SUSTAINABILITY JOINT INDUSTRY PROGRAMME

Steel decarbonisation in the offshore wind industry

An integrated approach to decarbonising steel in the offshore wind supply chain

July 2026

EnBW

JERA NEX BP

Ørsted

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ScottishPower Renewables

sse Renewables

RWE

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About the Sustainability JIP

The Sustainability Joint Industry Programme (JIP) is a developer-funded and developer-led collaborative initiative. The programme aims to accelerate decarbonisation action across future fixed and floating offshore wind farm projects for a Net Zero future.

This report summarises the key findings from the research related to steel decarbonisation and incentivising the use of lower emission steel within the offshore wind (OSW) industry.

The Sustainability JIP partners commissioned the Offshore Wind decarbonisation pathway, which was published in December 2024. The pathway provides a holistic framework for understanding and reducing emissions throughout the wind farm life cycle. It is encouraged to be used as a framework for stakeholders to work together in accelerating the global offshore wind industry's transition to Net Zero.

The Sustainability JIP Phase 2 (2025-2026) is a collaboration between the Carbon Trust and 8 OSW developers: EnBW, JeraNex bp, Ørsted, RWE Offshore Wind GmbH, ScottishPower Renewables, SSE Renewables, Statkraft and TotalEnergies.

Acknowledgements

The Carbon Trust collaborated closely with the Sustainability JIP Phase 2 project partners throughout the development of this project. Additionally, the Carbon Trust engaged with numerous stakeholders from the OSW supply chain and wider steel industry experts. While we will not list all contributing stakeholders for confidentiality purposes, we would like to thank all of those who provided input.

Disclaimer

This Pathway is intended to provide the vision and shared direction for steel decarbonisation within the offshore wind sector. It recognises that delivery will depend on complex, overlapping dependencies across multiple stakeholders, and that not all proposed activities may be feasible in every context. The Roadmap does not place formal obligations on stakeholders, but can be used to guide discussion, coordination and prioritisation of future activity.

Who we are

The Carbon Trust's mission is to accelerate the move to a decarbonised future. We have been climate pioneers for more than 20 years, partnering with leading businesses, governments and financial institutions globally. From strategic planning and target setting to activation and communication - we are your expert guide to turn your climate ambition into impact.

We are one global network of 350 experts with offices in the UK, the Netherlands, Germany, South Africa, Singapore and Mexico. To date, we have helped set 200+ science-based targets and guided 3,000+ organisations in 70 countries on their route to Net Zero.

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Abbreviations

BAU	Business as Usual
BF-BOF	Blast Furnace-Basic Oxygen Furnace
CBAM	Carbon Border Adjustment Mechanism
CIB	Clean Industry Bonus
CISA	China Iron and Steel Association
DRI	Direct reduced iron
EAF	Electric arc furnaces
EPD	Environmental Product Declarations
ETS	European Trading Scheme
GHG	Greenhouse gas
GW	Gigawatt
IEA	International Energy Agency
JIP	Joint industry programme
MENA	Middle East and North Africa
Mt	Megatonne
LESS	Low Emission Steel Standard
OEM	Original equipment manufacturers
OSW	Offshore wind
PCF	Product Carbon Footprint
SBTi	Science-Based Targets initiative
tCO2e	Tonnes of carbon dioxide equivalent
tCS	Tonne of crude steel

TRL	Technology Readiness Level

1. Executive summary

Steel is the largest single source of embodied carbon in offshore wind (OSW). Decisions made over the next five years will determine whether that carbon footprint shrinks or grows with deployment. Material inputs contribute 60 to 80% of lifecycle emissions from an average OSW development, with steel accounting for more than 50% alone.[1] As installed capacity scales by the early 2030s, steel demand from the OSW industry is forecast to rise from around 2.4 million tonnes in 2024 to more than 10.5 million tonnes per year. Decarbonising steel is therefore critical to ensuring the industry can deliver Net Zero outcomes.

Lower emission steel is technologically feasible, but it remains poorly defined as a concept, scattered in terms of production availability, and expensive. Scrap-based production routes using electric arc furnaces are already commercially available, yet they carry a price premium that offshore wind developers operating in highly capital-intensive, price-competitive tenders struggle to absorb. Demand for lower emission steel remains too fragmented to justify large-scale capacity expansion by steelmakers. The global scrap pool is physically finite and cannot, on its own, meet future demand. Additionally, there is no shared industry definition of what constitutes lower emission steel, which means procurement criteria and decarbonisation claims cannot be consistently benchmarked.

Financial support and policy mechanisms must both close the gap. Public funding, through grants, guarantees or subsidised lending, can help share the price premium across more parties, but is difficult to secure and sustain given competing government priorities and the uneven global distribution of steelmaking capacity. Private financial institutions apply a risk premium to emerging technologies such as iron ore electrolysis and to unestablished infrastructure such as clean hydrogen supply, which raises borrowing costs and makes private finance harder for developers to reach. Policy mechanisms such as carbon border adjustments can close the price gap by penalising high-emission alternatives, but do not directly increase the supply of lower emission steel and risk straining project viability if poorly designed.

Overcoming these challenges requires collective, system-level action. This report highlights a pathway, summarised on the next page, with ten key activities for the industry, policy-makers, and steel manufacturers, organised around four themes:

- Measurement and reporting activities establish a shared definition of lower emission steel and a consistent carbon accounting approach so that procurement choices can be compared.
- Demand generation activities coordinate the industry's purchasing power into a credible signal through collaborative initiatives and direct partnerships with steelmakers.
- Funding attainment activities engage public and private finance to improve access to sustainability-linked instruments and demonstrate the emissions return on investment.
- Circularity and effective design activities reduce the steel the industry needs in the first place, by improving recyclability of components and optimising the steel-mass to installed-capacity ratio.
- Alongside these, enabling policy measures can de-risk lower emission steel investment, through risk-sharing mechanisms, without undermining project viability.

[1] Carbon Trust, 2024. Sustainability Joint Industry Programme – Offshore wind decarbonisation pathway. Link

These actions turn a fragmented problem into a coordinated response, where early alignment on definitions and demand enables longer-term shifts in finance, production, and design.

Pathway to decarbonise steel in offshore wind

(Figure 8 in the report)

Theme	**SHORT TERM** to 2030 Definitions align and demand starts to coordinate.	**MEDIUM TERM** 2030–2035 Finance flows and circularity gains land.	**LONG TERM** to 2050 and onwards Virgin routes at commercial scale.
Measurement & reporting	1 Agree a collective definition of lower-emission steel (I, S, O, D) 2 Use a consistent carbon accounting approach (I, S, O, D, F)		
Demand generation	3 Communicate decarbonisation plans across the value chain (S, D, O) 4 Form direct partnerships and offtake agreements (D, O, S)	4 (continued)	
Funding attainment	6 Demonstrate environmental benefit per unit of investment (D, I, F)	5 Work with the finance sector on new instruments for steel decarbonisation (I, S, F)	
Circularity & effective design	8 Design changes to extend asset life and reduce steel intensity (D, O)	7 Improve recyclability of steel -based OSW components (D, O)	7 (continued)
Policy & regulation		9 Policy-makers to introduce risk -sharing mechanisms to help lower risk premiums (G) 10 Design policy that supports lower emission steel (G)	9, 10 (continued)

D OSW developers **O** OEMs **S** Steelmakers **F** Financial institutions **I** Industry bodies **G** Policy-makers (government) ⬚ Outcome by

2. Introduction

A critical window for steel decarbonisation action

Offshore wind (OSW) is set for rapid expansion, with average forecasts from leading industry bodies indicating annual capacity additions of around 30 GW between 2030 and 2035. Steel contributes more than half of the life-cycle carbon emissions of an average OSW development, and although steel demand from the OSW industry is currently modest relative to other industries at around 2.4 million tonnes in 2023, the forecasted growth rates suggest demand could rise more than fourfold to over 10.5 million tonnes per year by the early 2030s. Without decisive action, an industry built to decarbonise electricity risks embedding a significant and growing carbon footprint in the very infrastructure it deploys, making the decarbonisation of steel a critical enabler of delivering OSW's full climate benefits.

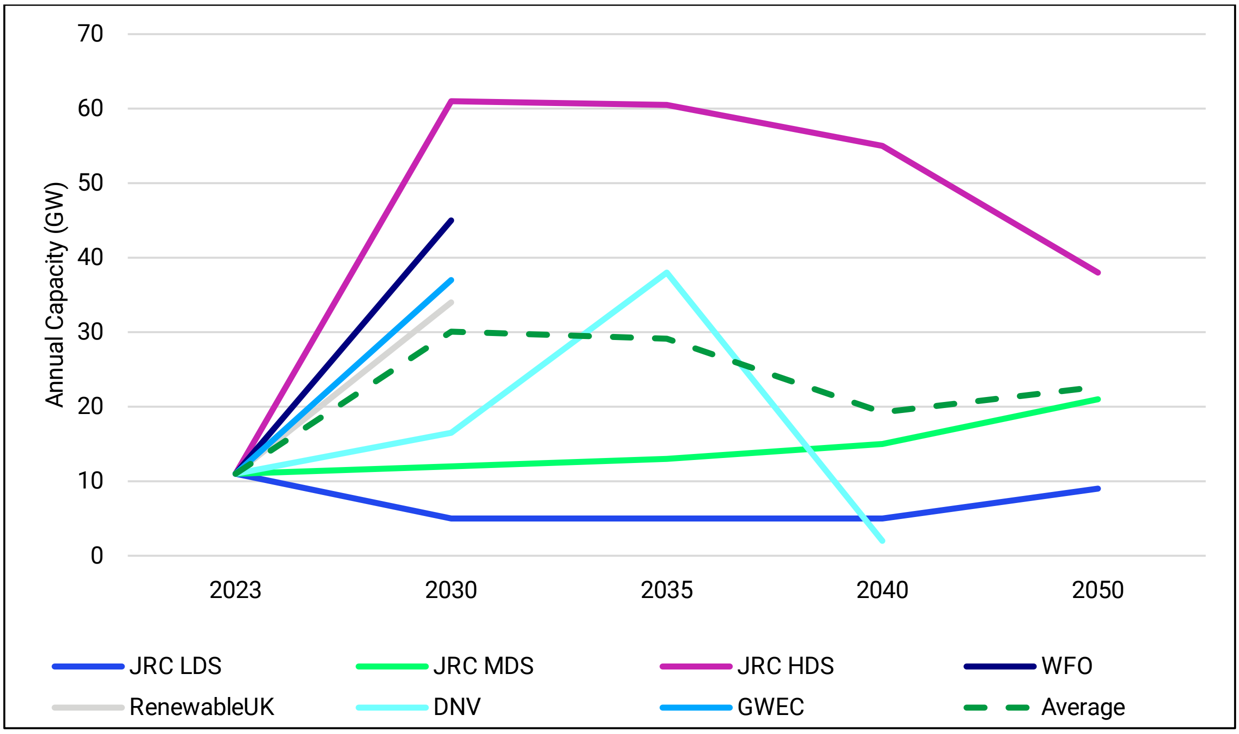

Figure 1: The average forecasted annual additions of OSW capacity based on a variety of industry bodies. Data source: DNV[2], WFO[3], RenewableUK[4], EU Commission[5] and GWEC[6]. The projections from WFO, RenewableUK, and GWEC are only provided through 2030, and DNV's are limited to 2040.

Figure 1 forecasts annual OSW capacity additions of around 30 GW between 2030 and 2035, ranging from under 10 to over 60 GW by 2030. The scenario that materialises will depend on decisions regarding investment, policy, and supply chain coordination that are still being made. Regardless of the exact scenario that emerges, meeting the annual additions will require a large and reliable steel supply chain.

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[2] DNV, 2025. Energy Transition Outlook. Link
[3] WFO, 2025. Global Offshore Wind Report. Link
[4] Renewable UK, 2024. UK wind and global offshore wind: 2024 in review. Link
[5] European Union, 2020. Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system. Link
[6] GWEC, 2024. Global Offshore Wind Report 2024. Link

In 2026, the supply chain is heavily concentrated, with more than half of global steel production in China, overwhelmingly produced via blast-furnace routes. Hence, the transition is also a question of resilience. Steel accounts for up to 90% of a turbine's mass[7] and diversifying into lower emission production routes, such as scrap-based electric arc furnaces and hydrogen-based direct reduced iron, could broaden the geography of steel supply for OSW into regions where new capacity is being built. This report explores the distribution of global steel production and discusses how reinvestment decisions and a supportive policy environment can better coordinate demand from the OSW industry to ensure that lower emission steel production routes are advanced.

What is lower emission steel?

There is no universally accepted definition to specify the net environmental impact of steel, and terms such as green or low carbon are used without a clear distinction. Widespread adoption of a classification framework is imperative to measure and track progress against benchmarks that are comparable across geographies. In practical terms, decarbonising the OSW steel supply chain requires reducing the average greenhouse gas emissions (GHG) per unit of crude steel procured by the industry.

How is lower emission steel made? Lower emission steel requires alternatives to traditional Blast Furnace-Basic Oxygen Furnace (BF-BOF) steelmaking processes, which use coking coal, the main contributing factor to the carbon intensity of steel.

Scrap-based steelmaking using electric arc furnaces (EAFs) is a mature, commercial technology, but scrap availability limits total output and it cannot meet projected global demand alone. Additional virgin capacity is needed, and two main virgin pathways avoid fossil inputs.

1) In the direct reduced iron (DRI) route, hydrogen replaces carbon as the reducing agent, with the resulting iron melted in an EAF to produce steel. Full decarbonisation is only achieved when hydrogen is produced via water electrolysis rather than natural gas.
2) Iron ore electrolysis offers another alternative route, using electric current to directly reduce iron ore dissolved in an oxide solvent, with the product subsequently processed in an EAF.

Both routes are technically proven but remain commercially immature and require significant scaling. Across all pathways, electric arc furnaces are essential, which means full decarbonisation ultimately depends on access to abundant, fully decarbonised electricity, both to power the furnaces and to supply the underpinning processes.

A key objective of this Pathway is to ensure that a greater proportion of steel components used within an OSW development are sourced from crude steel that meets the definition of 'lower emission' steel. We use 'lower emission' as a consistent, supplier-agnostic label for crude steel that sits below a defined tonnes of carbon dioxide equivalent per tonne of crude steel value, depending on the ratio of scrap to virgin metal used in manufacture. This aligns with the SteelZero initiative, where crude steel is classed as lower emission steel if it has a tonne of carbon dioxide equivalent per tonne of crude steel value within or below the 'Progress Level 2' boundary as per the sliding scale adopted by ResponsibleSteel, the Low Emission Steel Standard (LESS) and China Iron and Steel Association (CISA).[8] [9] Figure 2 shows the sliding scale of the four performance levels.

[7] Vestas, 2024. Vestas introduces low-emission steel offering for wind turbines. Link
[8] Climate Group, SteelZero. Link
[9] ResponsibleSteel, 2025, Public Statement: The EU Label for Steel Should Build on the Sliding Scale Approach, Link

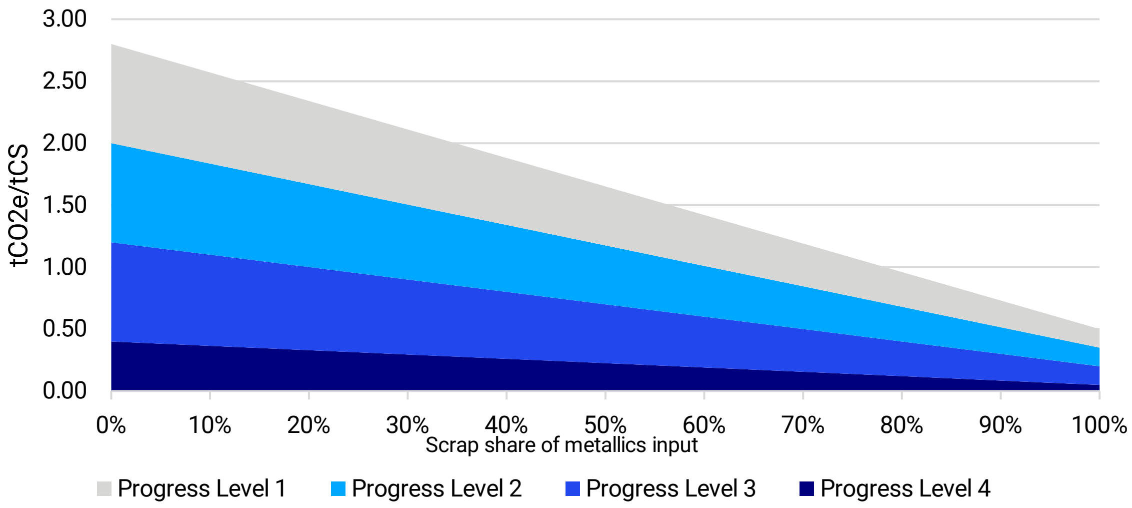

Figure 2: Crude steel that plots within Progress Level 2, 3 or 4 is classified as lower emission steel.

The current landscape of lower emission steel

Action to support sustained demand for lower emission steel is already underway. Some OSW developers have joined cross-sector efforts such as SteelZero and the First Movers Coalition, corporate initiatives acting to send strong demand signals to steel producers to invest in lower emission production by committing to procurement targets. Others have formed offtake agreements with steelmakers, committing to future purchases and strengthening the business case for the upfront investment required to deploy new production technology. Beyond developer-led action, governments and regulators hold mechanisms to incentivise lower impact materials. Policymakers have introduced carbon taxation mechanisms such as the Carbon Border Adjustment Mechanism (CBAM), which is designed to level the carbon cost of imported and domestically produced steel and may strengthen incentives to source lower emission steel over time. Mechanisms such as the Clean Industry Bonus (CIB) in the UK have been introduced to provide additional financial support to bidders (i.e. offshore wind developers) that invest in sustainable supply chains.

The OSW industry has an opportunity to send a growing, consistent demand signal to a steel market entering a window of major reinvestment decisions. Half of all steel plants globally are due for their next major investment decision before 2030.[10] Where that reinvestment lands, cleaner or conventional, will depend on whether there is lucrative demand for lower emission output at the point of decision.

That decision window is opening unevenly across the world. Many iron and steelmaking facilities across the U.S., Europe, the Middle East, and North Africa (MENA) are operating at less than 80% of rated capacity, undermining financial viability and, in some cases, leading to plant closures. Under-utilisation is driven by high labour and energy costs, weakening local demand, and subsidised steel imports. Major steelmaking countries, including China, Japan and South Korea, hold high steelmaking capacity (Figure 3). China alone accounts for 54% of global steel production, with 90% of its capacity running through blast furnace routes (Figure 4). The US, Europe and MENA show a more mixed distribution of production routes, with MENA at 85% of its production running through direct reduced iron (DRI) - electric arc furnace routes (although it should be noted that most current DRI production currently relies on natural gas as a reduction agent, limiting its decarbonisation impact).

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[10] Mission Possible Partnership, 2022. Making Net-Zero Steel Possible. Link

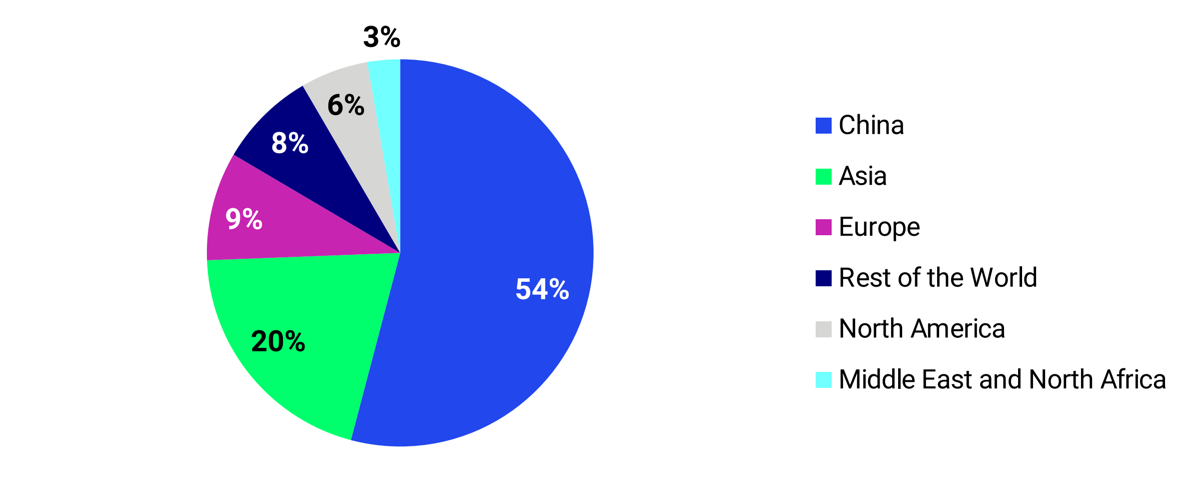

Figure 3: Share of global steel production by region, 2024.[12]

The practical implication is that 'a global transition' is not a single movement. OSW procurement and coordinated demand signals have the greatest near-term leverage in the regions where reinvestment pressure is already strongest, and the transition at a global scale will depend on each region's ability to use its own industrial strengths.

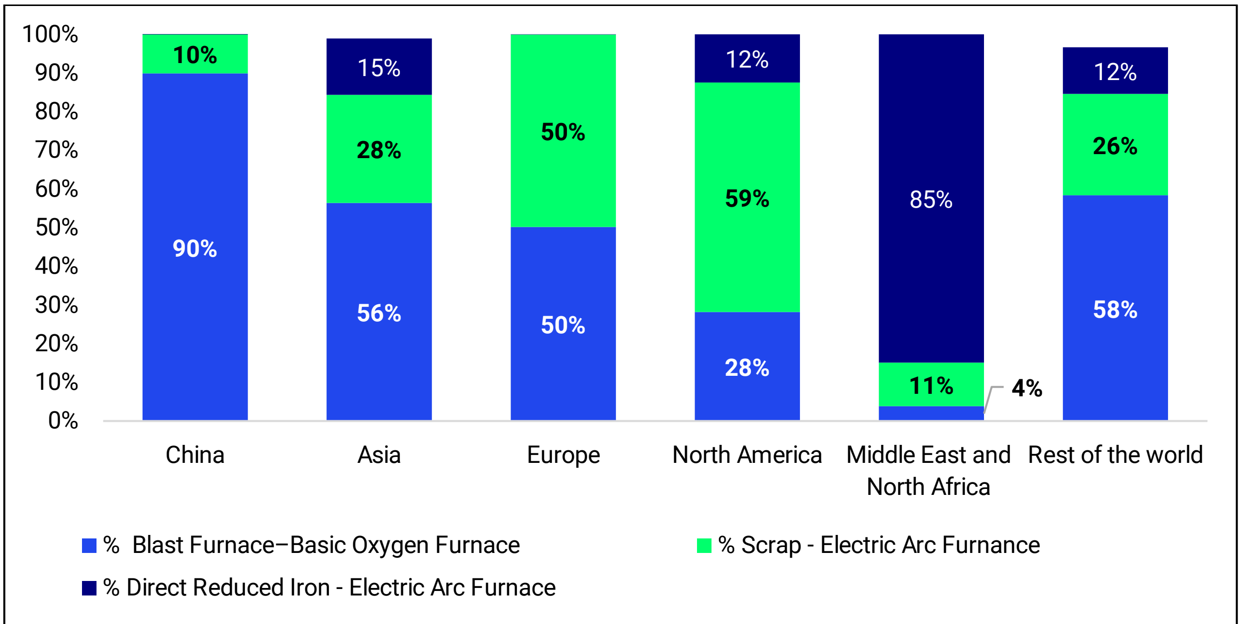

Figure 4: Steel production by region and production route in 2024.[11,12]

These early actions taken by industry to date sit alongside a set of barriers that the OSW industry has not yet been able to resolve through its own action alone. The Sustainability Joint Industry Programme undertook the analysis behind this report to identify those barriers, test them against quantitative scenario modelling and stakeholder interviews, and translate the findings into a coordinated response. The next section presents the core challenges for steel decarbonisation in OSW in the structure that organises the Pathway in Section 4.

[11] It should be noted that the categorisation in this chart (Figure 4) does not distinguish between processes within each production route (e.g. those that use green hydrogen or renewable electricity and those that do not.

[12] Steel Association, 2025. World Steel in Figures 2025. Link

3. Core challenges

It should be noted that several initiatives, including SteelZero and First Movers Coalition are addressing the challenges of green steel cross-sector. This report focuses on the OSW industry challenges and solutions only. The barriers to scaling lower emission steel in OSW fall into three connected groups, and each call for a different kind of response from policy- and decision-makers.

1. The commercial gap describes why lower emission steel is more expensive to purchase today than the alternatives and why current, fragmented demand is insufficient to resolve it.
2. The physical limit describes why scrap-based production alone cannot meet future demand, and what this means for the next generation of virgin production routes.
3. The enabling environment covers the supporting conditions needed to overcome the first two groups, namely financial support, well-designed policy and transparent measurement.

This three-part structure informs the Pathway in Section 4. The activities in the plan have interlinked dependencies such that individual activity may act towards resolution of more than one challenge. Delivery will require coordinated action across stakeholders, with progress dependent on each player contributing to resolve shared challenges. Some challenges may require indirect action from a stakeholder group, whilst others can be tackled more directly.

3.1. The commercial gap

3.1.1. Lower emission steel carries a price premium for capital-intensive developments

Scrap-based steel produced via electric arc furnaces powered by renewable electricity is commercially available, but it is more expensive for OSW developers than conventional blast furnace steel. This price premium primarily reflects the higher cost of scrap relative to iron ore and also accounts for commercial and capital costs associated with steelmakers' production. For OSW developers operating in capital-intensive, price-competitive auctions, this premium directly affects project economics and investment decisions. It is therefore a real and immediate commercial pressure for the developer.

The downstream effect on energy consumers, however, is much smaller. Boston Consulting Group's 2023 analysis of green steel in OSW quantified the impact on a representative 15 MW turbine. A green-hydrogen-fuelled direct reduced iron premium of €250 to €300 per tonne of steel adds around €900,000 to the capital cost per turbine, equivalent to less than 2% of total capital expenditure per megawatt installed. Spread across the turbine's 30-year operating life and 1.8 million MWh of generation, this translates into a levelised cost of energy increase of approximately €0.50 per MWh, or around 1% against typical North Sea project economics.[13] The trajectory of this premium over time depends heavily on how carbon pricing evolves alongside production route choices, and modelling these dynamics shows the gap narrowing and even reducing costs by 2050.

Figure 5a and b show how the cost and emissions intensity of an average tonne of crude steel procured by a European developer could evolve under a rising carbon price via the European Trading Scheme (ETS) (used as a carbon price reference point). Figure 5b illustrates how an average tonne of crude steel could align with a Net Zero pathway and reach price parity with the business-as-usual scenario between 2030 and 2040.

[13] BCG, 2023. The Winds of Change in Green Steel. Link

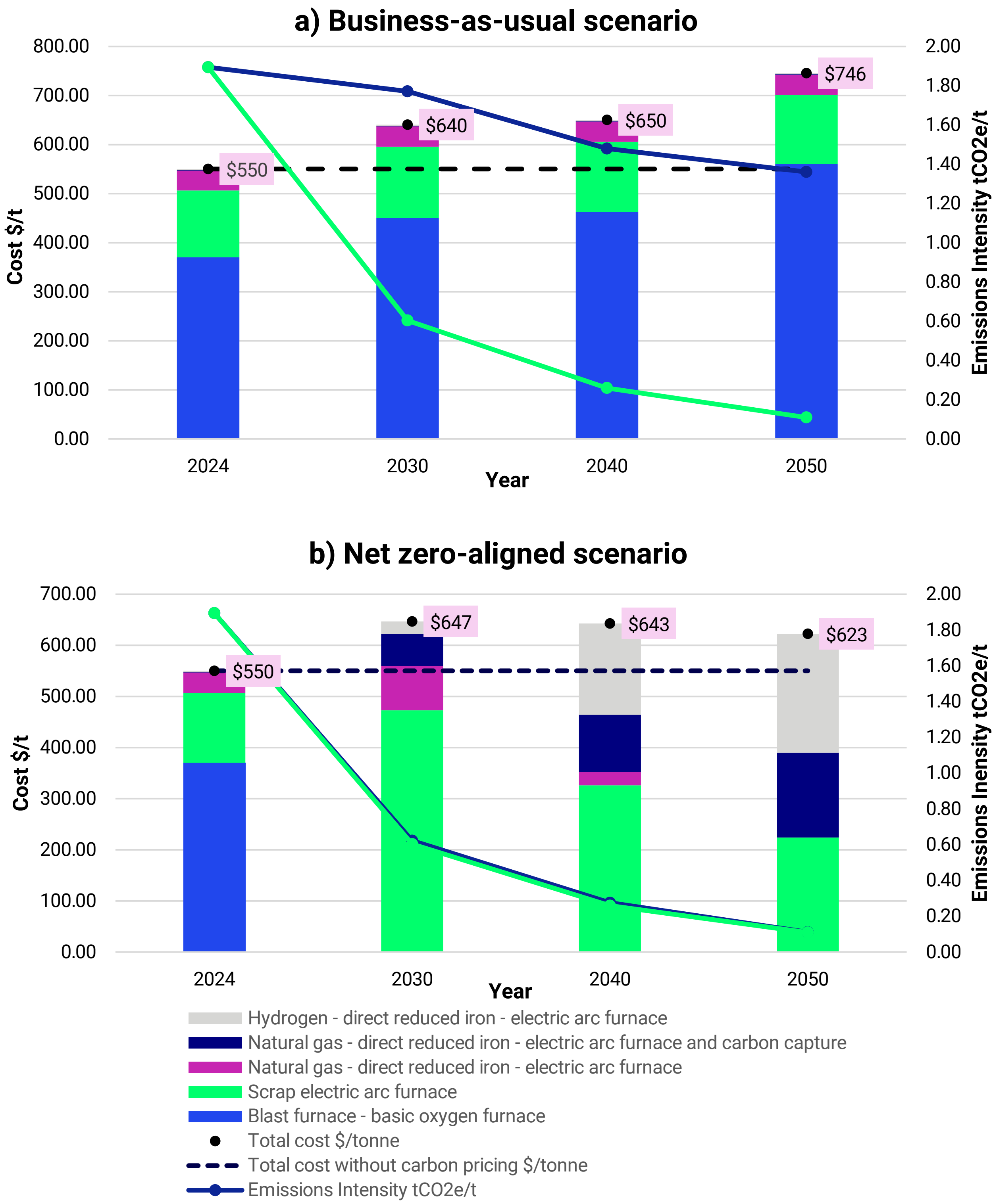

Figure 5: a) Proportion of steel produced via each production route under business-as-usual with incoming carbon pricing via ETS. b) Proportion of steel produced via lower emission production routes in a Net Zero-aligned procurement scenario.[14] See endnote for information on how this data was used.[i]

[14] Figure 5a and b are the result of analysis using data sourced from: Bloomberg, 2024. Green Hydrogen Prices Will Remain Stubbornly High for Decades. Link; European Union, EUR-Lex. Link; European Union, EUR-Lex. Link; International Energy Agency, 2021. A Roadmap for the Global Energy Sector. Link; IIASA, 2023. NGFS Phase 4 Scenario Explorer. Link; Science Based Targets, 2023. Steel Science-Based Target-Setting Guidance. Link

The modelling shows that with a deliberate shift in production routes, an average tonne of crude steel could align with a Net Zero decarbonisation pathway while reaching price parity with the business-as-usual scenario between 2030 and 2040 and falling below the business-as-usual price by 2050. Enabling mechanisms that drive that crossover earlier rather than later is one of the core challenges this Pathway seeks to address. The policy ask is therefore time-bound, to bridge the cost gap during the years when developers are absorbing it on behalf of the wider system.

In panel a), the production mix stays mostly blast furnace, costs rise because of carbon pricing under the ETS, pushing up the price of conventional steel, and emissions intensity (the navy line on the right axis) only falls slowly. The analysis shows that the industry arrives at 2050 with steel that is more expensive and still relatively high carbon.

In panel b), the production mix shifts deliberately toward lower emission routes. Costs still rise compared to today, but they peak around 2030 and then start coming back down as the cleaner routes scale and learning curves kick in. By 2050, lower emission steel is $123/tonne cheaper than business-as-usual steel, and the emissions intensity is far lower.

3.1.2. Significant investment is required to lower the price premium

The price premium associated with lower emission steel is driven by current supply-demand dynamics. The price premium is, in part, a symptom of how the market is currently structured. Steelmakers will only commit capital to new electric arc furnace capacity, or to commercialising virgin lower emission routes, when they can see confirmed buyers at the volumes that justify the investment. Today, demand for lower emission steel in the OSW sector is split across many OSW developers operating in different countries on different timelines, each responding to challenging market and competitive market conditions which make price premiums difficult to absorb. Developers are interested in lower emission steel products but even when combined with steel demand from other sectors, the current buying pool doesn't represent enough volume to trigger significant change in steelmaking investment. The result is a market that has yet to fully unlock its potential, where price premiums persist and OSW demand signals remain fragmented, limiting investment momentum.

3.2. The physical limit

3.2.1. The global scrap pool is finite, so new virgin production routes must advance

Scrap-based electric arc furnace steel faces a hard physical constraint: the global scrap pool is finite. This limits the extent to which scrap-based lower-emission steel alone can meet future OSW demand, particularly as global steel demand grows. Even if demand for lower emission steel rises and scrap-based production scales to its maximum, in the International Energy Agency's (IEA) Net Zero by 2050 roadmap, global steel demand in 2050 will consist of only 46% scrap-derived steel because forecast demand will exceed the scrap available from past production.[15]

Focusing only on scrap-based routes would theoretically decarbonise the OSW steel supply, but it would not foster wholesale decarbonisation of the steel sector or long-term affordable prices. Wider uptake will therefore ultimately depend on the commercialisation of alternative routes for virgin steel production, such as direct reduced iron and iron ore electrolysis, which are not yet available at scale.

[15] International Energy Agency, 2021. A Roadmap for the Global Energy Sector. Link

3.3. The enabling environment

3.3.1. Public and private finance support is hard to secure and to sustain

Direct financial support from public and private institutions could help bridge the cost gap, but securing and sustaining this support is challenging. Governments face competing priorities for limited decarbonisation funding and may also seek domestic economic benefits that are not guaranteed, given that steelmaking capacity and decarbonisation opportunities are unevenly distributed globally. Finance mechanisms may need to scale globally to support increased production of lower emission steel, particularly outside Europe; although regulations such as the CBAM may drive European trade toward a preference for lower emission steel, the global demand signal this creates may not be sufficient on its own to shift production at the scale required. China, for example, produced more than half of the world's annual steel supply in 2024, and more than 90% of its capacity uses the blast furnace route.[16]

For financial institutions, investing in the scale-up of emerging lower emission steel technologies without high technological readiness, such as iron ore electrolysis, and supporting unestablished infrastructure, such as clean hydrogen supply, involves higher risks than investing in mature markets. The return on investment is more uncertain for higher-risk investments, and financial institutions often apply a risk premium, increasing interest rates. That makes it harder for developers to access private finance. Finding ways to reduce or share investment risk, thereby reducing the risk premium, is important for developers seeking private financial support.

3.3.2. Policy tools can help, but they risk unintended consequences

Carbon tax mechanisms and policy incentives to adopt lower emission steel work as a double-edged tool. They penalise high-emission alternatives and progressively close the price gap, which benefits developers and manufacturers that have already transitioned. They can also strain the viability of projects for developers still exposed to conventional steel costs at the point of bidding. The challenge for policymakers is to time and structure these mechanisms so that they assist early movers without trapping projects already underway. Any policy or incentives mechanisms must not inhibit OSW developers from making projects financially viable. Any contractual incentives will need to be part of changes across the wider OSW-steel supply chain. It is important that one sustainability pursuit (i.e., decarbonisation of steel) does not prevent another from growing (i.e., decarbonisation of electricity production from wind).

3.3.3. Measurement frameworks do not yet reach finished components

Existing frameworks for classifying lower emission steel apply only to crude steel, making it difficult to assess and compare the impact of finished steel-based components such as towers, foundations and transition pieces. Product Carbon Footprints (PCFs) detailing the emissions associated with these finished components are often unavailable or lack transparency, partly because Original Equipment Manufacturers (OEMs) frequently procure steel via brokers sourcing from multiple mills. This obscures traceability to underlying crude steel emissions data and creates uncertainty for buyers, limiting their ability to reliably identify low-impact products. Thus, making progress in decarbonisation difficult to measure, report, and verify.

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[16] Global Energy Monitor, 2024. Medal to the Metal: Building momentum for iron and steel decarbonization. Link

4. The Steel Decarbonisation Pathway

Turning fragmented challenges into a coordinated response

We have developed, with industry, an integrated Steel Decarbonisation Pathway for the cooperative adoption of OSW developers, policymakers and wider market actors. This Pathway supports the decarbonisation of steel within the OSW supply chain by mapping the key stakeholders involved, recognising their interdependencies, and setting out where each can most effectively act to address system-level challenges. During stakeholder interviews and with the SUS JIP partners, we identified practical measures, each defined by a clear objective, targeted outcome, timeframe, and the stakeholders involved. We encourage all stakeholders identified in this Pathway to engage with the Sustainability Joint Industry Programme to work together on implementation.

4.1. How we built the Pathway

The Pathway in this report is the result of a three-step methodology combining secondary research, quantitative analysis and stakeholder engagement. A full description of the methodology sits in Appendix 1. The high-level summary is shown in Figure 6.

Figure 6: An overview of the Pathway methodology.

Step 1. Secondary research and stakeholder interviews. A review of more than 100 sources, supported by interviews with 15 stakeholders across developers, steelmakers, component manufacturers, non-profit collaborators, a government body and a renewable energy association, established the barriers to decarbonising OSW steel and the levers with the most potential to shift them.

Step 2. Quantitative analysis and scenario modelling. Secondary data was used to forecast OSW's share of global steel demand, quantify the emissions savings of lower emission steel against a business-as-usual baseline, and assess the routes to price parity. The results were tested in a workshop with OSW developers and steelmakers.

Step 3. Synthesis into an integrated Pathway. The findings from Steps 1 and 2 were synthesised into a plan of coordinated stakeholder activities. Individual activities within each opportunity area were assigned an objective, a targeted outcome, a measurement approach, an implementation timeframe and suggested stakeholder governance.

4.2. Objectives of the Pathway

This Pathway provides the OSW industry with practical measures to advance the uptake of lower emission steel across value chains, while also reducing the overall quantity of steel required. The plan is designed to support existing initiatives on lower emission steel and to enable a more informed OSW industry in wider policy discussion and multi-stakeholder collaboration.

The identified challenges in Section 3 cannot be solved in isolation by any one stakeholder group, so effective implementation depends on collaboration. This Pathway focuses on the actors crucial to accelerating the uptake in lower emission steel, whilst emphasising that stakeholders across the steel value chain have the collective influence to enable system-wide change.

4.3. Key stakeholders for implementation

Achieving an accelerated uptake in lower emission steel requires a systematic approach taken across stakeholder groups that each have power over a part of the OSW value chain. Engagement mechanisms include policy implementation, participating in collective initiatives, developing offtake agreements and enhancing circularity practices. The key activities outlined in this plan are suggested to be carried out in the short, medium and long term, requiring engagement from the interconnected stakeholders outlined in

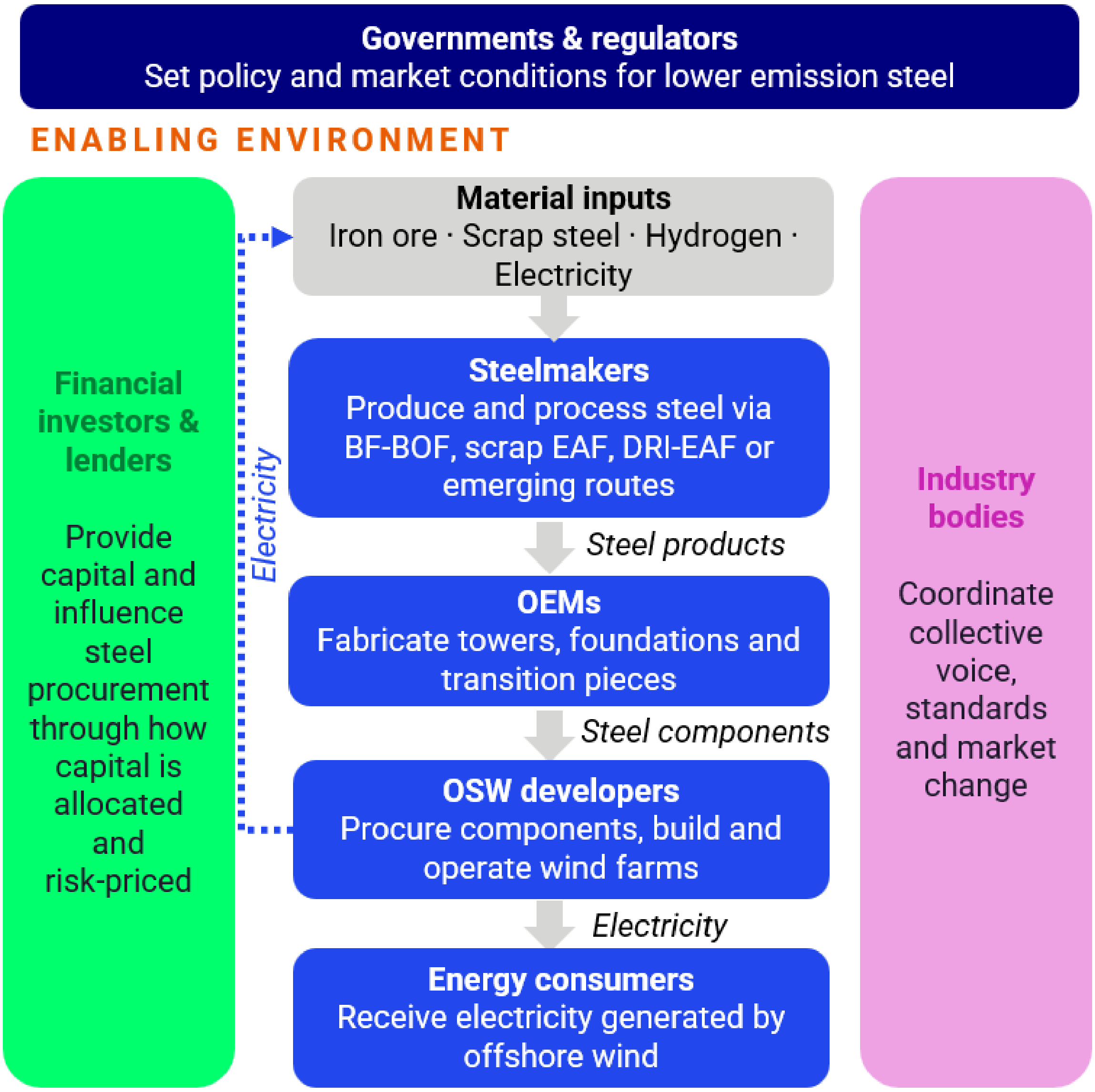

Figure 7. The stakeholder groups identified and considered within this analysis include, but are not limited to:

- Financial investors/lenders: Provide access to capital necessary to develop renewable infrastructure, with capital allocation influencing the type of steel procured for projects.
- Policymakers within government: Influence the uptake of lower emission steel by shaping the policy and market conditions that determine the commercial liability of lower emission steel.
- Regulators: Implement policies to support the transition to lower emission steel methods and as a result, influence demand.
- Industry bodies/ Joint initiatives: Represent OSW developers and suppliers to provide a unified industry voice and have the potential to coordinate market change.
- OEMs: Working at the interface between OSW developers and steel makers, OEM designs and contracting can strongly influence steel demands.
- OSW developers: Make commercial decisions that determine both the volume of steel demanded and can play a key role in enabling lower emission steel uptake.

- Steelmakers: The source of the primary material and can scale lower emission production technologies as a response to policy and demand signals

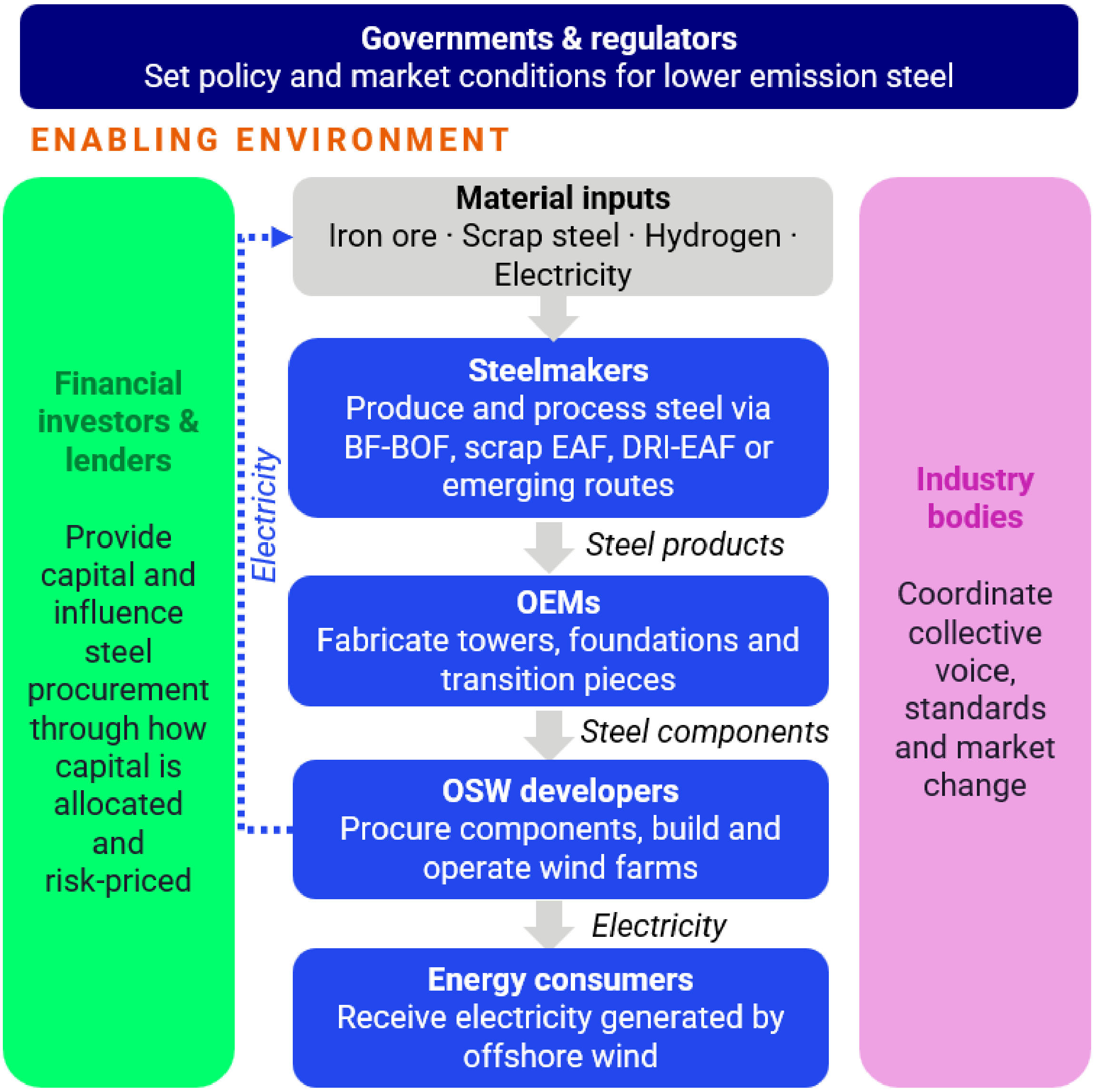

Figure 7: Stakeholder roles across the steel-to-energy value chain, showing where each stakeholder group acts in the system, from raw material production through to the energy consumer.

Governments and regulators set the enabling environment from above. Financial institutions and industry bodies operate across the chain. The central column shows the physical flow from crude steel through to electricity. The level of uptake of lower emission steel will be shaped by collaboration across these groups. Working through industry bodies or joint initiatives allows OSW developers and OEMs to strengthen their demand signals, while steelmakers could share the transition risks of moving into new production routes. Some actions require broad coordination, such as standardising the definition of lower emission steel to establish comparability and shared understanding across the OSW industry.

4.4. Priority industry activities to be taken

The activities set out in Table 1 respond to the urgent challenge that, despite being technically ready to deliver lower emission steel, fragmented demand signals, cost uncertainty, and misaligned incentives are critical blockers. We present activities focused on practical levers, including measurement, demand generation, financing, design and policy support, that industry actors can act on now to avoid locking in higher emission outcomes. Many of the relevant decisions are already being made for projects delivering through the 2030s, with impacts extending to 2050 and beyond, making early and coordinated action important. Some activities will take longer than others to fully implement but all should commence as soon as possible. Once implementation starts, activities will need to ramp up and sustain impact through time. Table 1 shows indicative target timings for completing full mobilisation of each activity, whilst Figure 8 schematically visualises relative sequencing.

In practice, the connections cut across boundaries. The commercial gap is most directly targeted by Activities 3, 4 and 6, which consolidate the industry's demand signal and make the investment case visible to finance. The physical limit of the global scrap pool is tackled indirectly: Activities 7 and 8 reduce demand pressure and expand the effective scrap supply through better recyclability and design, while the demand and financing activities are intended to create the market conditions under which virgin lower emission routes can reach commercial scale. The enabling environment is addressed by Activities 1, 5 and 6, which establish a shared definition, engage the finance sector and quantify the emissions return on investment. Additionally, Activities 9 and 10 aim to further support the enabling conditions by ensuring a well-designed policy framework conducive to transition is developed and sustained.

Table 1: Steel Decarbonisation Pathway.

Theme & objective	Suggested activity	Targeted result *What are we aiming for?*	What success looks like *What evidence is needed to demonstrate this?*	Target year for activity to be mobilised by
Measurement and reporting *Understand the impact of steel products across the value chain.*	1. Agree a collective definition for lower emission steel. The OSW industry should select a single definition of the targeted ambition level for crude steel emissions intensity. Lower emission steel is a useful broad definition for a minimum requirement, aligning with Progress Level 2 as defined by ResponsibleSteel.	Consistent terminology gives clear communication on the range of average emissions intensity for steel and improves clarity for ambition-setting across the OSW industry.	Steelmakers document the emissions intensity and share of scrap input of their crude steel, so output can be mapped to a Progress Level. OEMs use this information to calculate the average of steel content in finished goods.	2030
	2. Use a consistent carbon accounting approach for steel The industry should align to a chain of custody model for consistent use. This will enable the emissions intensity of crude steel from a variety of sources to be robustly traced and allocated through the supply chains of OSW developers; the benefit of lower emission steel can be attributed to end-users accordingly.	Steelmakers commonly produce product carbon footprints for their crude steel offerings. Compliance with a standardised chain of custody model for the OSW supply chain will allow finished products that use crude steel from a variety of sources to be compared on	Suppliers in the OSW supply chain state and follow a selected chain of custody model by following guidelines such as those published by the World Steel Association.[17] All steel-based finished goods can be assigned an emissions intensity such that	2030

[17] World Steel Association, 2024.Worldsteel guidelines for GHG chain of custody approaches in the steel industry Link

Theme & objective	Suggested activity	Targeted result *What are we aiming for?*	What success looks like *What evidence is needed to demonstrate this?*	Target year for activity to be mobilised by
		an emissions intensity (tCO_2e/tonne) basis.	carbon impact is easier to compare.	
Demand generation *Drive systemic decarbonisation within the steel sector.*	3. Steelmakers, developers and OEMs strengthen communication of decarbonisation plans. An industry-wide effort to communicate decarbonisation action plans and amplify demand voice for lower emission steel should be implemented via collaborative initiatives and coalitions. Communication of sustained demand can be supported by emphasising how steel procurement in the industry will increase as offshore generation capacity grows globally.	Steelmakers invest capital into lower emission production routes, assured of more consistent offtake from the amplified demand voice and evidence that the OSW industry will play an increasingly important role in future global steel demand.	The share of lower emission steel relative to conventional steel rises over time within steelmakers' annual crude steel output. Scaling supply helps ease the price premium currently attached to lower emission steel.	2030
	4. OSW developers should explore direct partnerships with key participants in steel fabrication and manufacturing. The OSW industry can form market agreements with steelmakers, including memoranda of understanding, supply and offtake agreements, and partnership agreements. Additionally, renewable generation outputs from OSW can	Partnerships foster a sustained demand voice from the OSW industry, and committed collaboration on the decarbonisation challenge with steelmakers, which further incentivises	The number of memoranda of understanding, supply and offtake agreements, and partnership agreements between developers, OEMs and steelmakers increases year on year.	2030-2035

Theme & objective	Suggested activity	Targeted result *What are we aiming for?*	What success looks like *What evidence is needed to demonstrate this?*	Target year for activity to be mobilised by
	supply lower emission steelmaking processes that require fossil-free electricity to reach full decarbonisation potential.	investment in lower emission production.		
Funding attainment *Ease the ability of developers to absorb lower emission steel price premiums.*	5. Work with the finance sector to improve visibility of existing finance and develop new options for financing steel decarbonisation in OSW projects. Industry bodies and steel manufacturers should engage with public and private financial institutions to improve understanding of where financing instruments already exist, and to advocate for new products that recognise the dual ambition of decarbonised electricity supply and reduced embodied emissions across the OSW value chain.	Public and private financial institutions increase the number of sustainability-linked financing instruments that steel manufacturers can use for required investments or OSW developers can apply for directly, such that there is a larger potential pool of project finance to support with absorption of price premiums.	The OSW industry gains access to a larger pool of project finance to invest in procuring lower emission steel.	2030-2035
	6. Demonstrate environmental benefit per unit of investment and assess risk profile. The OSW industry consistently records and communicates the emission intensity of each type of steel product used in OSW developments. This is such that investors can clearly understand the	Private investors gain a clearer understanding of the potential emissions and climate risk impact of their investments in lower emissions steel within the OSW value chain, improving	The OSW industry demonstrates eligibility for an increased number of sustainability-linked financing instruments and gains	2030

Theme & objective	Suggested activity	Targeted result *What are we aiming for?*	What success looks like *What evidence is needed to demonstrate this?*	Target year for activity to be mobilised by
	emissions differential between choosing between different procurement options to evaluate the cost of abatement.	their ability to release financing instruments for the industry to use.	access to a larger pool of project finance.	
Circularity and effective design *Reduce the mass of steel procured relative to generation capacity installed.*	7. Improve the recyclability of steel-based components used in OSW structures. The OSW industry should ensure, where possible, that product specifications given to suppliers prevent steel downcycling and preserve quality, enabling a higher yield from recycling processes.	Decommissioning operators can recover a greater proportion of steel for reuse at end of life, which sustains the pool of scrap available for producing EAF steel.	Developers receive waste reports from decommissioning that show an increasing proportion of recyclable steel recovered from the total removed at end of life. This may be more achievable for some steel grades than others.	2030-2035
	8. Implement design changes to extend development lifetimes and reduce the steel-mass to GW ratio. The OSW industry should optimise site layouts to minimise the ratio of steel mass to installed capacity, ensuring efficient steel use. Longer leases call for design choices that support extended life cycles and weigh foundation selection against carbon impacts.	Less steel is required in OSW designs to deliver the same installed capacity. Assets that operate for longer spread annual steel procurement over more operating years and generate additional revenue from the extended output.	Steel mass per GW in the OSW industry continues to decrease, and the revenue-to-investment ratio improves. Any transition toward alternative materials such as concrete must be monitored for its own embedded emissions.	2030

Theme & objective	Suggested activity	Targeted result *What are we aiming for?*	What success looks like *What evidence is needed to demonstrate this?*	Target year for activity to be mobilised by
Policy and regulation support *Implement legislation that supports de-risking lower emission steel investment.*	9. Introduce risk-sharing mechanisms to help lower risk premiums Policymakers can support with the implementation of risk-sharing mechanisms to help with repaying risk premium on interest payments relating to lower emission steel production or procurement, such as long-term guarantees or long-term price stability tools.	Policymakers introduce bespoke risk-sharing mechanisms for stakeholders investing in lower emission steel, limiting the potential costs associated with making use of a financing instrument to support with the investment.	OEMs and OSW developers make increasing use of sustainability-linked financing instruments such that lower emission steel is included in a greater proportion of wind farm proposals.	2030-2035
	10. Design policy that supports lower emission steel Policymakers should consider additional incentive mechanisms to achieve lower emission steel target quotas within society. Any changes need to be balanced with other policy priorities, ensuring that the industry is not prevented from delivering OSW developments. Additionally, changes need to be supported by appropriate financial mechanisms to lower the price premium and prevent the financial burden from being shifted onto the supply chain or electricity end-consumers.	Regulators implement clear and consistent incentives to encourage manufacturers and customers to use lower emission steel, so that steel decarbonisation occurs in tandem with that of other parts of the OSW value chain. The availability of lower emission steel is increased to support this via policy mechanisms to drive attainment of target quotas.	OSW projects are being constructed with a greater proportion of lower emission steel while remaining financially competitive and viable.	2030-2035

Pathway to decarbonise steel in offshore wind

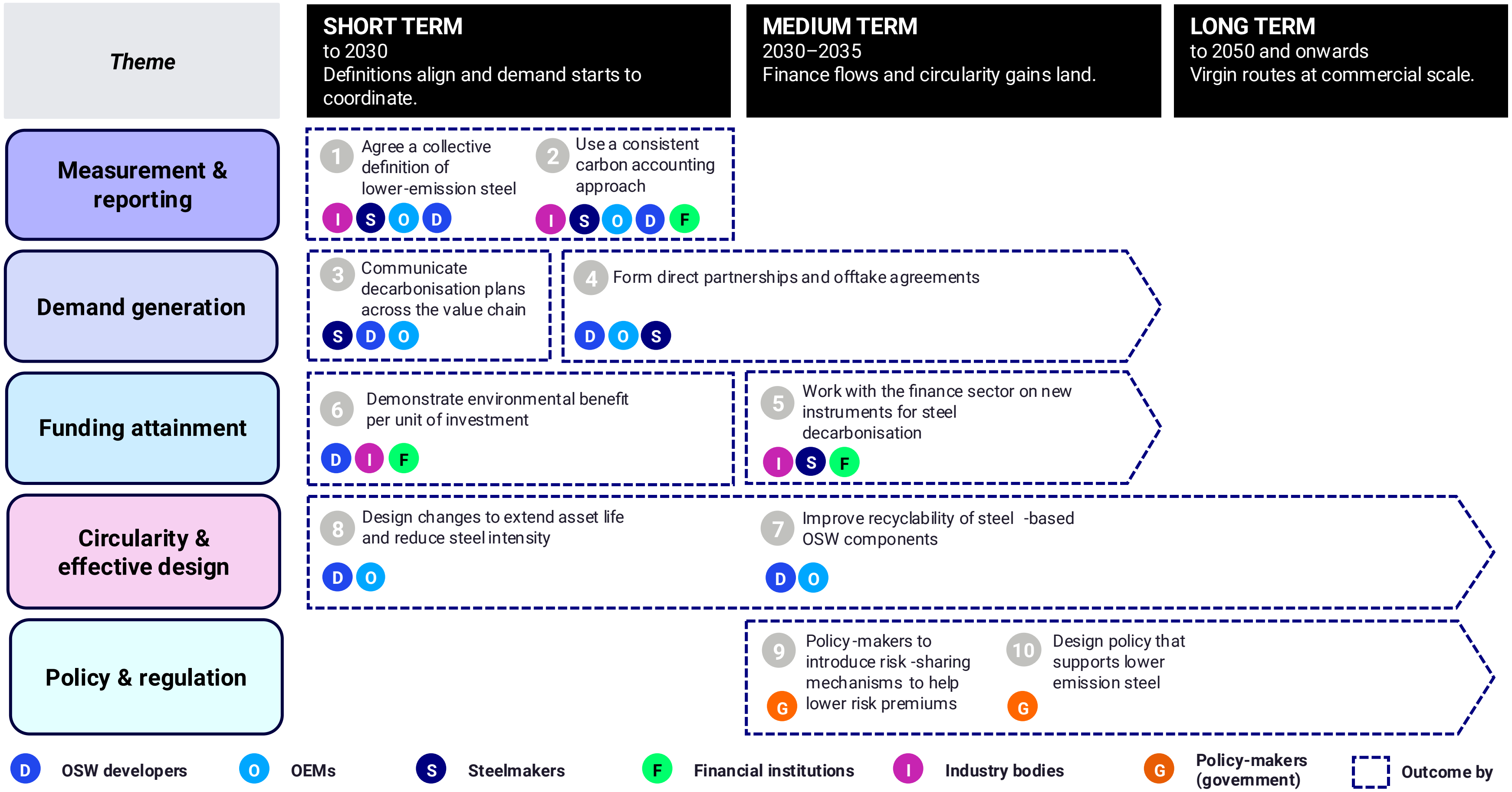

Figure 8: The ten activities ordered visually by theme and relative timing of targeted outcome. The activities are placed on the timeline according to when they should be fully mobilised by; the dashed borders indicate that the period over which this could occur. Borders that end with arrowheads on their right-hand side indicate that, although the activity is ideally implemented by the earlier part of the range, it may need sustained and ongoing longer-term implementation as the sector evolves.

5. Conclusion

Decarbonising steel in OSW is a sequencing problem, not a technology problem. The mature scrap-based route is already available. The virgin routes needed at scale are technically proven. The commercial, physical and enabling challenges that stand in the way are clearly defined. What has been missing is a coordinated sequence of moves that pulls industry stakeholders into alignment at the right time and translates the industry's considerable collective buying power into a credible demand signal that the rest of the steel sector can act on.

Figure 8 sets out that sequence. It captures the shift in the system state across three time horizons, names the ten priority activities required to produce the shift and identifies which stakeholder groups lead each activity. Short-term moves align definitions, coordinate demand signals and demonstrate the environmental value of early investment. Medium-term moves channel finance to help lower the remaining price premium and improve the circularity of OSW steel. Long-term moves reshape the design of OSW assets to use less steel per gigawatt of installed capacity and ensure that virgin, lower emission routes reach commercial scale. Governments and regulators sit alongside the pathway as policy-level enablers whose role is captured separately in the Pathway.

The short-term window is disproportionately valuable. The steps that matter most on the pathway are the ones closest to today. Agreeing on a shared definition, aligning demand signals and forming the first large-scale offtake commitments are the moves that unlock everything that follows. They send the signal that expands scrap-based capacity, narrows the premium, brings finance into the industry, and, in turn, makes the longer arc of virgin route commercialisation and design-led steel reduction viable. Without credible action in the short term, the medium and long-term horizons become harder to reach, rather than naturally sequential to them.

A key objective is to accelerate progress toward price parity. The activities are positioned to speed up the crossover point where lower emission steel reaches an equivalent price to that of conventional steel through a considered balance of alleviating existing premiums and disincentivising emissions intensive processes. Once price parity is reached, a longer-term objective is to then decrease the price of lower emission steel after the price parity point has been hit, to avoid a system where price parity is met but steel becomes a fundamentally more expensive commodity as we move into the future.

This is a collective task. No single stakeholder can deliver the pathway alone. OSW developers hold procurement power but not the financial sector's capital or the steelmakers' production capacity. Steelmakers control production but depend on credible buyers to justify investment. Industry bodies and original equipment manufacturers coordinate with each other, and governments set the policy environment. Governments and regulators are overarching enabling actors with the key to setting and enforcing regulations that drive change away from the status quo and provide a secure footing for the players within the OSW-steel supply chain to act confidently in their own areas of responsibility.

The value of the Pathway is in giving each group a specific, time-sequenced role that fits alongside the others, so that the OSW industry's ambition translates into societal decarbonisation rather than a displacement of emissions from one industry to another. The longer-term picture is one where the same coordination delivers cheaper, lower emission steel, more resilient supply chains, and lower energy costs for consumers, in an OSW industry that is no longer a growing source of embedded emissions but a credible part of the climate response it was built to deliver.

1.1. Appendix: Methodology

Step 1. Initially, a secondary research deep-dive was conducted to investigate:

- Defining and measuring the emission impact of steel within the OSW supply chain.
- Technological readiness of different steelmaking production routes and associated infrastructure.
- Barriers to decarbonising steel used within OSW developments.
- Opportunities for decarbonising steel used within OSW developments.
- Mechanisms to incentivise and accelerate the implementation of identified opportunities.

This research comprised the review of over 100 secondary sources, including reports, articles and press releases. This was complemented by interviews with 15 different stakeholders representing OSW developers, steelmakers, component manufacturers, non-profit collaborators, a government body and a renewable energy association. Interviews focused on individual stakeholder perspectives relating to the identified challenges and opportunities for decarbonising steel within the OSW industry. This ensured that a well-rounded consideration of potential solutions was conducted before laying out the initial structure of the Pathway.

Step 2. Following on from the initial deep-dive assessment, data from a variety of secondary sources was used to:

- Estimate and forecast the global steel supply and demand including the size of the OSW steel demand.
- Estimate the emission savings from lower emission steel versus BAU steel in these forecasts.
- Map out the embedded costs within the steel-OSW supply chain and evaluate how these may vary in future.
- Assess routes to price parity between standard steel and lower emission steel considering the viability of lower steel cost reduction levers.

This analysis helped to demonstrate the magnitude of the financial challenges identified in Step 1 and the importance and practicality of some of the proposed opportunities for transition. Scenario analysis was conducted to assess how variations in future steel production routes affect average steel costs and emissions intensity (see Section 4.1). The results were discussed in a workshop with a group of OSW developers and steelmakers to gather further perspectives on effective mechanisms for accelerating the uptake of lower-emission steel.

Step 3. The analysis and research conducted in Step 1 and Step 2 has enabled the formulation of the Pathway in this report. The insights developed emphasised the need for a unified approach to achieving the goals of the Pathway, considering how the realisation of significant decarbonisation of steel requires systemic action and therefore stakeholder activities that are integrated and well-directed.

Key system-level opportunity areas were identified, and within these individual actions were defined. Each activity was assigned an objective, targeted outcome, measurement approach, implementation timeframe and suggested stakeholder governance. As many of the activities are interdependent and reinforce each other, a recommended approach for coordinated implementation to realise the greatest system-level change is outlined in the Pathway conclusion.

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[i] The stacked bars are a measure of the $/tCS arising from each production route, the navy line depicts the forecast tCO_2e/tCS resulting from the combination of production routes, and the green line is the target tCO_2e/tCS for OSW steel procurement based on the SBTi's guidance for the steel sector.

Data includes unit costs for different energy and material inputs as well as capital and other costs. This is combined with resource quantities required for each production route and a forecast for how each production route may decarbonise through time. The impact of ETS is also incorporated, adding higher costs based on the magnitude of emissions generated in each production process.

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