to 2050. Net Present Value is estimated based on costs and benefits versus the counterfactual.

An overview of our approach is presented in the chart below. Our methodology for quantifying costs and benefits, including our approach to sensitivity analysis, is described in the remainder of this section.



Defining CO_2 shipping scenarios

To assess the impact of CO_2 shipping to the Welsh and UK economies in line with HM Treasury Green Book guidance, we have developed a future scenario for how the deployment of CO_2 shipping infrastructure could impact the economy in South Wales, and a counterfactual 'Do Nothing' scenario for what would occur in the absence of investment. These scenarios are described at a high level below.

Do Nothing (counterfactual)

South Wales de-industrialisation and lost industry

Cause: The UK does not have the available resource to look into developing an strategy for CO_2 shipping.

Description: The UK continues on its current approach and targets its funding towards industrial clusters that are able to connect to offshore stores via pipeline. Only the regions with proximate offshore storage sites are able to decarbonise via CCUS and South Wales is left behind.

Consequence: Industry in South Wales is placed under growing financial stress as it is forced to pay an increasingly high carbon price. Eventually, operations become too costly and companies are faced with the choice of either closing down or relocating abroad. In both situations, jobs are lost and communities are broken down as people have to relocate to find employment. The UK Government loses out on tax revenues from both the companies and their employees and has to import the goods that would have otherwise been manufactured locally.

CO_2 shipping solution

South Wales can decarbonise through CCS - jobs are preserved and created

Cause: The UK recognises that unlocking the full benefits of CCUS is dependant on investing in a range of CO_2 transportation options including via shipping and rail.

Description: In addition to the existing clusters awarded funding under the 'Track-1' competition and the 'Track-2' process, funds are also allocated to develop CO_2 T&S networks in other industrial regions with a proximate port. South Wales is able to decarbonise and continues to contribute to the UK economy.

Consequence: Jobs and communities are saved across South Wales as it continues to build on its rich heritage as an industrial centre. The manufacturing industry continues to thrive as other heavy industries look to move to the region. New business know that South Wales not only has a, high-skilled, high-value workforce, but it also has the CO_2 T&S infrastructure and blue hydrogen production to support their decarbonisation efforts.

Costs

To evaluate the economic feasibility of carbon capture and shipping in South Wales we chose to calculate a Levelized Cost of Abatement (LCOA). LCOA was one of the main assessment criteria of carbon capture clusters applying into 'Track-1' so this is an accepted method of assessing the cost of capturing and transporting CO_2. Our LCOA value includes the three main components of the carbon capture and shipping value chain: CCUS, Port Infrastructure (including liquefaction and marine terminal operations) and Shipping.

Detailed Methodology

Step 1: Find CAPEX and OPEX
We started by determining the annual cashflows for capital and operating expenditures involved in the processes for the project lifecycle. The data feeding into this was obtained from project partners and third-party sources (see bibliography).

Step 2: Identify volumes of carbon emitted
We then identified all the sites with potential to be CCUS enabled that also produced sufficiently large volumes of emissions to make CCUS financially viable. We totalled their emissions using data obtained from the National Atmospheric Emissions Inventory (NAEI).

Step 3: Compute LCOA
We subsequently computed the LCOA by dividing the sum of discounted cash flows by the sum of discounted carbon captured over the project's lifetime.

Step 4: Find sector-specific LCOA value
As the cost of abatement varies depending on the density of carbon emitted by the process, different sectors have different LCOAs. We, therefore, factored this into our final values. For estimating the LCOA CCUS, initial benchmarks were sourced from the International Energy Agency (IEA)[1] for various industries such as power generation, cement and steel. For the power generation sector, specific estimates were taken from partners which were then used as a base to extrapolate LCOA CCUS for other sectors, employing a unitary method to maintain the same cost ratios as IEA.

Step 5: Calculate final cost of abatement
Lastly, we multiplied the LCOA sector values by the volumes emitted by each sector in South Wales. We only included the emitters which were in proximity to a port for CO_2 shipping. The emissions figures used for each sector incorporate our projected emissions reduction profile specific to each sector. This ensures that the cost estimates are in alignment with the sector's anticipated emissions trajectory.

Components in the Value Chain (see detail on p14)

CCUS: This covers the process of capturing emissions at source across industries such as power generation, steel and cement manufacturing.

Port infrastructure costs: This covers the costs associated with the process of liquefying the captured carbon and marine terminal operations, including loading at the loading port, unloading at the receiving port and permanent storage.

Shipping: This covers the process of transporting the liquefied carbon to its final destination.

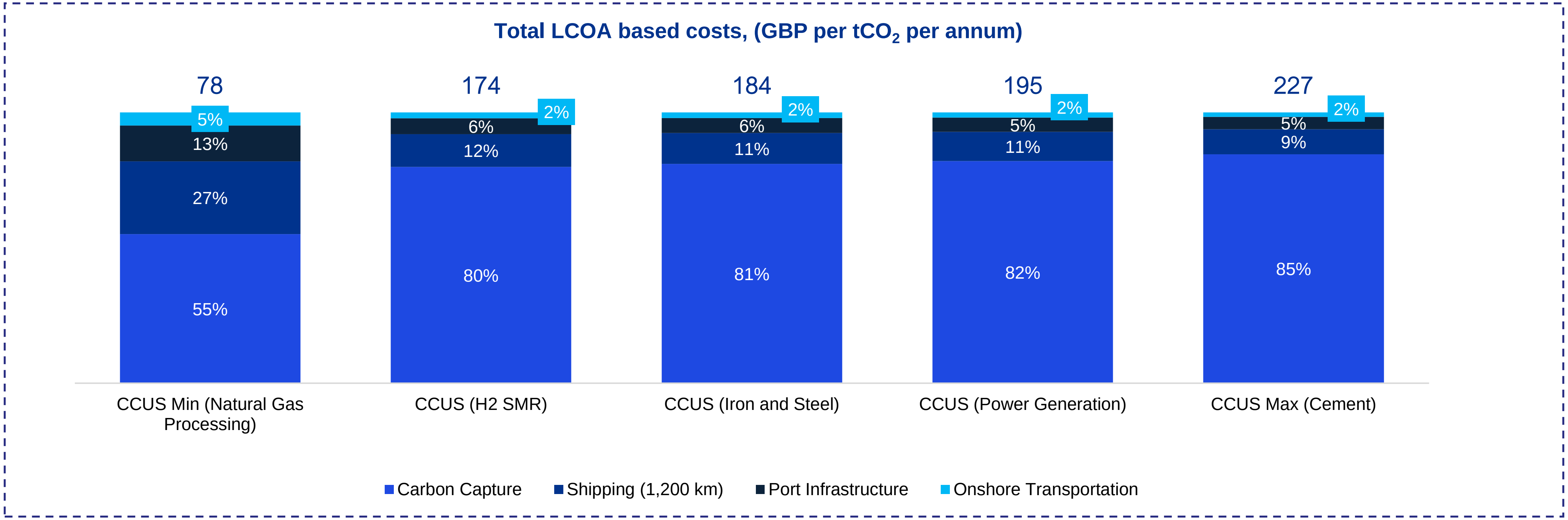
Data Sources

Our data is taken from a range of sources including primary conversations with industry experts and third-party publications (see bibliography). LCOA data for carbon capture has been taken from the International Energy Agency's 2019 data tables and has been fine-tuned as per an NZIW partner's estimates.

Note: 1. International Energy Agency, 'Carbon Capture, Utilisation and Storage', 11 July 2023, Carbon Capture, Utilisation and Storage - Energy System – IEA, Link

Costs

Our analysis shows the main cost component of CCUS and shipping solution in South Wales is the installation of carbon capture equipment regardless of the sector and shipping distance. We note that the proportional cost of the carbon capture element does vary based on the emission intensity of the sector. Carbon capture makes up a lower proportion of total costs the more dense the profile of the emissions released (in the example below natural gas processing results in the highest CO_2 density and cement production the lowest). Accordingly, the shipping cost component is higher for high density emissions and vice-versa.



Note: The presented LCOA figures are for the balanced case and are not representative of the expected CfD price; Port infrastructure costs are based on information shared by NZIW Partners and cover the costs associated with the process of liquefying the captured carbon and marine terminal operations, including loading at the loading port and unloading at the receiving port. % totals may not sum to 100% due to rounding.

Benefit 1: Avoided Loss of GVA (Gross Value Added)

Without CCUS it is likely that the heavy emitters in South Wales would be unable to afford the increasing cost of carbon and would be forced to either close or relocate their operations. This would have a severe loss of economic activity in the region which is what we have quantified below. We chose to use GVA as our measure of economic productivity as it measures the contribution of a corporate subsidiary, company or municipality to an economy, producer, sector or region.

Detailed Methodology

Step 1: Estimate the loss of GVA

Using the NAIE database, we extracted the South Wales emitters in the sectors that can be CCUS enabled and those producing sufficiently large volumes of emissions to make CCUS financially viable. We then lifted their turnovers from Companies House. Where companies had multiple UK sites, we pro-rata'ed their turnover based on other available metrics (i.e., employee numbers or production volumes per site).

Step 2: Calculate GVA at risk

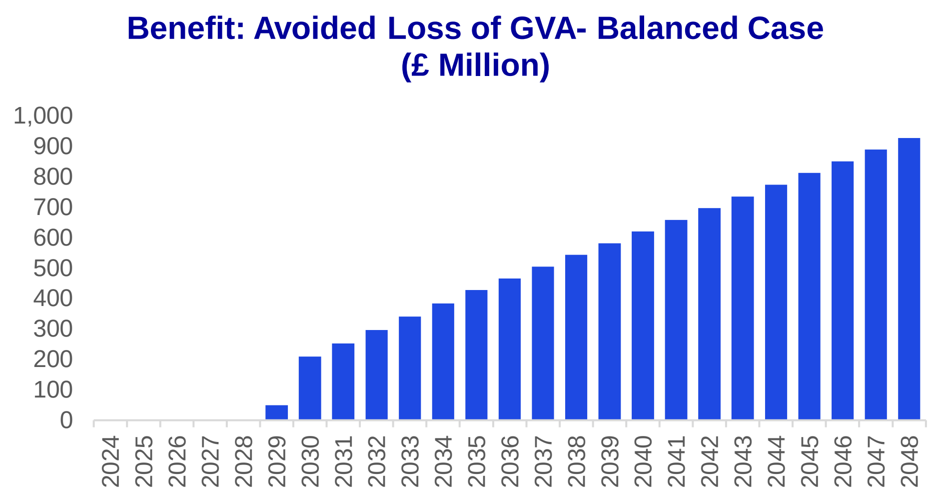
We then took ONS Turnover:GVA ratios from the ONS national Accounts to derive the 'GVA at risk' on a site-by-site basis. These were then totalled to get the total GVA at risk in South Wales. We note that turnover figures were unavailable for all companies, so the final figure is likely to be a conservative estimate.

Assumptions

We have assumed that industries would shut down or reduce their operations at a linear rate starting with 0% in 2026 eventually reaching 100% in 2040.

Units

We reported the final figures as amount in GBP saved. Note that these GVA numbers include the positive effects of safeguarding existing jobs.



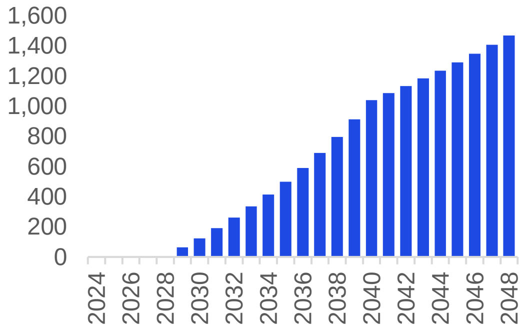
Benefit 2: Emissions Reduction Benefits (Valued at UK ETS Price)

The UK ETS is designed to incentivize companies to decarbonise by imposing a cost on any GHG emissions they generate above a sector-specific free allowance level. To promote emissions reduction, the cost of emitting will increase over time. This means that emission-intensive industries, such as those in South Wales, will have to pay more to continue their operations unless they transition to low-carbon technologies such as CCUS. While the implementation of the CCUS + shipping solution results in an apparent reduction of UK ETS revenue for the HM Treasury, the long-term benefits and the avoidance of more significant revenue losses under the 'Do Nothing' scenario provide strong justification for this solution.

Units

We reported the final figures as cost savings in GBP as the metric for the tCO_2 captured.

Benefit: Emissions reduction benefits - Balanced Case (£ Million)



Detailed Methodology

Step 1: Forecast the future cost of carbon: The market approach of UK ETS means that the future value of allowances is uncertain and forecasted future prices vary. For the purpose of this analysis, we used a time series starting at the current UK ETS price at around £66 per tonne of CO_2 increasing to around £194 per tonne by 2048, as per the latest trends and developments in the global carbon market[1]. The growth rate has been based on an LSE[1] report's future price estimates which correspond to a CAGR of 4.4%.[2]

Step 2: Estimate volumes of CO_2 captured: We used NAEI information to see the volume of CO_2 reported by each site in South Wales. We then filtered sites to include only those in sectors that can be CCUS enabled and those producing sufficiently large volumes of emissions to make CCUS financially viable. We have projected a decline in emissions at varying rates across sectors which also depends upon the rate of CCUS adoption. For power generation and natural gas processing, a slower rate of decline has been assumed, acknowledging existing transition challenges. Conversely, sectors like iron & steel and cement, have been projected to achieve zero emissions by 2050, in line with ambitious climate targets.[2]

Step 3: Multiply emission volumes by the forecasted cost of carbon: The total volume of emissions was then multiplied by the likely future cost of carbon to give the value of the emissions reduction benefits.

Long term benefits analysis: CCUS + shipping solution vs the 'Do Nothing' scenario:

Socio-environmental impact: The primary aim is the reduction of emissions, transcending mere financial considerations. Beyond the monetary spectrum, there's a significant non-financial upside. The curbing of emissions equates to fewer health concerns and a reduced strain on the healthcare system, which, over time, translates to substantial cost savings from the socio-economic point of view

Revenue analysis compared to the Do Nothing counterfactual scenario: While there's a potential reduction in ETS revenue with the adoption of CCUS + shipping, it's pivotal to juxtapose this against the counterfactual scenario. In the absence of this solution, the rising carbon prices would have further strained industries, possibly leading to closures or output reductions. Hence, by adopting CCUS + shipping, while there might be a temporary decline in UK ETS revenue, industries are more likely to remain operational, which maintains a level of ETS revenue that might otherwise be completely foregone and sustains economic activity. In addition, there is preservation and potentially enhancement of GVA and GVA derived tax receipts for the Treasury

Note: 1. London School of Economics and Political Science, 'How to price carbon to reach net-zero emissions in the UK', May 2019, Link; 2. Bullish sentiment on global carbon prices continues to persist, 2023, Link; Please note that shipping related emissions are not part of the analysis

Benefit 3: GVA Benefits from Additional Employment

Installing CCUS and the associated infrastructure will result in the creation of new highly-skilled, highly paid jobs during both the construction and operational phases. These new jobs will have positive impacts for the UK economy in terms of GVA generated.

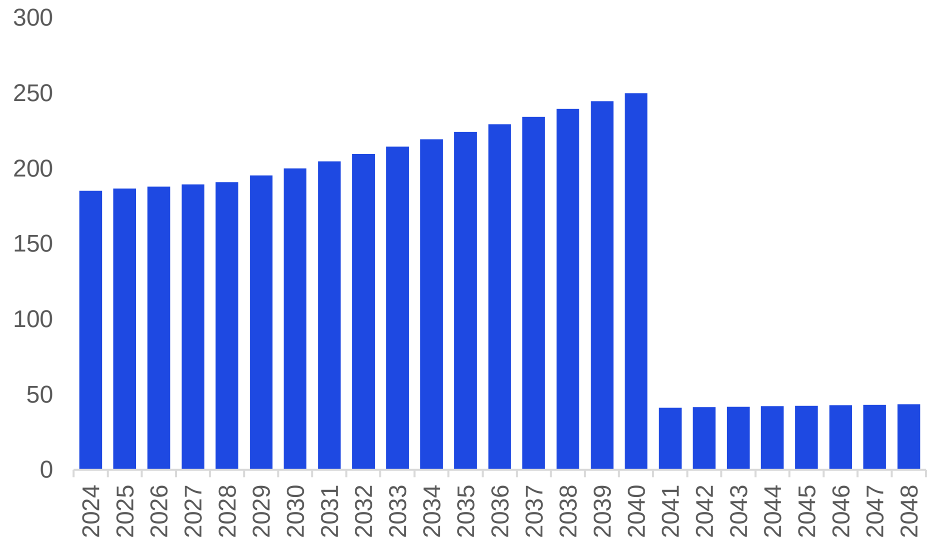
Detailed Methodology

Step 1: Estimate new FTE jobs
We firstly identified how many new jobs would be created through the installation of CCUS infrastructure as well as the modification of port facilities (including liquefaction) and marine terminals to both deliver and receive the captured CO_2. The final input numbers were provided by one of the project partners based on prior economic analysis. We have not, however, included the new roles that will be created through the operation of the CO_2 ships, so the estimate is likely to be a conservative one.

Step 2: Estimate GVA contribution per workforce job (WFJ)
Installing and running CCUS equipment will help create new skilled jobs in the South Wales. We have referred to the UK Government data on annual GVA contribution perWorkforce Job (WFJ) for the year 2020 and the corresponding figure for the target year 2050 to get the Compound Annual Growth Rate (CAGR) for the GVA per WFJ for the project timeline.

Step 3: Allocating the GVA across project lifecycle
We then multiplied the GVA per WFJ with the expected number of annual jobs for the CAPEX and OPEX phases, essentially dividing the GVA across two phases 2024-40 in which a mix of CAPEX and OPEX GVA is expected and 2041-48 for only the OPEX based GVA.

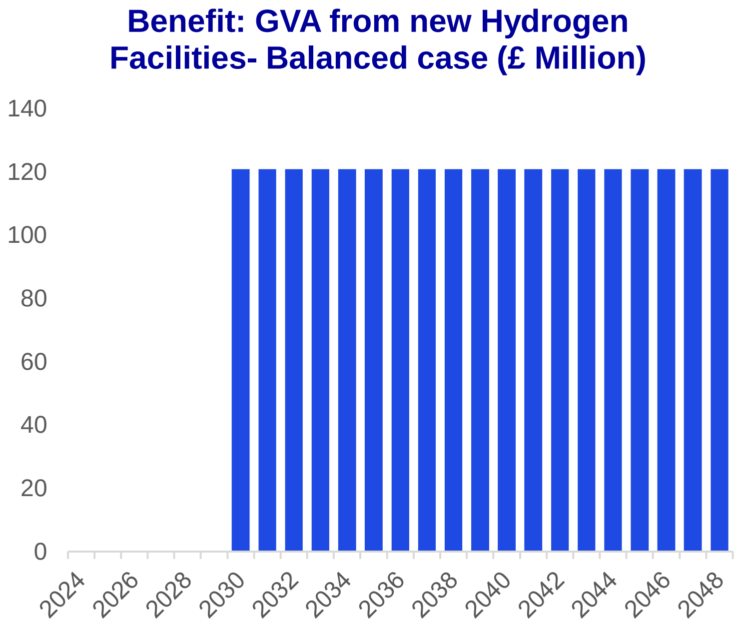
Benefit: GVA from New Jobs Creation- Balanced Case (£ Million)[2]



Note: 1. UK Government statistics on workforce jobs (WFJ), July 2022, Link; UK Government GVA per WFJ 2050 estimates, Link. 2. We have assumed construction of new facilities would begin in 2024: there are multiple dependencies here (e.g. on policy) and construction could begin at a later date.

Benefit 4: GVA from New Hydrogen Facilities

If CCUS is supported in South Wales, there is a potential to build new, low-carbon, blue hydrogen facilities. This would not be possible without the investment in CO_2 shipping and associated infrastructure so has been factored into the overall assessment of economic benefits. This new facility will result in additional employment in the area both during the construction and operational phases. Also noteworthy, is the role that this facility would play in the decarbonisation of smaller industries unable to install CCUS as well as in domestic properties by creating a new supply of low carbon fuel. These impacts have not been included in our economic assessment but are worthy of consideration.



Detailed Methodology

Step 1: Hydrogen production estimates

To estimate the anticipated hydrogen production volumes, we firstly identified the expected MW capacity of the likely hydrogen projects in the region. We secondly identified the appropriate energy efficiency rates for hydrogen production to calculate the Million Tonnes per annum (Mtpa) : MW ratio before multiplying the latter with MW to get Mtpa.[1]

Step 2: Hydrogen pricing

Our hydrogen pricing is based on the current market value of hydrogen. We sourced this data from the S&P Global Platts Hydrogen Price Wall.[2]

Step 3: GVA calculation

The final estimated GVA figure was obtained by multiplying the hydrogen production estimates with the hydrogen price per unit to get the total cost of production. This cost was subsequently converted to revenue using an appropriate gross margin before multiplying with the appropriate GVA multiplier to get the GVA cashflows.

Note: There is still considerable uncertainty surrounding the future price of hydrogen – we have used the latest (Sep 2023) prices based on best available data; 1. Chemical Engineering Transactions, 'Hydrogen production via Steam Reforming with CO2 Capture', 2010, Link; 2. S&P Global, 'Platts Hydrogen Price Wall', Sep 2023, Link

Benefit 5: GVA (Gross Value Added) from RWE PNZC

Without the investment into CCUS the Pembroke power generation station is likely to close or at the minimum is expected to experience a significant downturn in operational activity levels. Considering this power station is one of the key facilities in Milford Haven energy cluster, closing operations would lead to a significant loss of GVA and jobs in the area. On the other hand, the planned investment is expected to provide learning and skill development opportunities for the local community in the identified growing fields of technologies related to energy transition and net zero.

Detailed Methodology

Step 1: Selecting the level of economic activity
The project report used estimates for high, medium and low activity scenarios. For this report, we have used GVA cashflows as per the medium activity scenario.

Step 2: Calculate GVA potential
We then took average GVA cashflows from the medium CAPEX and OPEX scenarios.

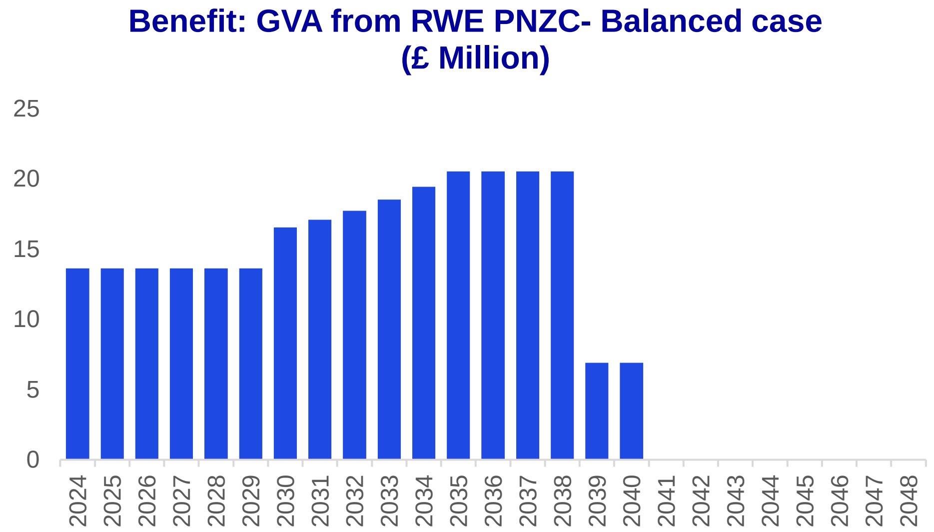
Step 3: Extract the relevant portion of the overall project GVA
To accurately represent the project's multi-faceted nature, which includes CCUS, battery storage, hydrogen electrolyser, and floating offshore wind, we divided the GVA cashflows calculated in previous step by four. This methodology provides a balanced economic estimate tailored to the project's unique components.

Assumptions

- Medium activity scenario is assumed to be the most likely scenario.
- An equal contribution to the overall GAV coming in from the four different project components i.e., CCUS, battery storage, hydrogen electrolyser, and floating offshore wind

Units

We reported the final figures as amount in GBP created.



NPV results: Balanced case

The table below provides an overview of the final figures for all the benefits and costs identified in this report. This table is based on the balanced case and figures are in GBP millions

1. Economic impact

Result of the sensitivity analysis; NPV:

- High benefits case: £18.8 Billion
- Balanced case: £7.9 Billion
- Low benefits case: £4.0 Billion

2. Jobs

- **CAPEX:** On an average around 10.3k jobs per year to be created during the construction life of the project equivalent to ~51.3k person years
- **OPEX:** Around 600 permanent new FTE jobs to be created for the operational lifecycle of the project equivalent to ~12.6k person years

3. Comparison of scenarios

There is a positive NPV for shipping versus a 'do nothing' scenario

4. Net Benefits as a percentage of South Wales GVA

The net benefits generated by this project are not only substantial in absolute terms but also represent a significant percentage of South Wales' overall Gross Value Added (GVA). This indicates the project's substantial impact on the regional economy, beyond its immediate scope, reinforcing its strategic importance for economic development and sustainability in South Wales.

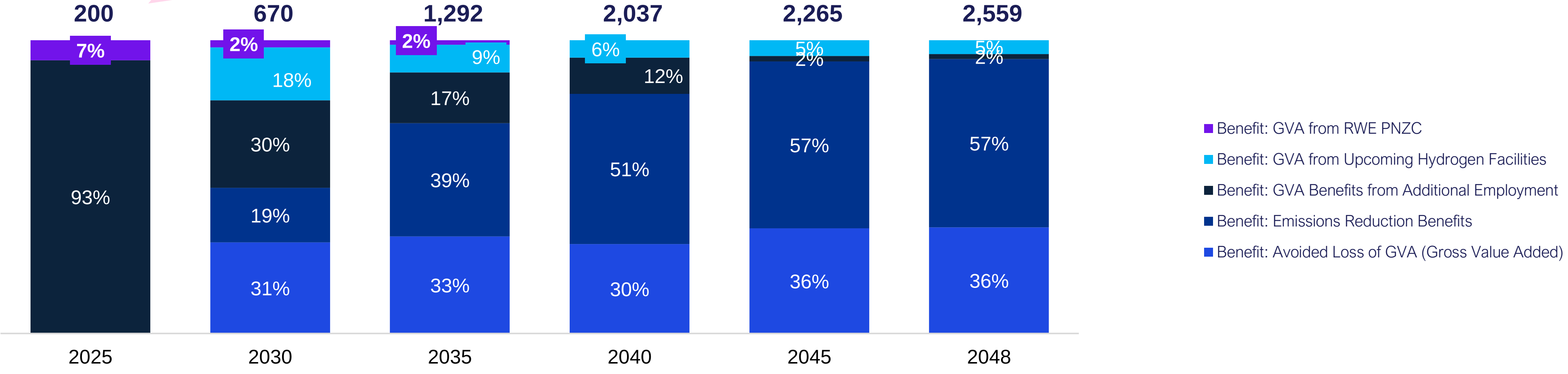
Project Year	Year	Benefit: Avoided Loss of GVA (Gross Value Added)	Benefit: Emissions Reduction Benefits	Benefit: GVA Benefits from Additional Employment	Benefit: GVA from Upcoming Hydrogen Facilities	Benefit: GVA from RWE PNZC	Total Benefits	LCOA (Considering both CAPEX and OPEX)	Net Benefits = Total Costs - Total Benefits	Net Benefits as a % of South Wales GVA
1	2024	0	0	185	0	14	**253**	**0**	**199**	***3%***
2	2025	0	0	187	0	14	**253**	**0**	**200**	***3%***
3	2026	0	0	188	0	14	**253**	**0**	**202**	***3%***
4	2027	0	0	189	0	14	**253**	**0**	**203**	***3%***
5	2028	0	0	191	0	14	**253**	**0**	**205**	***3%***
6	2029	49	65	196	0	14	**367**	**137**	**186**	***3%***
7	2030	208	125	200	121	17	**710**	**252**	**419**	***7%***
8	2031	252	191	205	121	17	**821**	**370**	**416**	***7%***
9	2032	296	261	210	121	18	**935**	**484**	**422**	***7%***
10	2033	340	336	214	121	19	**1,054**	**594**	**435**	***7%***
11	2034	383	415	219	121	19	**1,178**	**703**	**455**	***8%***
12	2035	427	499	224	121	21	**1,307**	**810**	**482**	***8%***
13	2036	466	591	229	121	21	**1,437**	**918**	**508**	***8%***
14	2037	504	690	234	121	21	**1,575**	**1,027**	**542**	***9%***
15	2038	542	797	240	121	21	**1,721**	**1,137**	**584**	***10%***
16	2039	581	914	245	121	7	**1,862**	**1,248**	**619**	***10%***
17	2040	619	1,040	250	121	7	**2,027**	**1,361**	**676**	***11%***
18	2041	658	1,086	41	121	0	**1,906**	**1,361**	**545**	***9%***
19	2042	696	1,134	42	121	0	**1,992**	**1,361**	**631**	***11%***
20	2043	735	1,184	42	121	0	**2,081**	**1,361**	**720**	***12%***
21	2044	773	1,236	42	121	0	**2,172**	**1,361**	**811**	***14%***
22	2045	811	1,290	42	121	0	**2,265**	**1,361**	**904**	***15%***
23	2046	850	1,347	43	121	0	**2,361**	**1,361**	**999**	***17%***
24	2047	888	1,406	43	121	0	**2,459**	**1,361**	**1,097**	***18%***
25	2048	927	1,468	43	121	0	**2,559**	**1,361**	**1,198**	***20%***

Note: Expected economic impact of the development of the CCUS component of the RWE's Pembroke Net Zero Centre

Evolution of benefits over time

Our analysis shows that the avoided loss of GVA and emissions reduction benefits relative to the counterfactual are the two major benefits for the combined CCS and Shipping solution. The annual contribution to the benefits ranges from 50% to 93% across project lifecycle.

In 2025, which falls within the CAPEX phase, the plants are not yet operational for CCUS and shipping. However, the year and the CAPEX phase sees significant benefits in the form of GVA generated from new construction jobs for the facilities. During this CAPEX phase, the emphasis of benefits thus shifts from operational savings or revenue generation to the immediate economic value created by employment in construction - also called direct GVA.

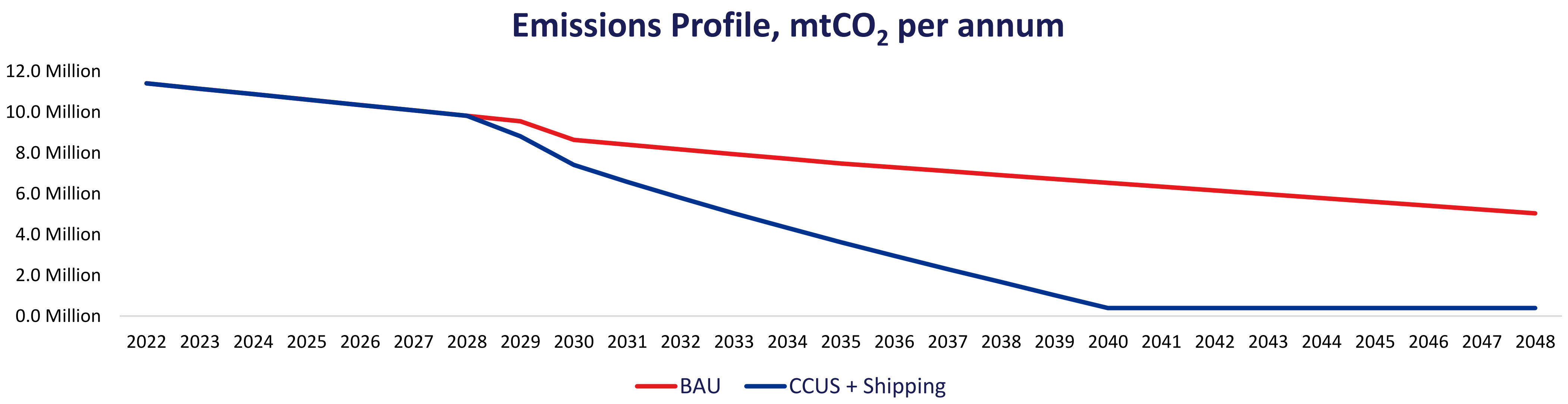


Note: Figures correspond to the balanced case and have been rounded

Emissions profile

Protected emissions trajectory with CCUS Implementation:

The chart below shows the emissions trajectory when CCUS is introduced from 2029 onwards versus the Do Nothing counterfactual. From 2029, emissions reduce relative to Do Nothing as CCUS begins to be deployed in industrial facilities. The Do Nothing profile is based on sector-specific assumptions about the future development of industry in South Wales in the absence of CCUS, with sectors exposed to international competition facing higher levels of plant closure than markets focused on meeting domestic demand. The CCUS + Shipping profile is based on the gradual deployment of CCUS from 2029 until 2040.



04 Affordability Assessment

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Approach

Affordability analysis is part of the economic case and aims to establish whether investment public purse (either through general taxation or sector-specific levies) is affordable based on the exchequer benefits of that investment. We have estimated the funding gap for the CO_2 shipping infrastructure investments required in South Wales based on the difference between project costs and benefits in terms of avoided carbon costs. We then estimated the benefits to the exchequer from safeguarding GVA at plants that can access CCUS with the shipping infrastructure in place. Affordability analysis is a complex area requiring a detailed set of assumptions about capital allowances for investment (which will have impact on the tax take). Given the uncertainties around these factors at this stage, we have instead compared the ratio of tax to GVA in the wider economy (which will also capture other relevant taxes e.g., VAT, income tax) to the tax to GVA ratio that would be needed for the Government to cover its investment through increased tax receipts relative to the Do Nothing counterfactual.

Methodology for calculating the funding gap

This is based on the assumption that private sector emitters will be willing to invest in CCUS infrastructure if the economic payback (in the form of reduced UK ETS costs) outweighs the costs. We therefore estimate:

1. Discounted benefit cashflows related to the emissions reduction benefits (Benefit 2 on slide 23)
2. Discounted cost cashflows considered based on LCOA (Levelized Cost of Abatement) methodology
3. NPV: Discounted costs (Step 2) less Discounted benefits (Step 1) equals funding gap

Methodology for calculating the annual tax benefit for two GVA cases

1. Establish relationship between GVA and tax receipts: Longitudinal data was taken from UK ONS for the period 1997 to 2017
2. The data showed a clear relationship between the GVA and tax receipts: Historical tax receipts to GVA in the UK have been steady at around 30%
3. This ratio was then used to calculate the annual tax receipts against two cases:

   A. **GVA Case A**: GVA cashflows of existing plants that continue operations due to CCUS intervention

   B. **GVA Case B**: GVA cashflows associated with keeping the plants open in South Wales, i.e., case A along with the wider economic activity generated by CCUS e.g., new hydrogen plants, indirect/induced wage effects from creation of new jobs

Sensitivity Analysis on Tax Receipts

1. **Breakeven Scenario for GVA Case A**: Tax receipts as a percentage of GVA required to meet the funding gap
2. **Breakeven Scenario for GVA Case B**: Tax receipts as a percentage of GVA required to meet the funding gap

Results

Given the inclusion of all potential GVA components, the required tax receipts as a percentage of GVA for breakeven, standing at around 23%, is less than the long-term average of 30%. This underscores the feasibility and economic sense of the proposed funding.

1. Funding Gap

We estimate that public funding (either from general taxation or through consumer levies) of around £2.4 Billion is required to support CCUS in South Wales given our expectation of future carbon prices

2. Comparing Funding Gap with Tax Receipts

Assuming 30% of the GVA goes back to the government in the form of tax receipts.

- GVA Case A: Keeping the plants open and preserving their GDP generates £2.2 Billion in the form of discounted NPV of Tax Receipts which is close to 91 percent of the Funding Gap
- GVA Case B: While for overall GVA benefits (including new hydrogen and CCUS plants, indirect/induced wage effects from creation of new jobs in addition to keeping the plants open): Discounted NPV of Tax Receipts is £3.1 Billion which is more than the Funding Gap

Sensitivity Analysis

1. We have estimated the proportion of GVA which the Government would need to recover in tax from South Wales CCUS customers once the necessary shipping infrastructure is in place (i.e., from 2030 onwards) to recoup the public outlay
2. Breakeven Scenario for GVA Case A: We find that around ~33% of CCUS customers’ GVA would need to be recovered in tax receipts to recover the public outlay. While this is higher than the Tax Receipts : GVA ratio in the UK economy as a whole (observed in national statistics to be around 30% over time), the project’s broader economic impact, the near and long-term benefits such as job retention and creation and alignment to UK’s net zero goals, offer compelling reasons for investment
3. Breakeven Scenario for GVA Case B: Additionally, ~33% (Case A) may be a cautious estimate because it only considers the tax receipts from the industrial base, rather than the wider economic activity generated by CCUS e.g., new hydrogen and CCUS plants, indirect/induced wage effects from creation of new jobs. If we include wider components of GVA (Case B), only around ~23% of GVA generated would need to be recovered in tax to pay back public outlay

05
Sensitivity Analysis

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Sensitivity: Details on balanced case

There is considerable uncertainty around the future costs and benefits of a CO_2 shipping solution. We have therefore developed ranges around key economic parameters in order to capture the range of potential outcomes.
To perform the sensitivity analysis, we identified five variables and created three cases that impact the final NPV figure. These are:

Variable	High Benefits Case	Balanced Case	Low Benefits Case
CCUS adoption (percentage)	Immediate 100% adoption in 2029	Gradual adoption between 2029-2040	Gradual adoption between 2029-2048
Shipping distance (round trip, km)	1,200km	1,200km	2,000km based on the special case where the ships pick up CO_2 from Thames or Southampton and then go on to Scotland rather than going directly to Scotland from South Wales in which case the 1200km distance applies
LCOA estimates for port infrastructure costs	Lower estimate, NZIW partner information	Higher estimate, NZIW partner information	Higher estimate, NZIW partner information
LCOA CCUS (£ per tCO_2)	£50	Different values for different sectors with an average around £100 per tCO_2	£200
UK ETS growth rate (2023-2050, percentage)	5.9%	4.4%	2.9%

To capture the uncertainties around future costs and benefits, we developed a series of sensitivities around key cost parameters e.g., CCUS adoption rate, choice of store, port infrastructure costs, carbon capture costs and carbon prices.

For carbon pricing, we aligned UK ETS price growth rate with an LSE[1] report's projected price of £160/tCO_2 by 2050 which corresponds to a CAGR of 4.4% (balanced case). For other two cases, we adjusted this rate to explore the project's resilience under different carbon pricing scenarios.

Our sensitivities also account for different rates of CCUS penetration once the infrastructure is available which examines the impact of varying rates of CCUS adoption over time. By adjusting this variable, we can assess how different levels of CCUS implementation—ranging from immediate full-scale deployment to a more gradual approach—affect the overall NPV of the project. The sensitivities considered are summarised below.

Note: 1. London School of Economics and Political Science, 'How to price carbon to reach net-zero emissions in the UK', May 2019, Link

Sensitivity: NPV results

The table below shows how the NPV outcomes vary when key variables are adjusted to account for uncertainty. Even in a scenario with high CCUS costs and slower growth in carbon prices, there is still a strong net benefit to investment in CO_2 shipping infrastructure.

	Sensitivity Analysis Summary				
		High Benefits Case	Balanced Case	Low Benefits Case	Commentary
	Sensitivity assumptions				
	CCUS adoption (percentage)	Immediate 100% adoption in 2029	Gradual adoption between 2029-2040	Gradual adoption between 2029-2048	Faster adoption avoids plant closure leading to higher benefits
	Shipping distance (round trip, km)	1,200km	1,200km	2,000km	Longer distance reduces benefits as shipping costs are higher
	LCOA estimates for port infrastructure costs	Lower estimate, NZIW partner information	Higher estimate, NZIW partner information	Higher estimate, NZIW partner information	Higher costs leading to lower NPV
	LCOA CCUS (£ per tCO_2)	50	As per NZIW partner information and IEA	200	Negatively related to NPV
	UK ETS growth rate (2023-2050, percentage)	5.9%	4.4%	2.9%	Increase positively impacts NPV due to higher emissions reduction benefits
	Outputs (£bn)				
Benefits	NPV (Avoided loss of GVA)	6.0	6.0	6.0	Constant, assuming plant stay open from 2029 once CCUS is available
Benefits	NPV (Avoided emissions reductions)	17.7	8.5	4.4	Depends upon CCUS adoption rate and UK ETS price
Benefits	**Sum of avoided costs versus Do Nothing**	**23.7**	**14.6**	**10.4**	
Benefits	NPV (GVA from new jobs)	3.2	2.8	2.4	Varies based on CCUS deployment rate
Benefits	NPV (GVA from new hydrogen plant)	1.3	1.3	1.3	Constant based on fixed installed capacity
Benefits	NPV (GVA from Pembroke Net Zero Centre)	0.2	0.2	0.2	Constant, as per RWE PNZC report
Benefits	**Sum of benefits**	**28.5**	**18.9**	**14.4**	
Costs	NPV (Costs of CCUS development)	9.7	11.0	10.4	Depends upon LCOA costs, CCUS adoption rate
Total	**Overal NPV**	**18.8**	**7.9**	**4.0**	

Note: Totals may not sum due to rounding.

06 Assumptions

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Assumptions

Discount Rate and Inflation Rate

Discount Rate: 3.5% as recommended by the UK Green Book

Inflation Rate: 1% (long term average)

UK ETS price growth rate

4.4%, based on EU ETS emissions cap reduction rate between 2023-2030

Project Lifecycle

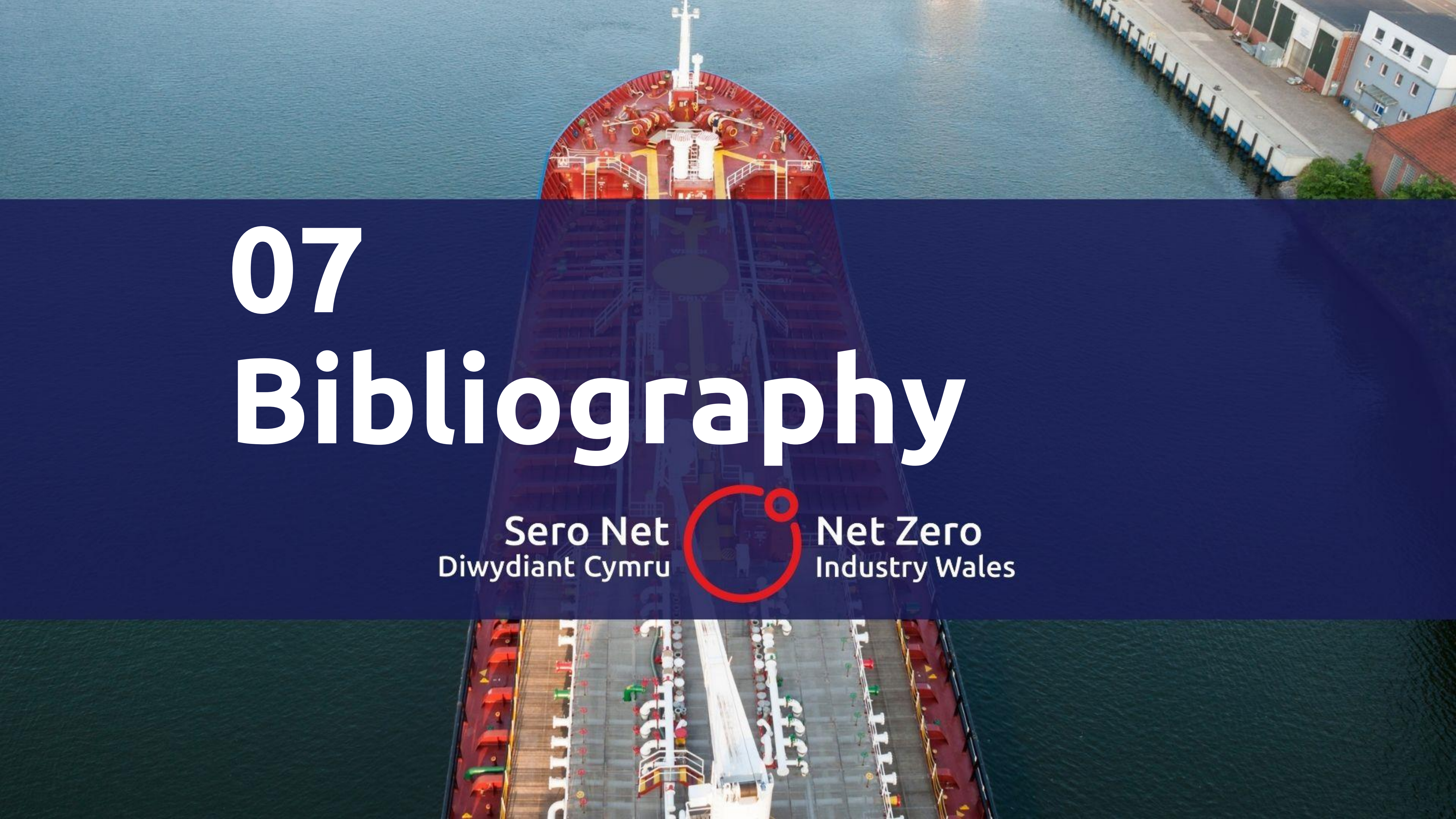
20 years as recommended by Green Book. This is operational life which is in addition to the CAPEX duration. The timeframe for our analysis therefore runs out to 2048.

No growth in emissions at existing plants

Example, the recently announced UK Government and Tata Steel deal to invest in electric arc furnace method for steel manufacturing which ensures lower emissions as compared to the current method.

Efficiency of CCUS units

95%



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