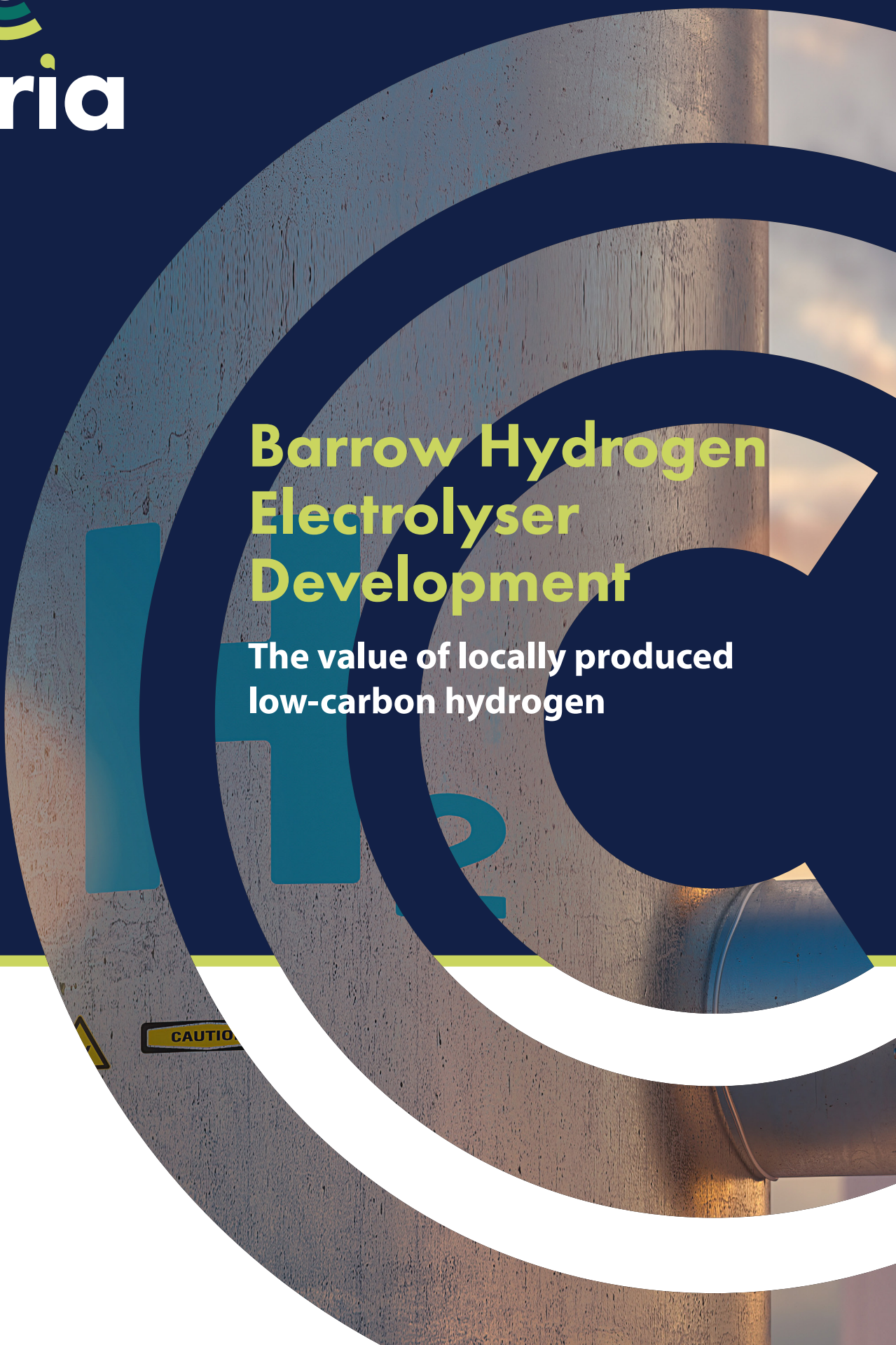
Curia

Barrow Hydrogen Electrolyser Development

The value of locally produced low-carbon hydrogen



Contents

Foreword

Hydrogen is the most abundant element in the universe and the simplest of all atoms, but it is only present as a gas in the Earth's atmosphere in small amounts. It can, however, be manually produced by many processes. It is then referred to by different colours (green, yellow, brown, grey, blue, pink and turquoise) and stored as a gas. At a later stage, the hydrogen can be converted back into electricity in 'fuel cells' or simply burned for heat. Reacting the hydrogen with oxygen forms water, a clean by-product.

Most of today's hydrogen production occurs through heating steam and methane, it also relies heavily on fossil fuels and produces carbon emissions (so-called grey hydrogen). Green hydrogen refers to hydrogen created via a zero-carbon emission process that uses electricity (from renewable sources) to split water into its component parts (H2 and O2) using electrolysis. By using electricity from wind and solar farms, electrolysers (where the reaction takes place) allow for the storage of surplus energy in the form of hydrogen gas.

Hydrogen gas is an industrial input with many uses, such as

- A replacement for natural gas, comprised principally of methane in industrial uses
- A replacement for petrol and diesel in transport that uses fuel cells
- Heating homes and businesses - with modification to gas networks
- As a fuel, perhaps a carbon-neutral substitute for shipping and aviation fuel - after conversion to ammonia
- Fertiliser - after conversion to ammonia
- In the creation of methanol, a feedstock in the plastics industry
- Being burned and the subsequent heat generating electricity

Some of the uses above will only become feasible in the market if there is a large, cheap and reliable source of low-carbon hydrogen that benefits from economies of scale and the infrastructure required to distribute this alternative fuel. Like solar and wind power generation before it, hydrogen is a low-carbon technology and could revolutionise the economy once critical mass is achieved.

The main reasons to invest in low-carbon hydrogen at a national level fall into three categories; environmental, economic and strategic.

Environmental

The obvious reason to invest in green hydrogen is as a low-carbon replacement fuel. It can also be used to store energy when electricity is plentiful. This energy can then be released again when electricity is scarce.

At an economy-wide level, hydrogen has the potential to remove fossil fuel usage from significant sectors where electrification is unfeasible.

Economic

It could serve the UK well to support the hydrogen industry and thereby gain a first-mover advantage in this industry of the future, potentially securing an export market share.

The UK is already a world leader in offshore wind energy, which puts it in a good position to be a world leader in the production of green hydrogen within this decade. To lead in the production of green hydrogen, it is essential that pilot projects are implemented in the UK as soon as possible to: gain practical experience; capitalise on efficiencies through learning curves; and scale effects on production equipment, such as electrolysers and hydrogen vehicles.

The initial projects will be developed at a pre-commercial phase, have limited electrolyser capacities - typically well below 50 MW - and have limited immediate direct social and economic value. However, these pioneer projects, and the resulting collaboration between a network of hydrogen stakeholders (including hydrogen producers, hydrogen off-takers, local authorities and academic institutions), will lead to new hydrogen innovation clusters. These clusters will catalyse an important positive feedback cycle and lead to new skills and jobs. This cycle will ensure continuous demand growth, which will justify the implementation of the required hydrogen infrastructure. This infrastructure could include pipelines and export terminals, which will take many years to develop but could be complete by 2030 if the investment is made now.

Strategic

As the war in Ukraine has demonstrated, the UK is dangerously dependent on the international markets for natural gas. It is similarly tied to the markets for other fossil fuels. Decarbonisation presents an opportunity to decouple our supply of energy from these markets and therefore, gain strategic autonomy.

For these reasons, it is both prudent and advantageous for the UK to develop hydrogen as an alternative fuel and energy source.

Headline Findings

Economic Benefits

£3.78 million

£3.78 million Gross Value Added (GVA) to the local economy by 2030 [1]

- Increase of 0.21% to local GDP [2]
- £56 per benefit to households in Barrow-in-Furness [3]
- Contributes to The Town Investment Plan, generating £63.2 million in additional GVA [4]

318 jobs

318 jobs supported by development [5]

- 5 during the development phase
- 19 during the construction phase
- 3 during operation phase
- 247 secured from decarbonisation
- 43 estimated new jobs required at hydrogen offtakers

Social Benefits

15 jobs

15 jobs upskilled for ongoing work [6]

- **6 out of 7** hydrogen consumers expect to see improvements in air quality [7]
- Improving Net Zero literacy

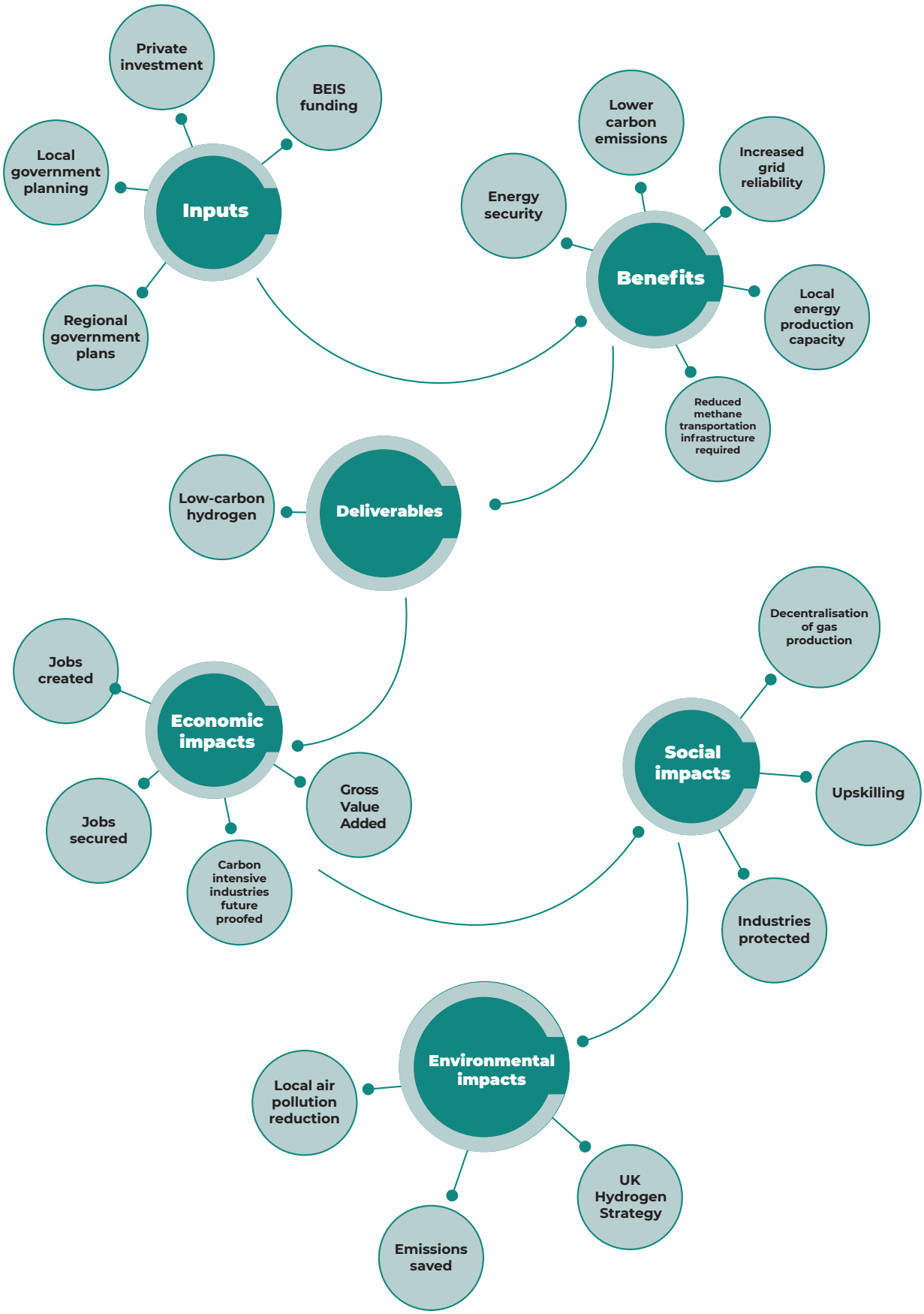
Environmental Benefits

0.42%

0.42% of UK Hydrogen Strategy 2030 low carbon hydrogen production target [8]

- **2%** of the UK Hydrogen Strategy 2025 low carbon hydrogen production target [9]
- **6.14%** of Local Authority's emissions saved [10]
- **23,526** tonnes of carbon emissions saved per annum [11]
- **£1,835,043** equivalent of carbon dioxide emissions foregone [12]
- The production of hydrogen by electrolysis helped the national grid to balance the intermittency of renewable energy sources, allowing more to be safely added to the grid for further decarbonisation [13]

1 Internal BEIS estimates of GVA. BEIS numbers divided by 21 MW electricity consumption of this project
2 ONS 2020 Local Authority GDP figures
3 67,400 Barrow-in-Furness population in 2021 https://www.ons.gov.uk/visualisations/censuspopulationchange/E07000027/
4 https://brilliantbarrow.org.uk/wp-content/uploads/2022/05/Barrow-Town-Investment-Plan-Screen-Optimised.pdf and letter from Director of People and Place, Borough of Barrow in Furness 5th September 2022
5 See Appendix 1
6 Based on Curia Survey results from hydrogen offtakers 2022
7 Curia Survey results from hydrogen offtakers 2022
8 UK Hydrogen Strategy, https://www.gov.uk/government/publications/uk-hydrogen-strategy
9 Ibid
10 Assuming 66% capacity used to produce hydrogen to replace natural gas. 2.75 tonnes of CO_2 per tonne of natural gas combusted. 2.58 tonnes of natural gas to release same energy as tonne of H_2 - https://www.world-nuclear.org/information-library/energy-and-the-environment/hydrogen-production-and-uses.aspx. 2019 Local authority emission figures used - BEIS
11 Ibid
12 Assuming a UK ETS carbon price of £78 per tonne. KPMG
13 National Grid. (2022) What is hydrogen? Available at https://www.nationalgrid.com/stories/energy-explained/what-is-hydrogen. Accessed 16 November 2022


Private investment
BEIS funding
Local government planning
Inputs
Regional government plans
Lower carbon emissions
Increased grid reliability
Energy security
Benefits
Local energy production capacity
Reduced methane transportation infrastructure required
Low-carbon hydrogen
Deliverables
Jobs created
Economic impacts
Jobs secured
Gross Value Added
Carbon intensive industries future proofed
Decentralisation of gas production
Social impacts
Upskilling
Industries protected
Local air pollution reduction
Environmental impacts
UK Hydrogen Strategy
Emissions saved

Executive Summary

The Barrow Green Hydrogen electrolyser project is leading the way in UK hydrogen production and will help catalyse a UK hydrogen economy that will be worth £900 million GVA by 2030 [14].

This development will secure and create over 300 jobs - through its construction and operation - in the fifty eighth most income-deprived area in the country. The facilities will establish a new cluster of expertise and training opportunities, leading to a greater understanding of the requirements for anticipated future skills and employment opportunities.

It will enable a fleet of fuel cell vehicles, which will integrate with another disruptive technology supply chain and collaborate across the value chain to improve the overall effectiveness of fuel cell technology. This will further support opportunities for entrepreneurship, leading to local and national economic growth.

14 Internal BEIS estimates of GVA. BEIS numbers divided by 10.5 MW electricity consumption of this project.

By introducing hydrogen as a storage medium for renewable energy, this project will increase the diversity of both the North West and overall UK energy sector and will lead to reduced dependence on the international gas market. Due to the decentralised nature of hydrogen production and the UK's current leadership in renewable energy, Barrow Green Hydrogen will help to develop a diverse and resilient supply market. This will lead to the manufacturing of hydrogen electrolysers in the UK and help to position the UK as a potential world leader in this market.

Barrow Green Hydrogen will generate revenue from the sale of hydrogen and demonstrate that smaller production facilities can be located across the country next to renewable energy production sources (including onshore and offshore wind, solar, and biomass). This will enable renewable energy to be stored across the country and will help to balance supply and demand. In turn, this could lead to new jobs wherever renewable energy is produced across the country. Enabling greater local energy production, and reducing dependence on either national or international energy, will help to level up the economy.

As the price of renewable energy falls and electrolyser technology efficiency improves, the cost of hydrogen will fall further and become an increasingly important element of the UK's diversified energy sector. Generating low-carbon hydrogen is not only part of the Government's plan, but it also precludes the need to burn natural gas, thereby leading directly to a reduction in carbon emissions as the UK's energy grid transitions at a more rapid rate to renewable energy. This will also lead to the enhancement of the natural environment and air quality. Poor air quality is the largest environmental risk to public health in the UK. Long-term exposure to air pollution can cause chronic conditions such as cardiovascular and respiratory diseases, as well as lung cancer, all of which lead to reduced life expectancy [15]. This improved air quality will lead to improved health and wellbeing and reduce the demand on public services.

This project will lead to a greater understanding of the use of the required disruptive green technologies and drive new efficiencies to deliver at a lower cost in the future. It will also provide opportunities for collaborations between academia and industry to bring new applied research to market. This will lead to the development of scalable and future-proofed new methods that will modernise the UK's energy grid.

Barrow Green Hydrogen will provide 21 MW c.0.42% of the Government's 5 GW hydrogen production target by 2030. However, the real value to the nation from this project will form in proving the ability to de-risk and the commercial viability of low-scale facilities in the short term. This will catalyse further investment in this area and support the UK's journey to Net Zero.

In summary, the development will lead directly to new opportunities in the high-growth hydrogen economy, help tackle economic inequality, fight climate change and improve local wellbeing.

The benefits in this report have been quantified by synthesising data using a variety of methods and research sources that include: BEIS UK Hydrogen Strategy; stakeholder survey responses; analysis of expected impact by multiple stakeholder groups (including potential suppliers and offtakers); CITB labour forecasting tools for job calculations; the UK Government's social value model and Unitrove natural gas calorific value calculator.

15 Health matters: Air pollution (no date) GOV.UK. Available at: https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution (Accessed: November 6, 2022).

Economic Benefits

The economic benefits, to Barrow and the surrounding areas, of hosting a hydrogen electrolyser stem from the GVA of its operation the high-tech sustainable jobs created and the effect on the local labour market, including the jobs shielded from the wrenching change of decarbonisation by the replacement of natural gas with low carbon hydrogen.

GVA

Calculating the GVA of this facility is primarily based on assumptions about production, electricity price and the price of (green) hydrogen. Production is relatively simple to calculate. Carlton Power expects to see a 66% uptime for their electrolyser, delivering 21 MW of hydrogen.

The long-term electricity and hydrogen prices are harder to calculate and will develop as the technology develops. In 2022, the price of electricity is increased due to restricted supplies of gas available, due to the Russia - Ukraine conflict. As the UK decarbonises electricity production, the price should become immune to price rises and falls in the global and european markets for oil and gas and therefore to 2022 or 1973-style disruptions.

On the other hand, the commercial use of hydrogen as an energy carrier is a nascent market, estimated prices are inexact as both supply and demand are expected to fluctuate significantly in the coming years. For example, as the supply of hydrogen increases, we can expect the demand to rise— businesses will use hydrogen to decarbonise their operations. This demand may swamp supply, causing a higher hydrogen price, or it may merely keep up with the Government's projections.

Given these uncertainties, this report has utilised the Government's projections as laid out in the UK Hydrogen Strategy, divided by the hydrogen output of the current proposal. On this basis, this development could add £1.89 million GVA to the local economy by 2030.

Job market changes

Calculations of the changes to the job market (see Appendix 1) show that Barrow and its surrounding areas can expect to see an additional five jobs (FTE) added during the development phase of this project, 19 during the construction phase and three permanent roles during the operation phase. In letters of support for the project, 64% of stakeholders stated that they expect to see sustainable job creation and growth as a result of this project (see Appendix 2). Supporters range from Simon Fell, MP for Barrow-in-Furness, to the Cumbria Local Enterprise Partnership.

64% of these letters of support also expect this project to support the development of a skills cluster, allowing Barrow to concentrate its economic development on producing hydrogen and the industries that green hydrogen allows for.

Job market protection

As the UK decarbonises, significant disruption to jobs across the economy is likely. Currently, the UK economy's foundation is the exploitation of fossil fuels and a built-in assumption is the negligible cost of emitting carbon dioxide and other greenhouse gases. As the exploitation of fossil fuels ends and the emissions of greenhouse gases are increasingly expensive and/or regulated, there may be fast and radical shifts in the job market - the likes of which have not been seen since the 1980s.

As seen in previous shifts, particularly deindustrialisation, the rapid redeployment of labour across the economy and geography can cause lasting impacts on the individuals and communities affected. Where possible, decarbonisation should preserve economic relationships as they are, curtailing disruption to people's lives and lessening the economic and social upheaval during the change.

43 new jobs can be expected as hydrogen offtakes adjust the processes to receive hydrogen.

In addition, by easing manufacturers away from natural gas and towards hydrogen in and around Barrow, at least jobs 247 will be secured, which might otherwise be put at risk by decarbonisation.

In each case, these jobs are secured against the risks that decarbonisation will bring in future decades. While the economic benefits should not be underplayed, the social benefits could eclipse them in the long-term. Communities will be secure to develop long-term economic relationships and culture without unnecessary disruption.

Social Wellbeing Benefits

For Barrow and the surrounding areas, the social benefits of this development include the upskilling of roles in the local economy. This upskilling will lead to a better-trained workforce, expected improvements in air quality - leading to better local health outcomes - and a wider increase in wellbeing from decarbonisation in general. Specifically, businesses are already feeling pressure from their customer bases to decarbonise. As the ways in which products are produced comes into line with societal expectations, base positive effects on how people view their local area are expected.

Upskilling

As stated earlier, 64% of stakeholders that have delivered letters of support expect this development to support the creation of a skills cluster in Barrow. Analysis shows that at least 15 roles are expected to be upskilled during the construction and operation of this facility.

As people are upskilled and a cluster of excellence is developed, reductions in local poverty are expected. This reduction is particularly relevant in Barrow, the fifty eighth most income-deprived local authority area in the country. Falls in poverty have positive effects on a range of indicators, including education, improved mental health and local investment.

Improved air quality

The product formed from burning hydrogen in air, is water. Any shift from using natural gas to hydrogen, in well-regulated combustion, should lead to a slight improvement in air quality. Any switch from using fossil fuels to hydrogen fuel cells should lead to a much larger improvement in local air quality.

Emissions from the combustion of fossil fuels are proven[16] to cause mortality and disease, so any reduction is to be welcomed.

Decarbonisation

As the issues surrounding climate change become more urgent, people around the UK are more conscious of the impact of their actions and the contribution of their local economy to the climate.

This consciousness is reflected in local political outcomes. For example, in 2019, Barrow Borough Council declared a climate emergency which in 2020 resulted in the approval of a Climate Change Policy[17]. Increased access to low-carbon hydrogen as an energy carrier will allow the local area to pursue their climate goals and hopefully, achieve their aims.

The ability of a community to set goals, make changes and see the outcome of their actions can only improve overall social wellbeing, particularly when this happens in conjunction with such well-understood environmental benefits.

16 Vohra, K. et al. (2021) Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem, Environmental Research. Academic Press. Available at: https://pubmed.ncbi.nlm.nih.gov/33577774/

17 Climate change policy — Barrow BC (no date). Available at: https://www.barrowbc.gov.uk/_resources/assets/attachment/full/0/8373.pdf (Accessed: November 13, 2022).

Environmental Benefits

The environmental benefits of local electrolysis for the production of hydrogen are threefold. Firstly, the replacement of natural gas with low-carbon hydrogen will result in significantly lower carbon emissions into the atmosphere. Secondly, the protection of local manufacturing industries from measures to reduce carbon emissions, such as carbon taxes or increased regulation, will reduce emissions from the transport of outsourced manufactured goods. Thirdly, the addition of hydrogen electrolyzers to the grid adds to the demand for electricity when it is cheap and therefore, plentiful. Low electricity prices are now correlated with output from renewable generation sources. Therefore, by adding demand when electricity is plentiful, the national grid should be able to add more intermittent renewable energy sources than they otherwise would.

Direct emission reductions

This report's analysis begins with the assumption that all of the hydrogen produced at the Barrow site will be used to replace natural gas as an energy source. Natural gas is the most carbon-efficient fossil fuel source, so if any of the hydrogen produced at Barrow is used in hydrogen fuel cells that are used to replace petrol or diesel in transport, then these numbers will prove conservative.

These numbers show that before any upgrades and expansion, this project will result in a reduction of 23,526 tonnes of carbon emissions annually. This represents over 6% of the entire local authority's emissions - a significant step towards a Net Zero Barrow. Using the current carbon price as a benchmark, this represents £1,835,043 equivalent of carbon dioxide emissions foregone [18]. These numbers are likely to be conservative as the carbon price will increase over time.

Local manufacturing

As prices increase on the UK Emissions Trading Scheme, more sectors will be brought into the scheme and the regulation to reduce UK carbon emissions will increase. The incentives for businesses to move their manufacturing abroad - where regulations are less strict and carbon dioxide can be emitted at a lower cost - will also increase.

By providing a low-carbon fuel for industries to use, this behaviour will be disincentivised, leading to manufacturing being maintained onshore and reducing emissions associated with the transport of goods around the world.

Grid balancing

The electrolysis of hydrogen is a relatively reactive process and is able to be turned up or down as is convenient. Naturally, Carlton Power will endeavour to run their electrolyser when electricity is abundant and therefore, cheaper. This model of demand will have a balancing effect on the grid, making it more resilient and resulting in renewable energy sources needing to be shut down less often[19].

This will allow more intermittent renewables to be added to the grid while maintaining stability and therefore, reducing carbon emissions indirectly.

18 Assuming a UK ETS carbon price of £78 per tonne. KPMG

19 Mathis, W., Morison, R. and Gillespie, T. (2022) UK's National Grid Issues Warning as wind power sets record, Bloomberg.com. Bloomberg. Available at: https://www.bloomberg.com/news/articles/2022-05-25/uk-wind-power-sets-record-on-gusty-weather?leadSource=uverify+wall (Accessed: November 6, 2022).

The Social Value Model

In 2020, the Government introduced The Social Value Model[20]. It is used by the public sector to evaluate the social value in tender responses. The model itself is a sensible way to benchmark projects and ensure they align with the goals of the Government. This section evaluates where this project will further the goals set out by this framework.

Theme/Policy Outcome	Ref	Criteria	Sub Criteria
Help local communities to manage and recover from the impact of Covid-19	MAC 1.1	New opportunities in the high growth sector of the hydrogen economy. [Number of full-time equivalent (FTE) employment opportunities created under the contract, by UK region, for those who were made redundant due to Covid-19].	
	MAC 1.4	Increased health and reduced demand on public services.	
Tackling economic inequality: create new businesses, new jobs and new skills	MAC 2.1	Create opportunities for entrepreneurship and help new organisations to grow, supporting economic growth and business creation.	
	MAC 2.2	Create employment and training opportunities in the high-growth hydrogen economy, which currently has known skills shortages.	Understanding of employment and skills issues and of the skills and employment shortages of high-growth sectors. Understanding of employment and skills issues and of the education and training issues relating to the contract. Illustrative examples: demographics, skills shortages, new opportunities in high growth sectors.

20 The social value model - gov.uk (no date) : https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/940826/Social-Value-Model-Edn-1.1-3-Dec-20.pdf (Accessed: November 7, 2022).

Theme/Policy Outcome	Ref	Criteria	Sub Criteria
Tackling economic inequality: increase supply chain resilience and capacity	MAC 3.1	Create a diverse supply chain to deliver the contract, including new businesses and entrepreneurs, start-ups, SMEs, VCSEs and mutuals. Plans for engaging a diverse range of businesses in engagement activities prior to appointing supply chain members (including activities prior to the award of the main contract and during the contract term).	Growing and diversifying supply chain opportunities is at the heart of the Government's Industrial and Civil Society Strategies. An economy with diverse, resilient and innovative supply markets is a cornerstone of prosperity. It provides the best environment to start and grow a business. Markets with a broad range of suppliers of different types can offer better value for money, promote innovative solutions and give public services access to expertise and knowledge on complex issues. There is also a commercial advantage to spreading risk more broadly since it reduces commercial risk.
	MAC 3.2	Support innovation and disruptive technologies throughout the supply chain to deliver lower cost and/or higher quality goods and services.	Understanding of opportunities to drive innovation and greater use of disruptive technologies, green technologies, efficiency and quality to deliver lower cost and/or higher quality goods and services. Activities that promote collaboration to access new technologies/green technologies and/or approaches. Measures to ensure the development of scalable and future-proofed new methods to modernise delivery and increase productivity.
	MAC 3.3	Support the development of scalable and future-proofed new methods to modernise delivery and increase productivity.	Understanding of scalable and future-proofed new methods to drive greater modernisation of delivery and increase productivity.
Fighting climate change	MAC 4.1	Deliver additional environmental benefits in the performance of the contract, including working towards Net Zero greenhouse gas emissions.	Enhancing the natural environment, such as habitat creation, increasing biodiversity, such as increased numbers of pollinators. Green space creation in and around buildings in towns and cities, e.g. green walls, utilising rooftops for plants and pollinators. Improving air quality.
Wellbeing: improve health and wellbeing	MAC 7.1	Demonstrate action to support health and wellbeing	
	MAC 7.2	Influence staff, suppliers, customers and communities through the delivery of the contract to support health and wellbeing - including physical and mental health.	
Wellbeing: improve community integration	MAC 8.1	Demonstrate collaboration with users and communities in the co-design and delivery of the contract to support strong integrated communities.	Understanding of local demographics, needs and opportunities for the co-design of the goods, services and works to be delivered under the contract.
	MAC 8.2	Influence staff, suppliers, customers and communities through the delivery of the contract to support strong, integrated communities through engagement; co-design/creation; training and education; partnering/collaborating; and volunteering.	

Methodology

Curia has produced this report using a mixture of analyses produced by BEIS as part of the UK Hydrogen Strategy and other respected open-source information, for example, the Office for National Statistics (ONS) data and the census.
A survey of Carlton Power's stakeholders has been conducted, potential hydrogen offtakers, and suppliers for the proposed construction.

The numbers above have been synthesised to the best of Curia's ability, using techniques and sources stated in their footnotes. Where possible, Curia has modelled incomplete data up to scale, using averages and estimated output to demonstrate potential value.

Further analysis of the benefits of each scheme will be undertaken as the project progresses through the development, construction and operation phases.

Sources and Endnotes

Appendix 1: Job Projections

Direct Project Jobs				
Development Phase	CP	Consultants		Total
FTE	1.5	3.5		5
Construction Phase	SPIE	Plug Power	PM Team	
FTE	8	5	6	19
Operations Phase	ProjectCo	Hoyer		
FTE	3			3

Offtaker Jobs	KC			
Direct Employees	407			
Indirect Employees				
% energy from H2	60.8%			
Jobs secured	247*			247
Additional Jobs**	47			43

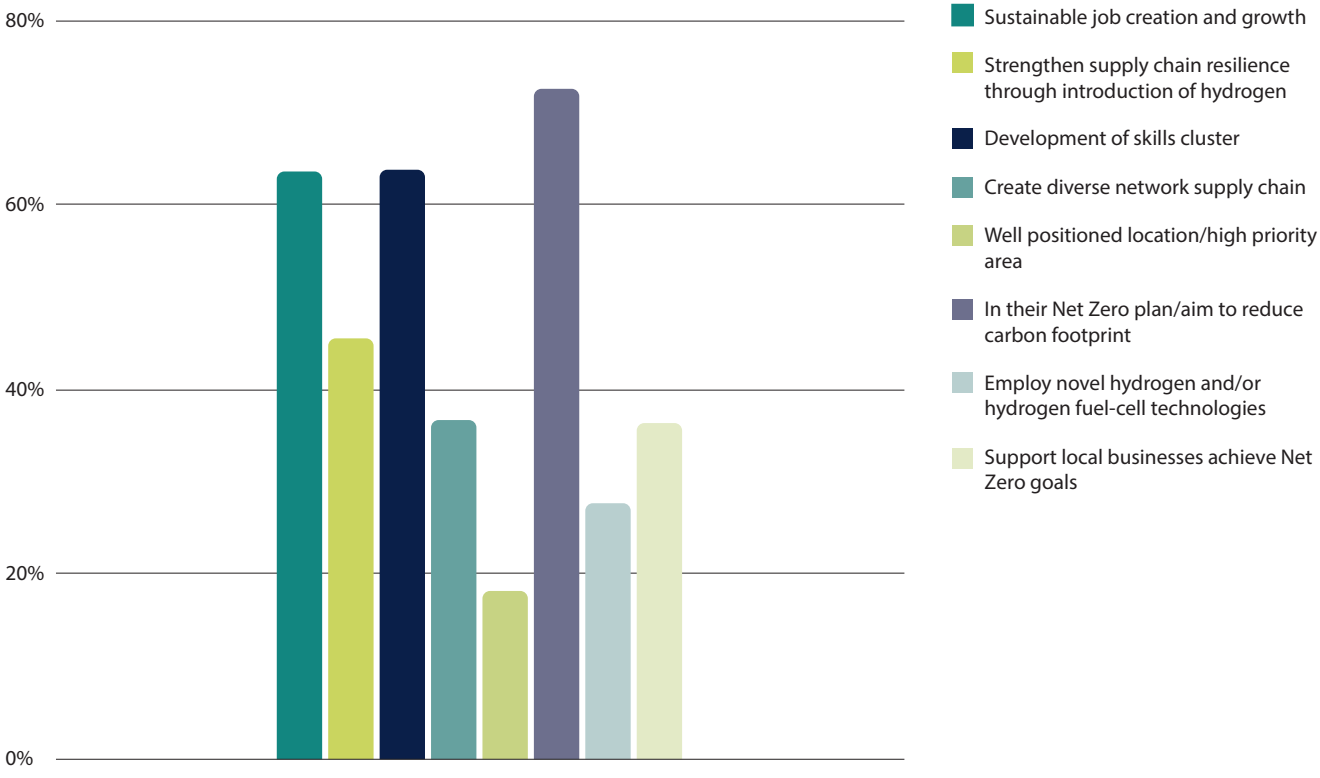
Wider Ecosystem				
FTE				0

Total				318

* Jobs that currently exist and are now powered by green energy and so are resistant to economic impacts of decarbonisation
** Calculated by upscaling the increase from similar customers

Appendix 2: Analysis of letters of support

% of letter of support that that mention these goals



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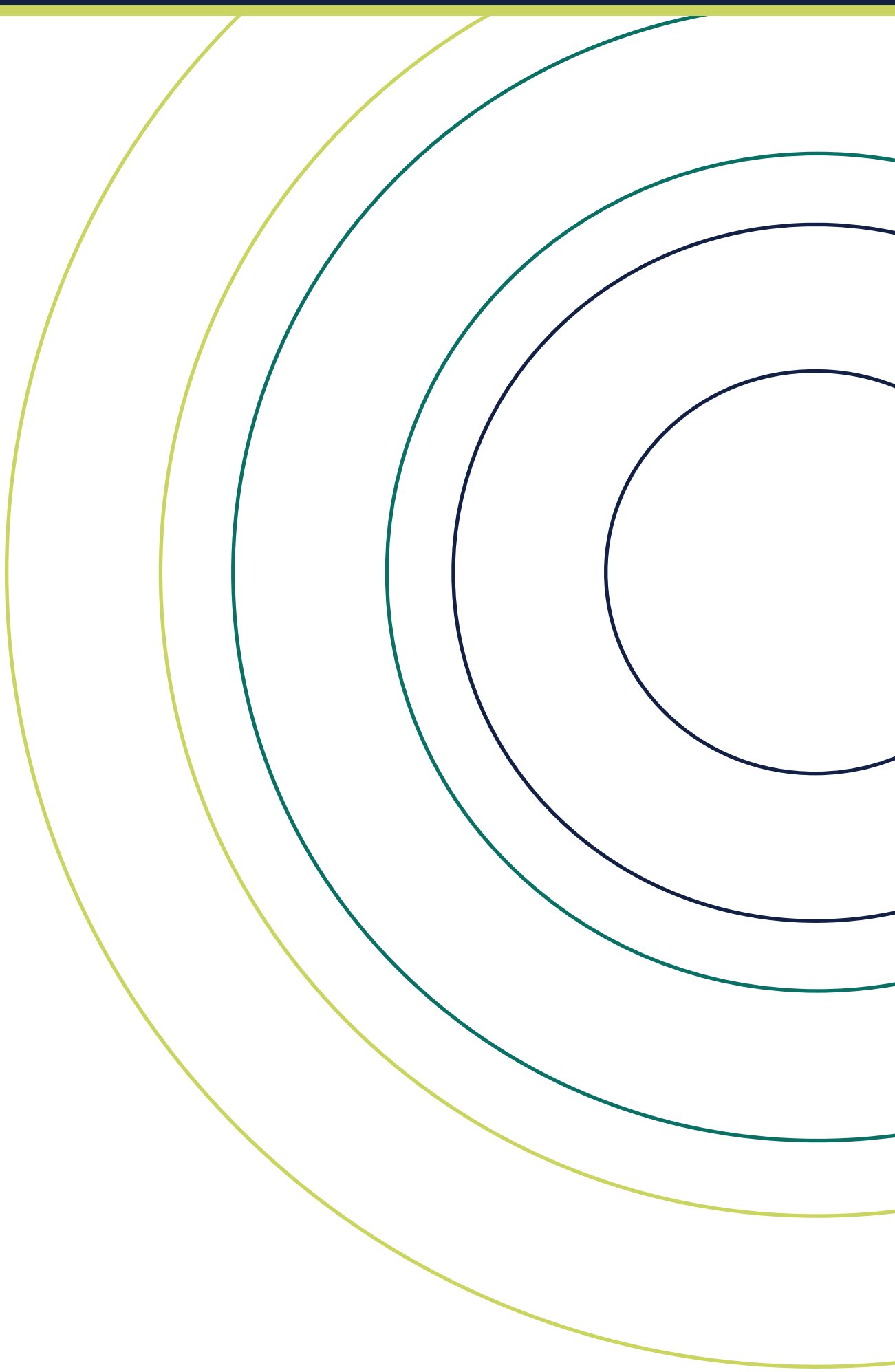
Anderson Strategy facilitates the development of strategic plans and reports to accelerate the green and digital 'twin transitions' and help government and business:

- build clarity, direction and focus
- identify and quantify value creation opportunities
- understand social, environmental and economic impact
- inform policy creation
- communicate to stakeholders
- and attract funding for development



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